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PROTEIN FOOD PROMOTION

November 22—December 1, 1970

ORGANIZED BY

Institute of Food Research and Product Development,
Kasetsart University.

Nutrition Division, Department of Health.

United States Organization Mission to Thailand.

FOREWARD

The executive board of the seminar on the Protein Food Promotion have agreed to divide the contributions into two parts. Part one consists of articles related to the topics in the seminar contributed by outstanding scientists from many countries, i.e. the United States, Japan, Indonesia, Netherlands, and etc, totalling more than fourty articles. With regard to the articles on works in Thailand the board has provided further information on the on-going projects and the budget available. This information occurs in the beginning of each article. Specifically, this project is the work of the Department of Health, Ministry of Public Health and the Institute of Food Research and Product Development, Kasetsart university, the Prime Minister's Office. The National Food and Nutrition Policy is printed at the end of the article. This policy became legal at the national level since October 27, 1970. Hence. it is clear that the government of Thailand is concerned about food and nutrition of the nation.

The middle section of part I contains technical information and are of great value to students and interested researchers of food science and technology and nutrition.

The executive board are indebted to the scientists who have sent in their contributions. Because of the outstanding value of each article, the board found it impossible to exclude them. Hence, as you have seen already, Part I is quite large. This volume will also be a benefit to Thailand, a developing country, since valuable writings are scarce here. The contributors may be assured that their efforts have not been in vain.

The value of this seminar is due to the kindness of the contributors who have spent their time and energy. The board would like to express its very sincere thanks to all of those who have contributed in one way or another.

The Executive Board

คณะกรรมการดำเนินการสัมมนา

1. ปลัดสำนักนายกรัฐมนตรี หรือผู้แทน
2. ปลัดกระทรวงสาธารณสุข หรือผู้แทน
3. ปลัดกระทรวงอุตสาหกรรม หรือผู้แทน
4. ปลัดกระทรวงเกษตร หรือผู้แทน
5. ปลัดกระทรวงมหาดไทย หรือผู้แทน
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7. เลขาธิการสภาพัฒนาการเศรษฐกิจแห่งชาติ
8. เลขาธิการคณะกรรมการส่งเสริมการลงทุนเพื่อกิจการอุตสาหกรรม
9. ผู้อำนวยการสำนักงบประมาณ
10. ผู้ว่าการสถาบันวิจัยวิทยาศาสตร์ประยุกต์แห่งประเทศไทย
11. เลขาธิการสภาวิจัยแห่งชาติ
12. ผู้อำนวยการกองอำนวยการรักษาความปลอดภัยแห่งชาติ
13. อธิการบดีมหาวิทยาลัยเกษตรศาสตร์

ประธาน **พลโทบุญเรือน บัวจรูญ**
ปลัดสำนักนายกรัฐมนตรี

รองประธาน **ม.จ. จักรพันธุ์เพ็ญศิริ จักรพันธุ์**
อธิการบดีมหาวิทยาลัยเกษตรศาสตร์

เลขานุการ **นายอมร ภูมิรัตน**
ผู้อำนวยการสถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร
มหาวิทยาลัยเกษตรศาสตร์

ระหว่างวันที่ 22 พฤศจิกายน--1 ธันวาคม 2513

ณ มหาวิทยาลัยเกษตรศาสตร์

จัดโดย มหาวิทยาลัยเกษตรศาสตร์
กรมอนามัย
คณะผู้แทนบริหารเพื่อการพัฒนาระหว่างประเทศ

เจ้าหน้าที่

ฝ่ายเลขานุการสัมมนา

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— พนักงานพิมพ์ดีดภาษาอังกฤษ เจ้าหน้าที่สถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร

ฝ่ายจัดสถานที่และอุปกรณ์นิทรรศการ

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— นายสุชน นิวมานนิตย์ สถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร

ฝ่ายสันทนาการ

— ดูงานจังหวัดเชียงใหม่ น.ส. โสภา นิพิธสุขการ กองโภชนา กรมอนามัย

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ฝ่ายยานพาหนะ

— กองโภชนาการ กรมอนามัย

ฝ่ายที่พัก

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— นางวีณะ วีระไวทยะ กองโภชนาการ กรมอนามัย

— น.ส. อมรา ภูมิรัตน สถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร

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— นายแพทย์อมร นนทสุต กองโภชนาการ กรมอนามัย

ฝ่ายโฆษณา และจัดให้มีการสัมภาษณ์ผู้มาบรรยาย

— นายอมร ภูมิรัตน สถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร

ฝ่ายจัดการจราจร

— นายอมร ภูมิรัตน และตำรวจสถานีตำรวจนครบาลบางเขน

รายการสัมมนา

วันที่ 22 พฤศจิกายน — วันที่ 1 ธันวาคม 2513

1. หัวข้อ การส่งเสริมอาหารโปรตีนในประเทศไทย

2. วัตถุประสงค์

การจัดสัมมนานี้เพื่อก่อให้เกิดความรู้ในเรื่องความจำเป็นของร่างกายในอาหารประเภทโปรตีน ซึ่งไม่อาจจะแบ่งชั้นวรรณะ หรือขีดคั่นความต้องการได้ ทุกคนไม่ว่ารวยหรือจนจำเป็นที่จะต้องบริโภคอาหารที่มีโปรตีน และแนะแนวทางให้เกิดการพัฒนาในการผลิต ในการตลาดจากวัตถุดิบที่มีภายในประเทศ และให้มีราคาถูกตามรายได้

3. ขอบเขต

— แหล่งโปรตีนที่มีอยู่ภายในประเทศอันมีความสัมพันธ์กับปัญหาทางด้านโภชนาการ
— การส่งเสริมผลิตผลการเกษตรที่มีปริมาณโปรตีนสูง อันจะช่วยขจัดปัญหาการขาดอาหาร
— ความสำคัญทางด้านการที่จะทำให้ผลิตภัณฑ์ที่ผลิตขึ้นตามวัตถุประสงค์ให้เป็นอุตสาหกรรม
— การส่งเสริมและพัฒนาตลาด

ระเบียบวาระการสัมมนา

วันอาทิตย์ที่ 22 พฤศจิกายน — วันอังคารที่ 24 พฤศจิกายน 2513

นักวิทยาศาสตร์ชาวต่างประเทศไปดูการเลี้ยงเด็กที่ศูนย์โภชนาการเด็กที่จังหวัดเชียงใหม่ (ซึ่งใช้อาหารเสริมโปรตีน)

เจ้าหน้าที่ต้อนรับ

— เจ้าหน้าที่ของกองโภชนาการ กรมอนามัย
— เจ้าหน้าที่ของสถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร มหาวิทยาลัยเกษตรศาสตร์

วันพุธที่ 25 พฤศจิกายน 2513 ภาคเช้า

หอประชุมมหาวิทยาลัยเกษตรศาสตร์

8.30 — ลงทะเบียน

9.00 — เริ่มพิธีเปิด เชิญผู้มาฟังการสัมมนาเข้าห้องประชุม

9.15 — ปลัดสำนักนายกรัฐมนตรี กราบเรียน ฯพณฯ นายกรัฐมนตรีถึงที่มาแห่งการจัดสัมมนา

9.45 — ฯพณฯ นายกรัฐมนตรี กล่าวเปิดการสัมมนา

10.00 — พัก

10.30 — ความมุ่งหมายของการสัมมนาเรื่องการส่งเสริมอาหารโปรตีนโดย ฯพณฯ ร.ม.ช. กระทรวงสาธารณสุข

10.45 — Recent Progress in Protein Food Development

Dr. G.R. Dimarco, Chairman,

Department of Food Science, Rutgers University

วันพุธที่ 25 พฤศจิกายน 2513 ภาคบ่าย

ห้องบรรยายของสถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร

ประธานที่ประชุม ปลัดกระทรวงสาธารณสุข

13.30 — "Protein and Protein Food Sources in Relation to Nutrition Problems"

— Dr. Kalyan Bagchi

Nutrition Adviser and

Assistant General of Health Services

Directorate General of Health Services

Government of India

Nirman Bhavan.

14.15 — ข้อซักถาม—เสนอแนะ

14.45 — พัก

15.00 — "Nutrition Problems"

— Dr. Gerald F. Combs, Chief

International Programs Staff

Nutrition Program

National Institute of Health.

— Dr. Fredric W. Hill, Chairman

Department of Nutrition

University of California, Davis.

16.00 -- ข้อซักถาม—เสนอแนะ

วันพฤหัสบดีที่ 26 พฤศจิกายน 2513 ภาคเช้า

ห้องบรรยายของสถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร

ประธานที่ประชุม ปลัดกระทรวงเกษตร

9.00 — "The Role of Agriculture in Meeting the Protein Gap"

— Dr. R.J. Dimler, Director

Northern Utilization Research and Development

Division

Agricultural Research Service

U.S. Department of Agriculture

Peoria Illinois

9.40 — ข้อซักถาม--เสนอแนะ

10.15 — พัก

10.30 — "Recent Developments in Processing Protein Rich Agricultural Products"

— ผู้ว่าการสถาบันวิจัยวิทยาศาสตร์ประยุกต์แห่งประเทศไทย

— อธิการบดีมหาวิทยาลัยเกษตรศาสตร์

11.20 — ข้อซักถาม--เสนอแแนะ

วันพฤหัสบดีที่ 26 พฤศจิกายน 2513 ภาคบ่าย

ห้องบรรยายของสถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร

ประธานที่ประชุม ปลัดกระทรวงมหาดไทย

13.30 — "Role of Agriculture in Expanding Protein Sources"

— Dr. Hans-Dieter Paver

Kohlenstoffbiologishe

Forschungsstation e.V.

Germany

14.15 — ข้อซักถาม—เสนอแนะ

14.45 — พัก

15 00 — L-Lysine Fortification of Cereals

ผู้แทนบริษัท Kyowa Hakko Kogyo Co., Ltd.

15.30 — ข้อซักถาม—เสนอแนะ

วันศุกร์ที่ 27 พฤศจิกายน 2513 ภาคเช้า

ห้องบรรยายของสถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร

ประธานที่ประชุม ผู้อำนวยการสำนักงบประมาณ

9.00 — "The Role of Government and Industry in Protein Food Development Programmes"

- Dr. G.D. Kapsiotis

Senior Officer

Protein Food Development

Nutrition Division Group

— Dr. M.R. McRoberts

Regional Nutrition Officer

FAO, Bangkok.

9.40 — ข้อซักถาม—เสนอแนะ

10.15 — พัก

10.30 — "The Government's Policy in the Promotion of Food Industry"

— เจ้าหน้าที่ของคณะกรรมการส่งเสริมการลงทุน ฯ

11.15 — ข้อซักถาม—เสนอแนะ

วันศุกร์ที่ 27 พฤศจิกายน 2513 ภาคบ่าย

ห้องบรรยายของสถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร

ประธานที่ประชุม เลขาธิการคณะกรรมการส่งเสริมการลงทุน ฯ

13.30 — "Role of Commercial Sector"

— Dr. F.E. Horan, Director of Research

Archer Daniels Midland Company

Decatur, Illinois.

14.15 — ข้อซักถาม - เสนอแนะ

14.45 — พัก

15.00 -- Problems in Commercial Food Promotion related to Government's Policy

— ผู้แทนบริษัทในประเทศไทย

15.45 — ข้อซักถาม—เสนอแนะ

วันเสาร์ที่ 28 พฤศจิกายน 2513

ล่องเจ้าพระยา

วันอาทิตย์ที่ 29 พฤศจิกายน 2513

หยุด

วันจันทร์ที่ 30 พฤศจิกายน 2513 ภาคเช้า

ห้องบรรยายของสถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร

ประธานที่ประชุม ปลัดกระทรวงอุตสาหกรรม

9.00 — "Promotion and Marketing of Protein Products"

— Dr. Martin J. Forman, Director

Nutrition & Child Feeding Service

Office of War on Hunger

Department of State

Agency for International Development, Washington.

9.30 — ข้อซักถาม - เสนอแนะ

10.00 — พัก

10.15 — Industrial Participation in the Thai Food Program

— Dr. C.C. Loo, Manager

Product Development

General Milk Company Division

Carnation Research Laboratories, Van Nuys,

California.

10.30 — Vegetable Protein Processing

— Mr. Sven-Eric Kroon, Sales Engineer

Separation Division, Food Processing

Alfa-Laval AB

Tumba, Sweden.

10.45 — "The Role of Agro-Industries in Promoting Production of Protein."

— Dr. E.A.M. Asselbergs,

Food and Agricultural Industries

Agricultural Service Division, FAO.

— Dr. S.S. De,

Food and Agicultural Industries Officer

Agricultural Services Division, FA.O

11.15 — ข้อซักถาม—เสนอแนะ

วันจันทร์ที่ 30 พฤศจิกายน 2513 ภาคบ่าย

ห้องบรรยายของสถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร

ประธานที่ประชุม เลขาธิการสภาพัฒนาการเศรษฐกิจแห่งชาติ

13.30 — การถกแถลง—ซักถาม—เสนอแนะ

— บริษัทห้างร้านของผู้ที่มาร่วมสัมมนาทั้งภายในประเทศและต่างประเทศในหัวข้อ "Relationship of the Government's Policy to the Commercial Food Promotion"

15.00 พัก

15.15 — การถกแถลง—ซักถาม—เสนอแนะ ต่อจากตอนต้น

— บทความที่เสนอมาในระยะหลัง ถ้ามี

วันอังคารที่ 1 ธันวาคม 2513 ภาคเช้า

ห้องบรรยายของสถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร

ประธานที่ประชุม ปลัดกระทรวงศึกษาธิการ

9.00 — "Mass Feeding Program as a Market for Protein Food Products"

— Dr. John Perryman, Executive Director

American School Food Service Association, Denver.

9.30 — ข้อซักถาม—เสนอแนะ

10.00 — พัก

10.15 — "Protein Food Products Developed in Thailand"

— นายอมร ภูมิรัตน ผู้อำนวยการ

สถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร มหาวิทยาลัยเกษตรศาสตร์

— นายแพทย์อมร นนทสุต ผู้อำนวยการ

กองโภชนาการ กรมอนามัย

11.20 — ข้อซักถาม—เสนอแนะ

วันอังคารที่ 1 ธันวาคม 2513 ภาคบ่าย

ห้องบรรยายของสถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร

13.00 — สรุปผลการประชุม โดย

คณะกรรมการจัดสัมมนา

ปลัดสำนักนายกรัฐมนตรี หรือผู้แทน

ปลัดกระทรวงสาธารณสุข หรือผู้แทน

ปลัดกระทรวงอุตสาหกรรม หรือผู้แทน

ปลัดกระทรวงเกษตร หรือผู้แทน

ปลัดกระทรวงมหาดไทย หรือผู้แทน

ปลัดกระทรวงศึกษาธิการ หรือผู้แทน
เลขาธิการสภาพัฒนาการเศรษฐกิจแห่งชาติ
เลขาธิการคณะกรรมการส่งเสริมการลงทุน เพื่อกิจการอุตสาหกรรม
ผู้อำนวยการสำนักงบประมาณ
ผู้ว่าการสถาบันวิจัยวิทยาศาสตร์ประยุกต์แห่งประเทศไทย
เลขาธิการสภาวิจัยแห่งชาติ
ผู้อำนวยการกองอำนวยการรักษาความปลอดภัยแห่งชาติ
อธิการบดีมหาวิทยาลัยเกษตรศาสตร์
ร่วมด้วยคณะกรรมการชั่วคราวที่ดำเนินการรวบรวมสรุปผลการสัมมนา
นายอมร ภูมิรัตน, สถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร
นายแพทย์อมร นนทสุต, กองโภชนาการ กรมอนามัย
นายคารี วงศ์อารยะ, กรมพัฒนาชุมชน
นายสมบัติ วงศ์พรหมเมฆ กรมส่งเสริมการเกษตร
น.ส. ยุวดี กาญจนษัฐิติ, วิทยาลัยการศึกษาพระนคร
กับผู้บรรยาย

— Dr. G.R. Dimarco, Chairman
Department of Food Science
Rutgers University.

— Dr. Kalyan Bagchi
Nutrition Adviser and
Assistant Director General of Health Services
Directorate General of Health Services
Government of India
Nirman Bhavan.

— Dr. Gerald F. Combs, Chief
International Programs Staff
Nutrition Program

National Institute of Health.

— Dr. Fredric W. Hill, Chairman

Department of Nutrition

University of California, Davis.

— Dr. R.J. Dimler, Director

Northern Utilization Research and Development Division

Agricultural Research Service

U.S. Department of Agriculture

Peoria, Illinois.

— Dr. Hans-Dieter Payer

Kohlenstoffbiologische Forschungsstation e V.

Germany.

— ผู้แทนบริษัท Kyowa Hakko Kogyo Co., Ltd.

— Dr. G.D. Kapsiotis

Senior Officer, Protein Food Development Group

Nutrition Division, FAO, Rome.

— Dr. M.R. McRoberts

Regional Nutrition Officer, FAO Bangkok.

— เจ้าหน้าที่ของคณะกรรมการส่งเสริมการลงทุน ฯ

— Dr. F.E. Horan, Director of Research

Research Manager for Agricultural Production

Archer Daniels Midland Company

Decatur, Illinois.

— ผู้แทนบริษัทอีเวอร์ราเธอร์

— Dr. Martin J. Forman, Director

Nuttition & Child Feeding Service,

Office of War on Hunger

Departmeut of State

Agency for International Development

Washington.

— Dr. C.C. Loo, Manager

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General Milk Company Division,

Carnation Research Laboratories, Van Nuy, California.

— Mr. S-E Kroon

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Tumba, Sweden.

— Dr. E.A.M. Asselbergs, Food and Agricultural Industries

Agricultural Services Division, FAO.

— Dr. S.S. De, Food and Agricultural Industries

Agricultural Services Division, FAO.

— ผู้แทนของบริษัทต่าง ๆ ที่เข้าร่วม

— Dr. John Perryman, Executive Director

American School Food Service Association,

Denver.

— นายอมร ภูมิรัตน, ผู้อำนวยการ

สถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร มหาวิทยาลัยเกษตรศาสตร์

— นายแพทย์อมร นนทสุต, ผู้บรรยาย

กองโภชนาการ กรมอนามัย

— และผู้เข้าร่วมการสัมมนาทุกท่าน

สรุปผลการสัมมนา โดยคณะ กรรมการ ชั่วคราวที่ดำเนินการ รวบรวมนำ เสนอ ต่อที่ประชุม เพื่อขอข้อคิดเห็น สรุปผล และนำผลสรุปเสนอต่อ ค.ร.ม. ต่อไป

19.00 — พิธีปิดการสัมมนา

— เลี้ยงอาหารค่ำที่หอประชุมมหาวิทยาลัยเกษตรศาสตร์

(21.00 น. แจกสรุปผลการสัมมนา)

โครงการพัฒนาอาหารโปรตีน

โครงการนี้กรมอนามัย กระทรวงสาธารณสุข เป็นเจ้าของโครงการร่วมกับสถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร มหาวิทยาลัยเกษตรศาสตร์ โดยมีการแบ่งหน้าที่กันดังนี้.—

— สถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร มหาวิทยาลัยเกษตรศาสตร์ มีหน้าที่ในการผลิตอาหารขึ้นโดยอาศัยเป้าหมายดังนี้

- ต้องเป็นอาหารชนิดที่จัดเข้าระบบการบริโภคของคนไทยตามท้องถิ่นต่าง ๆ
- ต้องมีคุณค่าทางโภชนาการที่ร่างกายต้องการและเกิดประโยชน์
- ต้องมีราคาถูกในเกณฑ์ที่คนไทยเราสามารถจะจัดหาซื้อได้
- ต้องใช้วัตถุดิบภายในประเทศ

— กรมอนามัย จะต้องนำผลิตภัณฑ์นั้น ๆ ไปจัดเลี้ยงเด็กตามแหล่งต่าง ๆ ตามสถานที่ ๆ กำหนด

- ทดลองเลี้ยงหาข้อมูล
- ประสานงานกันในการจะแก้ไขปรับปรุง
- ทำหน้าที่เป็นสื่อในการส่งเสริม—แนะนำ—อบรมให้เกิดผลมากที่สุดเท่าที่จะทำได้
- สรุปผล

ทั้งนี้ ยังได้รับความร่วมมือจากกรมวิทยาศาสตร์ และกรมวิทยาศาสตร์การแพทย์ ในด้านการตรวจวิเคราะห์คุณค่าทางอาหาร และทางชีวะเคมี

งานของทั้งสองหน่วยนี้พอจะสรุปได้ดังนี้.---

1. วัตถุประสงค์

เป็นที่ทราบกันแล้วว่า การขาดสารอาหารโปรตีนและแคลอรี่เป็นปัญหาทางโภชนาการที่สำคัญของพลโลกที่ยากจนทั้งหลาย แม้แต่ในประเทศไทย ประชาชนตามชนบทถึงแม้จะได้บริโภคอาหาร ที่มีสารอาหารโปรตีนและแคลอรี่อยู่ในระดับพอเพียงก็ตาม แต่ตามความเป็นจริงแล้ว จำนวนสารโปรตีนดังกล่าวเป็นโปรตีนที่ได้จากพืชเสียกว่าสองในสาม และส่วนมากก็ได้จากข้าวซึ่งเป็นโปรตีนที่มีคุณภาพต่ำไม่พอเพียงกับความต้องการของร่างกาย โดยเฉพาะอย่างยิ่งสำหรับเด็กเล็ก ฉะนั้น การขาดสารโปรตีนในเด็กเล็ก จึงพบอยู่เสมอ โดยเฉพาะ

เด็กที่เริ่มหย่านม เพราะว่าอาหารเพิ่มเติมส่วนใหญ่ที่ได้รับคือข้าว เด็กในวัยนี้เป็นวัยที่อยู่ในระยะกำลังเจริญเติบโตทั้งด้านร่างกายและสมอง จึงจำเป็นต้องได้รับอาหารโปรตีนที่มีคุณภาพสูงเพื่อให้เหมาะสมกับความต้องการ ถ้าร่างกายขาดอาหารดังกล่าวก็จะทำให้ร่างกายไม่เจริญเติบโตเต็มที่ และทำให้สติปัญญาทึบได้ ซึ่งเมื่อเกิดขึ้นแล้วจะแก้ไขให้กลับคืนได้ยาก ฉะนั้น การปรับปรุงหรือพัฒนาอาหารโปรตีนสำหรับเด็ก จึงเป็นสิ่งสำคัญที่ควรจะได้ดำเนินการเป็นอย่างยิ่ง วัตถุประสงค์ของโครงการพัฒนาอาหารโปรตีนเพื่อที่จะ

1.1 ส่งเสริมการพัฒนางานด้านเทคโนโลยีอาหาร และงานอื่นที่เกี่ยวข้อง

1.2 ผลิตอาหารสำเร็จรูปที่มีสารโปรตีนสูง หรืออาหารที่มีคุณภาพสูง เพื่อใช้เป็นอาหารเสริมสำหรับเด็กหลังหย่านม และเด็กก่อนวัยเรียน

1.3 ทดลองตรวจสอบอาหารสำเร็จรูปทั้งในห้องทดลอง และในเขตปฏิบัติการเพื่อดูคุณค่าทางอาหารและความนิยมของผู้บริโภค

1.4 เมื่อได้รับความนิยมแล้วก็จะได้เผยแพร่ส่งเสริมให้เป็นไปในรูปการค้า เพื่อสนับสนุนให้อาหารนี้แพร่หลายในหมู่ประชาชนต่อไป

ในการปรับปรุงส่งเสริมการบริโภคอาหารโปรตีนนี้ จะดำเนินการโดยการเพิ่ม หรือเสริมอาหารที่มีโปรตีนสูงเข้าไปในอาหารประจำวัน ซึ่งอาหารที่ใช้เสริมนี้ต้องเป็นอาหารโปรตีนที่มีคุณภาพสูงเป็นผลิตผลที่มีมากในประเทศ มีราคาถูกพอสมควร คนทั่วไปนิยมรับประทานอยู่แล้ว และมีทางให้ผลิตภัณฑ์เกิดประโยชน์

2. วิธีดำเนินงาน

เพื่อบรรลุวัตถุประสงค์ข้างต้น กรมอนามัย ร่วมกับสถาบันค้นคว้า และพัฒนาผลิตภัณฑ์อาหารได้ดำเนินงานดังนี้

2.1 จัดให้มีอาหารสำเร็จรูปซึ่งทำจากปลาทะเลและถั่วเขียว ถั่วเหลือง

2.2 อาหารสำเร็จรูปนี้จะได้รับการตรวจวิเคราะห์หาโปรตีน และกรดอมิโน ตลอดจนค่าทางชีวะภาพด้วย

2.3 อาหารเหล่านี้จะถูกปรุงแต่งออกมาเป็นตำรับต่าง ๆ

2.4 จะนำไปทดลองเลี้ยงเด็กวัยก่อนเรียน (อายุ1–5 ปี) และทดสอบความนิยมอาหารนี้ ๆ จากแม่และเด็กด้วย เด็กวัยก่อนเรียนที่จะได้รับการเลี้ยงอาหารเหล่านี้ จะมาจากครอบครัวที่มีรายได้ไม่เกินปีละ 3,000.— บาท

2.5 จะทดลองเลี้ยงเด็กหมู่บ้านละประมาณ 100 คน ใน 25 หมู่บ้าน รวมเป็นเด็กทั้งหมด 2,500 คน ซึ่งจะเปิดเขตทดลองใน 4 จังหวัด คือ จังหวัดแพร่ 5 หมู่บ้าน เชียงใหม่ 5 หมู่บ้าน ร้อยเอ็ด 5 หมู่บ้าน และอุบลราชธานี 10 หมู่บ้าน

2.6 เลือกหมู่บ้าน ที่เหมาะสมหนึ่งหมู่บ้าน หรือมากกว่าของ แต่ละจังหวัดเป็น หมู่บ้านเปรียบเทียบ โดยจะมีเด็กในหมู่บ้านประมาณ 100 คนเช่นกัน

2.7 จัดตั้งศูนย์สำหรับเลี้ยงเด็กกลางวันขึ้นในหมู่บ้าน โดยจะขอให้ชาวบ้านมีส่วนร่วมดำเนินการด้วย และเลือกบุคคลที่เหมาะสมจากหมู่บ้านนั้น หมู่บ้านละ 3 คน มาเข้ารับการอบรมระยะสั้นเพื่อเป็นเจ้าหน้าที่เลี้ยงเด็กเหล่านี้ และจะมีเจ้าหน้าที่ฝ่ายอนามัย เช่น ผดุงครรภ์โภชนากร หรืออาจจะเป็นอาสาสมัครก็ได้ เป็นผู้ควบคุมการดำเนินงานและให้คำแนะนำแก่พี่เลี้ยง

2.8 การร่วมปฏิบัติงานในศูนย์จะเป็นแบบอาสาสมัคร แม่ของเด็กจะได้รับการขอร้องให้ผลัดเปลี่ยนกันมาช่วยโครงการนี้ และจะได้รับการแนะนำในด้านการปรุงอาหาร การเลี้ยงดูเด็กรวมทั้งทดสอบความนิยมในอาหารแต่ละอย่างด้วย กับข้าวที่ปรุงขึ้นเพื่อเลี้ยงเด็กจะพยายามไม่ให้แตกต่างจากอาหารที่กินอยู่ที่บ้านมากนัก ทั้งนี้เพื่อผลในการเปรียบเทียบ

2.9 ค่าใช้จ่ายนั้น จะใช้จากงบประมาณของโครงการทั้งสิ้น

2.10 ศูนย์เลี้ยงเด็กกลางวันนี้จะอยู่ในความรับผิดชอบของนายแพทย์อนามัยจังหวัด

2.11 จะมีการสำรวจอาหารที่เด็กได้รับอยู่แล้วเป็นประจำ โดยเฉพาะอาหารเสริมประเภทที่เด็กชอบรับประทานและมีขายอยู่ในหมู่บ้าน ทั้งนี้ เพื่อหาทางเสริมคุณภาพอาหารเหล่านั้นให้สูงขึ้น

2.12 จะมีการสำรวจและศึกษาสภาวะทางอุตสาหกรรมอาหาร และจะจัดให้มีการสัมมนาเพื่อจัดให้มีหน่วยงานสำหรับดำเนินการในด้านการค้าโดยเฉพาะ และย้ำให้ทราบถึงบทบาทที่จะต้องร่วมดำเนินงาน ให้เป็นผู้นำในการศึกษาวิจัยด้านเทคโนโลยีอาหารและการค้า การสัมมนาอาจจะให้เป็นส่วนหนึ่งของการสัมมนาอาหารและโภชนาการแห่งชาติ

2.13 ตำรับอาหารเสริมต่าง ๆ ที่ผ่านการรับรองแล้ว จะได้รับการสนับสนุนให้ดำเนินการเป็นการค้าขึ้น ซึ่งจะเป็นขั้นสุดท้ายของโครงการที่จะช่วยให้เด็กวัยก่อนเรียนตามชนบท ในภาคเหนือและภาคตะวันออกเฉียงเหนือจำนวน 1.6 ล้านคน ได้รับผลจากโครงการนี้

2.14 จะจัดหาทุนอุดหนุนโครงการเลี้ยงเด็กวัยก่อนเรียนและเด็กวัยเรียนด้วย

2.15 การดำเนินงานด้านอื่น เช่นงานโภชนาการ สุขาภิบาล ก็จะดำเนินไปพร้อมกัน เพื่อว่าเมื่อโครงการนี้สิ้นสุดลงแล้ว ชาวบ้านจะดำเนินการต่อไปได้เอง

3. ระยะเวลาดำเนินงาน

ระยะเวลาการดำเนินงานของโครงการแบ่งออกเป็น 2 ระยะ คือ

3.1 **ระยะที่ 1** กำหนดไว้ 5 ปี โดยจะเริ่มต้นตั้งแต่เดือนเมษายน 2511 ในปีแรกจะมีเด็กวัยก่อนเรียนได้รับเลี้ยงเป็นจำนวน 500 คน และจำนวนเด็กจะเพิ่มขึ้นเป็น 2500 คน ใน พ.ศ. 2513 ส่วนการตรวจสอบผลและการปฏิบัติงานอื่น ๆ ที่เกี่ยวข้องกับโครงการนี้ก็จะดำเนินการไปพร้อมกัน

3.2 **ระยะที่ 2** เมื่อการดำเนินงานระยะที่ 1 ประสพผลสำเร็จแล้ว ก็จะมอบหมายให้เจ้าของโรงงานอาหารต่าง ๆ ซึ่งสนใจรับไปทำเป็นการค้าต่อไป และในระยะนี้ควรจะเป็นระยะที่องค์การและรัฐบาลให้ทุนอุดหนุนการเลี้ยงอาหารเด็กวัยก่อนเรียน และเด็กวัยเรียนทั้งในและนอกเขตปฏิบัติการ

4. ลักษณะของความช่วยเหลือ

องค์การยูซอมให้ความร่วมมือสนับสนุนโครงการนี้ โดยจัดสรรความช่วยเหลือให้ในรูปผู้เชี่ยวชาญ วัสดุอุปกรณ์ และทุนการศึกษา ดูงานคือ

4.1 ผู้เชี่ยวชาญ องค์การยูซอมได้ส่งผู้เชี่ยวชาญระยะสั้นด้านอาหารและการวิจัย จำนวน4 คน มาช่วยหน้าที่เจ้าของโภชนาการ กรมอนามัย และสถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร ในด้านการให้คำปรึกษาและแนะนำการวางแผนดำเนินการ ตลอดจนการทดลองค้นคว้าวิจัยอาหารโปรตีน คือ ส่งมาช่วยกรมอนามัยดังนี้ :—

ปี พ.ศ. 2511—2512

1. ผู้เชี่ยวชาญในระยะสั้นเกี่ยวกับปลาทะเล จำนวน 1 คน
2. ผู้เชี่ยวชาญทางด้านถั่วเหลืองจำนวน 3 คน

ทั้ง 4 คนนี้เป็นเงินค่าใช้จ่ายทางยูซอมจ่าย $ 7,500

ปี พ.ศ. 2512-2513 ทางยูซอมจะได้เชิญผู้เชี่ยวชาญมาร่วมงานสัมนาในหัวข้อ Protein Food Promotion หรือการส่งเสริมอาหารโปรตีน ซึ่งทางยูซอมตั้งวงเงินไว้ให้ $ 20,000 เงินจำนวนนี้ผู้เชี่ยวชาญทั้งหมดจะนำมาใช้ในประเทศเกี่ยวกับค่าที่อยู่ ค่าใช้จ่ายต่าง ๆ ในระหว่างการสัมมนา (22 พ.ย.—1 ธ.ค. 2513)

ปี พ.ศ. 2513-2514

ทางยูซอมมีโครงการจะส่งผู้เชี่ยวชาญมาสำรวจผล โดยตั้งงบไว้ $ 10,000

รวมยอดเงินผู้เชี่ยวชาญทั้งหมด $ 37,500

42. **วัสดุอุปกรณ์** องค์การยูซอมได้ให้ความช่วยเหลือด้านวัสดุอุปกรณ์โครงการนี้ คือรถยนต์ เครื่องมือเครื่องใช้ในการผลิตอาหาร ตลอดจนส่วนประกอบต่าง ๆ คิดเป็นมูลค่าสำหรับปี 2511—13 เป็นเงิน 2,300,000 บาท

สำหรับค่าวัสดุทั้งหมดอาจจะแยกรายการออกไปได้ดังนี้.

4.2.1 ให้แก่กรมอนามัย 2511 - 2512

4.2.2 รถยนต์ 4 คัน ให้แก่สถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร 2511--2512

4.2.2.1 Tank, milk holding 150 gallons.

4.2.2.2 Milk can, 10 gallons, stainless steel, with covev.

4.2.2.3 Farm Milk StorageTank, 200 gallons, refriqcratcd, stainless steel.

4.2.2.4 Plate Heat Exchanger.

4.2.2.5 Polyethylene tubing (for packing).

4.2.2.6 Scoops smoll, flat sottom.

4.2.2.7 Thermometer, dial 1-3/8", 0 - 220°F.

4.2.2.8 Thermometer, dial 1-3/8", 50--400°F.

4.2.2.9 Milk can carrier, 10 gallon type.

4.2.2.10 Rietz, Angle Disintegrator, stainless steel.

4.2.2.11 Moyno pump, staiuless steel.

4.2.2.12 Frey, Stuffer (Sausage filling).

4.2.2.13 Mixer, ½ H.P.

4.2.2.14 Surge Tank.

4.2.2.15 Centrifugal pump.

4.2.2.16 Homogenizer.

4.2.2.17 Positive rotary pump

4.2.2.18 Sanitary pipes, etc

4.2.2.19 Tygon tuhing Formulation.

4.2.2.20 Hose Clamps.

4.2.2.21 Stainless tubing 3/8".

4.2.2.22 Wrench for1.5 Sanitary pipe & fittings.

4.2.3 ให้แก่สถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร 2512—2513 (ยังไม่ได้รับ)

Kette Vacuum Type capacity 50 gallons.

Combination Cooker Extruder

รวมค่ารถยนต์ และเครื่องมือทั้งหมดที่ได้รับจากยูซอมแยกเป็นปีดังนี้.--

2511—2512		$ 67,000.—
2512 - 2513		$ 48,000.—
	รวม	$ 115,000.—

(ประมาณ 2,300,000.— บาท)

4.3 ทุนการศึกษาดูงาน ได้ให้ความช่วยเหลือในการจัดส่งข้าราชการกรมอนามัย กรมการฝึกหัดครูคณะสาธารณสุขศาสตร์ มหาวิทยาลัยแพทย์ศาสตร์ สภาพัฒนาเศรษฐกิจแห่งชาติ กรมประมง และสถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร ไปศึกษาดูงาน ณ สหรัฐอเมริกา มีรายการดังนี้.

4.3.1 กรมอนามัยได้รับ

ปี พ.ศ. 2511--2512 (4 เดือน)

4.3.1.1 นายอรุณ รัตนกุล นักวิทยาศาสตร์ตรี แผนกอุตสาหกรรมสัตว์น้ำ กองสำรวจและค้นคว้า กรมประมง

ไปดูงาน Fisheries Technology ที่ Fisheries Technological Laboratory, Bureau of Commercial Fisheries, US Department of Interior, College Park, Maryland เป็นเวลา ๔ เดือน กลับมาแล้วได้ช่วยค้นคว้าการใช้ประโยชน์จากปลาทะเลเพื่อให้อาหารโปรตีนสำหรับประชาชน

4.3.1.2 นายประสิทธิ์ สุนทโรทก ผู้อำนวยการวิทยาลัยครูเชียงใหม่

4.3.1.3 นางอโนทัย เจตนเสนา อาจารย์เอกแผนกวิชาโภชนาศาสตร์ คณะสาธารณสุขศาสตร์ มหาวิทยาลัยแพทย์ศาสตร์

ทั้งสองท่าน เมื่อกลับมาแล้วได้ช่วยส่งเสริมและเผยแพร่วิชาโภชนาศาสตร์แก่นักศึกษา เพื่อให้แพร่หลายไปในหมู่นักเรียนและประชาชนทั่วไป

4.3.1.4 น.ส. อรทิพย์ ตันสกุล วิทยากรเอก หัวหน้าแผนกสาธารณสุข กองโครงการสังคม สภาพัฒนาเศรษฐกิจแห่งชาติ

ได้ช่วยในด้านการพิจารณาวางแผน โภชนาการให้สอดคล้องกับแผนพัฒนาเศรษฐกิจแห่งชาติ

4.3.2 **สถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร**

ปี พ.ศ. 2511–2512 (4 เดือน)

4.3.2.1 นายสมชาย ประภาวัต นักวิทยาศาสตร์ชั้น 2 ของสถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร มหาวิทยาลัยเกษตรศาสตร์

4.3.2.2 นายณรงค์ นิยมวิทย์ นักวิทยาศาสตร์ชั้น 2 ของสถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร มหาวิทยาลัยเกษตรศาสตร์

ฝึกงานเกี่ยวกับโปรตีนที่ Meals for Million Foundation เกี่ยวกับการสกัดโปรตีนจากพวกธัญพืชและอื่น ๆ

ปี พ.ศ. 2512–2513 (4 เดือน)

4.3.2.3 นางสาวสุจินดา ดนตรีเจริญ นักวิทยาศาสตร์ชั้น 1 ของสถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร มหาวิทยาลัยเกษตรศาสตร์

4.3.2.4 นายสุชน นิมมานนิตย์ นักวิทยาศาสตร์ ชั้น 2 ของสถาบันค้นคว้าและพัฒนาภัณฑ์อาหาร มหาวิทยาลัยเกษตรศาสตร์

ฝึกงานเกี่ยวกับโปรตีนที่ Meals for Million Foundation ดูงานที่ USDA และสถานที่สำคัญเกี่ยวกับอาหาร

4.4 ผู้ที่กำลังจะได้ไปศึกษา (2512–2514)

4.4.1 กรมอนามัย

ทุนศึกษาขั้นปริญญาโท	(2512–2513)	2 ทุน
ทุนศึกษาขั้นปริญญาโท	(2513–2514)	1 ทุน

4.4.2 สถาบันค้นคว้าและผลิตภัณฑ์อาหาร

ทุนศึกษาขั้นปริญญาโท	(2512 - 2513)	1 ทุน
ทุนศึกษาขั้นปริญญาโท	(2513 – 2514)	1 ทุน

4.5 ผู้ที่กำลังจะได้ไปฝึกงานและดูงาน (2512–2514)

4.5.1 กรมอนามัย

ทุนฝึกงาน 5 อาทิตย์	(2512–2513)	3 ทุน
ทุนดูงาน 2 อาทิตย์	(2512–2513)	5 ทุน
ทุนดูงาน 2 อาทิตย์	(2513 - 2514)	5 ทุน

4.5.2 สถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร

ทุนฝึกงาน 4 เดือน	(2513–2514)	3 ทุน

รวมงบค่าใช้จ่ายเกี่ยวกับฝึกงานทั้งหมดที่ยูซอมจ่าย $ 98,800.—

ประมาณ 1,976,000.— บาท

4.6 สรุปความช่วยเหลือที่ได้

4.6.1 ผู้เชี่ยวชาญ	$	37,500
4.6.2 เครื่องมือทั้งหมด	$	115,000
4.6.3 ทุนฝึกงาน—เรียน—ดูงาน	$	98,800
รวม	$	251,300

เงินไทยประมาณ 5,026,000.— บาท

5. ผลงานที่ผ่านมาแล้ว

5.1 ได้มีการทดลองผลิตอาหารโปรตีนราคาถูก อยู่ในระบบแห่งการบริโภค โดยใช้วัตถุดิบภายในประเทศ และมีคุณค่าทางโภชนาการสูง อาหารที่ผลิตมี.—

โปรตีนเกษตร
บะหมี่เกษตร
คุ๊กกี้เกษตร
ปลาร้าเกษตร
น้ำนมถั่วเหลือง
น้ำนมถั่วเหลืองข้นบรรจุกระป๋อง
โปรตีนสกัดจากหอยแมลงภู่
โปรตีนสกัดจากกากมะพร้าวหลังจากจากทำกะทิสดเข้มข้นบรรจุกระป๋อง หรือหลอดแล้ว เอากากที่เหลือมาสกัดโปรตีน

ฯลฯ

ทั้งนี้ใช้วัตถุดิบประเภทถั่ว—งา—หอย และอื่นๆ

5.2 ได้มีการทดลองเลี้ยงเด็กอายุ 1—5 ปี ใน 4 จังหวัด มีจังหวัดแพร่ เชียงใหม่ ร้อยเอ็ด อุบล จำนวน ๓๒ แห่ง จำนวนเด็ก 2,801 คน ตั้งแต่ปี 2511—2513

5.3 จำหน่ายผลิตภัณฑ์ที่มีโปรตีนในราคาถูกแก่นักเรียนประถมศึกษา

5.4 ประเมินผล และหาตลาด

6. งานที่จะทำในปี 2514

6.1 ดำเนินงานต่อเนื่องจากปีที่แล้ว โดยจะขยายขอบเขตการปฏิบัติงานให้กว้างขวางยิ่งขึ้น

6.2 ดำเนินงานในเรื่องทดลองและวิจัยต่อไป

6.3 ทำการประเมินผลการดำเนินงานที่แล้วมา

7. งบประมาณสมทบในปีที่ล่วงมา

7.1 ปี พ.ศ. 2511—2512 (4 เดือน)

กรมอนามัย		201,325.—	บาท
สถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร		80,620.—	,,
	รวม	281,945.—	บาท

7.2 ปี พ.ศ. 2512 - 2513

กรมอนามัย		613,550.—	บาท
สถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร		394,080.—	,,
	รวม	1,007,630.—	บาท

7.3 ปี พ.ศ. 2513—2514

กรมอนามัย		826,035.—	บาท
สถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร		324,140.—	,,
	รวม	1,150,175.—	บาท

8. งบประมาณสำหรับปี 2514 ที่กำลังพิจารณา

8.1 กรมอนามัย

8.1.1 คนงานเลี้ยงเด็กตามศูนย์ต่าง ๆ 75 คน ๆ ละ 300.— บาท		270,000.—	บาท
8.1.2 ค่าขนส่ง		20,000.—	,,
8.1.3 ค่าวัตถุดิบที่ใช้ในการปรุงแต่งเพิ่มเติมในการเลี้ยงเด็ก 2500 คน คนละ 75 สตางค์ จำนวน 260 วัน		487,500.—	,,
8.1.4 ค่าภาชนะบรรจุ		10,000.—	,,
	รวม	787,500.—	บาท

8.2.1	ค่าคนงาน—ช่าง—และอื่น ๆ เพื่อทดลองผลิตและผลิตรวม 29 คน จ้างตามคุณวุฒิและตามระเบียบราชการ	211,200.—	บาท
8.2.2	ค่าพาหนะ-เบี้ยเลี้ยงในการไปตรวจผลงานตามจังหวัดที่มีการ เลี้ยงอาหาร (40 วัน)	9,340—	บาท
8.2.3	ค่าพิมพ์เอกสารสรุปผลงานทั้ง ๓ ปี ไม่ต่ำกว่า 20 ยก (8 หน้ายก) รูปไม่ต่ำกว่า 40 รูป	20,000.—	,,
8.2.4	ค่าน้ำมันเชื้อเพลิงเกี่ยวกับหม้อน้ำในการทำอาหารและทดลอง	25,000.—	,,
8.3.5	ค่าเคมีภัณฑ์ เพื่อใช้ในการตรวจสอบหาข้อมูลต่าง ๆ ในเรื่องเกี่ยว กับอาหารเด็ก	45,000.—	,,
8.3.6	ค่าซ่อมแซมเครื่องมือ—เครื่องอาหลั่ยและ และอื่น ๆ ทั้งนี้เพราะเครื่องมือต่าง ๆ ที่มีอยู่ มีอายุประมาณ 10 ปีเศษ	65,000.—	,,
8.3.7	ค่าเครื่องเขียนพิมพ์รายงานเอกสารประกอบเป็นครั้งคราว	5,000.—	,,
	รวม	380,540.—	บาท

8.3 **รวมยอดที่ขอ**

8.3.1	กรมอนามัย	787,500.—	บาท
8.3.2	สถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร	380,540.—	,,
	รวม	1,168,040.—	บาท

9. สรุปค่าใช้จ่าย

ปีนี้เป็นปีที่ 3 ของโครงการหรือปีสุดท้าย เพราะโครงการนี้มีอายุ 3 ปี สรุปค่าใช้จ่ายที่ได้รับดังนี้.—

	จากอเมริกัน		งบฝ่ายไทย		
ผู้ชำนาญ	$	37,500	2511—2512 (4 เดือน)	281,945.—	บาท
เครื่องมือ	$	115,000	2512—2513	1,007,630.—	,,
เรียน—ฝึกงาน	$	98,800	2513—2514	1,150,175.—	,,
รวม	$	251,300	2514—2515 (ขอไว้)	1,168,040.—	,,
			รวม	3,607,790.—	บาท

เงินตามงบสมทบนี้ใช้ในการทดลองผลิตอาหารเพื่อเลี้ยงเด็ก 2,500 คน ตามศูนย์ใน 4 จังหวัดตลอดระยะเวลา

HOW THAILAND CLOSES THE PROTEIN GAP

Mr. Amara Bhumiratana

Institute of Food Research and Product Development.

Thailand is one of the developing countries in Southeast Asia. The neighboring countries are Burma, Laos, Combodia, Malaysia, South Vietnam, North Vietnam and Singapore. At present this group of countries is facing a great trouble of being in an area of communist's invasion. Therefore it is a great problem in having the countries developed and at the same time try to prevent the country from this invasion of communist and not only from directly invading but also from "COLD WAR" as well.

Thailand seems to be in a little bit better condition than her closest neighboring countries but those outer ring neighbors such as Singapore, Philippines or Taiwan are still better than Thailand in comparison. In 1966, the total income of Thailand is 78,753 million baht while the population is 31,508,000. From this figure, the average income per capita per annual is about 2,500 baht or equivalent to approximate $ 120.00 that is $ 10.00 per month. The Thais will spend 50% of their income for food expenditure only i.e. $ 5.00 per month. In this $ 5.00, $ 2.00 will be spent for rice consumption (400 gm./day, 12 kg./month) and the other $ 3.00 left for other food consumption. We will obtain incomplete protein from this amount of rice consumed approx. 20 - 25 gm. daily and we will have to consume protein food from other sources using those $ 3.00 left. In common sense we mostly think of fish, chicken, pork and beef as sources of protein. These mentioned animals contain approx. 17 - 20% protein and the prices (as flesh) range from $ 0.60/kg. to $ 1.25/kg. Now you will clearly see that we cannot spend that $ 3.00 for protein food from animal sources.

Everybody, rich or poor or of various races needs protein food. The Institute of Food Research and Product Development, Kasetsart University, is undertaking the research on the protein food development with the objectives to provide food of:

- low cost suitable for average income
- in the dietary pattern of rural Thais
- high in nutrition value
- utilizing local raw material available

In order to reach the objectives, the Institute of Food Research and Product Development, Kasetsart University, is co-operating with the Nutrition

Division, Department of Health. The Institute is acting as Food Plant which is responsible for the development of protein food and the Nutrition Division, Department of Health is conducting the field trials to determine feeding values and acceptability of the processed food supplements in some parts of the country mainly in the northeastern and northern part. The Institute of Food Research and Product Development itself is making some tests in the central part and having the extension program for southern part next year.

PROBLEMS ON FOOD

Besides the problem due to low income, there is also another great problem of the habit in food consumption. This habit is not at all easy to change. The Institute is trying to produce new products to be utilized in daily food consumption especially soymilk. For the past two or three years we have been improving our process of soymilk and now we are having a higher standard of acceptability. The problem we have at the moment is only the requirement in more advisory education in food consumption which we expect to request the co-operation from the Ministry of Education and the Ministry of Public Health.

RAW MATERIAL USED

To obtain low cost protein food with nutritive value close to that of egg, the use of applied nutrition has very slow effect in the developing country and the unbalanced condition between the increase in expenditure (especially on food) and the income of people. From the statistics, in 1965 - 1968 (1965 = 100) there is 20% increase in food expenditure and only 5% increase in other expenditures. Since we use up most of our income on food, it costs 10% increasing in average expenditure. From the annual report of the Bangkok Bank Ltd., the figures show that the Thais hardly have the increase in income for the past 6 years. Therefore to afford protein food only from animal sources is not quite possible because of its high prices. As for fish or other aquatic animals, the price is low only in the area of catching and there is a lot of problems in transportation. Hence, the Institute of Food Research and Product Development is aiming to utilize some following raw materials:

- mungbean
- soybean
- sesame
- trash fishes
- mussel

MUNGBEAN - Mungbean is one of an agricultural products of extensive growing in Thailand because we have already had an industry to utilize all mungbean available i.e. an industry of mungbean flour to be used in bakery and the production of bean thread. The approximate 20% of protein content in mungbean is left useless in this industry. It means 1/5 of mungbean production which is worth about 338.7 million baht (1966) a year was uselessly thrown away. Although the extracted protein from mungbean has a low PER, the experiments on mixing with protein obtained from other sources showed quite a satisfactory result. Mungbean is easy to grow and thus its production is quite popular. Its production ranks fourthly among the principal crops of Thailand i.e.

- rice
- maize
- cassava
- mungbean

SOYBEAN - Thailand is rapidly increasing the production of soybean. This is because the Thais used to consume lard for a long time and just turn to the consumption of vegetable oil a few years ago. Soybean is consumed as raw and not much as oil extraction. The production of vegetable oil at present is only at the beginning and mostly kapok oil, cotton seed oil and rice bran oil.

The experiments show that soybean is not only a main source of vegetable oil but also the main source of protein of low cost. We are very pleased that the Thai Government by the Department of Agriculture has signed the contract with the Government of Japan to start the soybean production project.

In corporation with this project, the Institute of Food Research and Product Development has begun to use soybean as a source of protein food such as

1. Soymilk - using the process of Mysore's together with that of Cornell's. Methionine is also added. The acceptability, both adults and children, is quite good. The Institute is also producing evaporated soymilk to solve the problem in transportation upcountry.
2. Full-Fat Soy Flour - The process is quite close to that of Peoria's. The Institute can produce good quality of full-fat soy flour of PER 2.03 (ANRC Casein 2.50) and using this flour to make desserts such as Cookies Kaset of PER 2.39 (Casein 2.50). We also use this flour as one of raw materials in

the preparation of Thai food.

3. Defatted Soy Flour - We have no equipment for the process of defatted soy flour but we are fortunate to have defatted soy flour from UNICEF through Department of Health so we are able to use it in many experiments of our protein rice food production e.g.

3.1 Instant Noodle - using local wheat flour and defatted soy flour.

3.2 Protein Extraction.

3.3 Baby Food - by mixing defatted soy flour with rice germ. PER is 2.54 (Casein 2.50).

3.4 Meatless Meat or Kaset Protein - This product consists of protein from mungbean, soybean, fish protein concentrate (not used in some formula) with the addition of some amino acids and calcium phosphate. We have, up till now, 16 formulas of Kaset Protein. The analysis shown PER of Kaset Protein Formula 9 = 2.14 and of Formula 10 = 2.21 with the digestibility as high as 97%. At present we have already prepared 30 menus of food in the dietary pattern of rural Thai and the acceptability is quite satisfactory. Kaset Protein produced has been used to feed 2,500 children in 4 cities of Thailand namely Chiengmai, Roi-et, Prae and Ubol for two successive years. The growth development in weight and height is good but the I.Q. measurement has not yet been tested. There is also lunch program for school children attending the schools nearby at the price of 5 cents per head, protein containing approx. 25 - 30 gm./meal. The percentage of acceptability is 95 (total number of children 400). The Institute intend to continue and extend

this program if possible.

Those remain to be done at present are the extension and evaluation of the program to propose to the government in order to obtain the project for the nation as a whole.

INTRODUCTION

Mr. Chairman, Ladies and Gentlemen, first of all may I say it is a great honour for me to have an opportunity to join this third international congress of food science and technology and to present this lecture. On behalf of the Institute of Food Research and Product Development, Kasetsart University, I wish to thank you all for coming to this lecture titled "HOW THAILAND CLOSES THE PROTEIN GAP" This lecture is a part of our work being done at the Institute in the past few years and I intend to present it today so that all of you who are experts in this field of Food Science and Technology can give the criticisms and valuable advices which will be of great assistance to our work or our nation as a whole and also to other developing countries in Southeast Asia.

I will give the lecture and show the slides at the same time. A picture will be of better understanding than 100 words of explanation.

SLIDE 1, 2

If this part of work has any good, I wish to pass it through the University of California, Davis and also every professor in the Department of Food Science and Technology. Without the academic training obtained from the University I wouldn't be able to present this lecture now. The Thai customs of ours have taught us to be grateful to our teachers and to pay them the respect as if they are our second parents.

SLIDE 3

Thailand is one of the countries in Southeast Asia. She is situated in the area which is well known as "Golden Peninsula". The surrounded neighboring countries are Burma, Laos, Cambodia and Malaysia with the outer ring neighbors such as North Vietnam, South Vietnam and Singapore. These countries are in the political area of troubles and have to face a lot of problems risen from this besides having themselves developed at the same time.

SLIDE 4

Thailand is as big as Spain or only close to the area of the Texas State. She has the total area of 514,000 sq. kms. and is divided into 4 geographical parts: northern, southern, central and northeastern.

SLIDE 5

Problems.

SLIDE 6, 7, 8, 9, 10

This is the pictures of baby at weaning stage, preschool children, school children and adults who are facing the problems of malnutrition. It is one of a great problems that Thailand has to find the solution for it urgently.

SLIDE 11

But why?

Why we are having such a problem?

SLIDE 12

In 1960, Thai population was 26,257,916 giving the average density per square kilometer of about 51 which is equivalent to density of the world population.

In 1969, we have the population of 34,738,000 and it is expected that in the year 2000 we will accommodate 70,000,000 people.

SLIDE 13

This is because one Thai family has about 6 members.

The Thai population growth rate is 3.2%

SLIDE 14, 15, 16, 17

Let us have a look at Thai agricultural products especially food grain.

In 1966,	Rice production	=	11,975,000 tons.
	Maize production	=	1,122,400 tons.
	Cassava production	=	742,000 tons.
	Mungbean production	=	131,800 tons.

SLIDE 18, 19

Of the total population in 1966 = 31,508,000 we have the estimates of national income = 78,753 million baht i.e. per capita income is 2,499 - 2,500 baht or equivalent to approximate $ 120.00 per annual.

From the annual report of the Bangkok Bank, Ltd., the income of Thai people in 1963 can be separated into groups of the followings:

Under $	150/annual	48.4 %	low income
$	150 - 300	20.8 %	low income
$	300 - 600	19.5 %	low income
$	600 - 900	5.7 %	low income

$ 900 - 1,200	2.4 %	medium income
$ 1,200 - 1,500	1.0 %	
$ 1,500 - 1,800	0.7 %	
$ 1,800 - 2,400	0.6 %	
$ 2,400 - 3,000	0.3 %	high income
Over $ 3,000	0.6 %	

SLIDE 20

From the statistics (of the expenditure of the Thai population in 1969) showing the distribution of private consumption, the Thais spend 46.4 % of their income for food only.

Per capita income	$ 120.00/annual
i.e.	$ 10.00/month
Food expenditure	$ 5.00/month
Rice consumption per capita is approximate 400 gm. (10 % moisture) daily (12 kg./month)	$ 2.00/month

Now, how can we spend the other $ 3.00 left for other protein food.

Everybody needs protein, doesn't matter rich or poor or of different races.

SLIDE 21

The change in standard of living of the Thais (1969 = 100) in 3 years causing 20 % increase in price of food BUT from the annual report of the Bangkok Bank, Ltd., the figures show that the Thai hardly have the increase in income for the past 6 years.

SLIDE 22

Another great problem is the habit in food consumption. The majority of the Thais consume mostly grains and little bit of meat. Some Thai dishes consist of up to 20 different kinds of ingredients which is served just for a favouring matter.

SLIDE 23

This graph shows that in lactation period there is hardly any difference in growth of the Thai children and American children but after weaning the body weight will start to get differ.

SLIDE 24, 25

The growth of Thai, American and Vietnamese boys and girls is different

and it can be said that the cause of this difference comes from the dietary pattern and the nutritive value of food consumed. This is definitely depended on the individual income which is of course the greatest factor of food consumption.

SLIDE 26, 27

This is our protein gap. "HOW THAILAND CLOSES THE PROTEIN GAP" is what to be shown next.

The Institute of Food Research and Product Development, Kasetsart University, has been given the duties to solve this problem.

SLIDE 28

In common sense we mostly think of fish, chicken, pork and beef as sources of protein food. Considering the conditions in Thailand it is hardly possible for the Thai to consume such protein food. Not only because of its high price but also lots of other factors as well. It will take a long time to promote the animal husbandry.

SLIDE 29

With these reasons, the Institute of Food Research and Product Development is aiming to produce protein food based on the following objectives:

- low in cost (based on income)
- eating pattern
- nutritive value
- local raw material available

SLIDE 30

Based on these objectives, the institute is trying to combine Food Science and Technology together with Nutrition. The Institute (Food Science and Technology) is acting as Food Plant which is responsible for the development of protein food and the Nutrition Division, Department of Health is conducting the field trials. Or take it easy, we can suppose that a Food Scientist is a bridegroom who get married to his bride, a nutritionist. The bridegroom as head of the family has the responsibility to find proper food for his bride, a mother to be, to feed their babies and observe the growth development, etc., after being fed.

SLIDE 31

First of all we consider the raw material available in our agricultural products such as mungbean, soybean, trash fishes, mussel, and etc.

Mungbean is one of our agricultural products which is widely grown.

There is industry for it. The factories use mungbean as a raw material for the production of bean thread and mungbean flour. Mungbean has approximate 20 % of protein content and is thrown away uselessly at present (worth about 1/5 of its production or 338.7 million baht a year).

Soybean is rapidly increased in production. It is one of the raw materials which can be the main source of vegetable oil production and protein food production.

Trash fishes and mussel can be cultured easily if wanted to have it as source of raw material.

SLIDE 32

How production of the new food products will meet consumer's requirements? We have to consider:

- area of consumption
- age
- class of people

SLIDE 33, 34, 35

The Institute of Food Research and Product Development has produced fresh soymilk and also the sterilized evaporated soymilk, the latter is for resolution in distant transportation.

The process is that of Mysore's together with Cornell's. The acceptability is quite high. The cost of this soymilk is 80 % lower than cow's milk. One liter costs 5 - 6 cents while cow's milk is 20 - 25 cents/liter.

SLIDE 36, 37

This slide shows the production of Full-Fat Soy Flour. We use this full-fat soy flour as ingredients (raw material) in preparation of Thai food. The process is followed that of USDA, Peoria's. The analysis is also attached at the end of this paper (PER = 2.22 ANRC Casein 2.50).

SLIDE 38, 39, 40, 41, 42

This is cookies made from full-fat soy flour. Quite satisfactory acceptability. Low price. The analysis is also attached at the end of this paper. (PER = 2.56, ANRC Casein 2.50)

SLIDE 43, 44, 45, 46

This is the production of Kaset Noodle using defatted soy flour and local wheat flour with the addition of some amino acids.

SLIDE 47, 48, 49, 50, 51

The production of meatless meat or Kaset Protein is in progress. We have been experimenting up to formula 15 now. The analysis shows:

KP. (Kaset Protein) No. 9	PER = 2.14
KP. (Kaset Protein) No. 10	PER = 2.21
KP. (Kaset Protein) No. 11	PER = 1.95
ANRC Casein	PER = 2.50

Based on these analyses we are improving these products accordingly and making the experiments up to formula KP. 15.

We also have the production using fermented fish flavour and KMPC (Kaset Marine Protein Concentrate) which has PER as high as 3.06.

SLIDE 52

Compare the price of animal protein and Kaset Protein.

	Price in Thailand	
	1,000 gm. as flesh	100 gm. protein
Pork	$ 1.25	$ 0.625
Beef	$ 1.24	$ 0.620
Chicken	$ 0.80	$ 0.533
Kaset Protein (60 %)	$ 0.70	$ 0.116

SLIDE 53

To improve the texture, we are mixing protein from mungbean together with protein from soybean and thus getting KP. 15. We, then, have Kaset Protein of much better texture, taste and quality.

SLIDE 54

Some of new protein food products that this Institute produces have the following nutritive value (as analysed by WARF Institute, Inc.):

	PER
Kaset Marine Protein Concentrate	3.10
Cookie Soy Flour	2.39
Baby Food Powder (Formula 17)	2.16
Kaset Full-Fat Soy Flour	2.03
Baby Food Powder (Formula 18)	2.54
ANRC Casein	2.50

The preparation of food is depended on the local area and its dietary pattern. We have conducted field trials using these foods for 2 successive years.

SLIDE 55, 56, 57, 58, 59, 60, 61, 62

To feed 2,500 children at 3 - 5 year of age in the northern and northeastern part of Thailand (beginning in 1968).

SLIDE 63, 64, 65

The Institute is conducting lunch program for 80 school children between 7 - 10 years old at Pibulppatham School which is about 5 miles away from our Institute. This lunch costs 1.- baht (or 5 ¢) per head. It consists of

- Soymilk
- Rice
- Thai dish to go along with rice
- Dessert

This lunch contains approximate 20 - 25 gm. protein. These group of children are quite poor. Some of them cannot afford even breakfast. The Institute has been feeding them for 2 successive years and this is the third year of feeding. We rotate 15 Thai dishes this year instead of 10 dishes as was in the past 2 years.

After one year of being fed this experimental group has 3 times in weight gained compared to the control group.

SLIDE 66, 67, 68, 69, 70

To have more tests in acceptability of such prepared food, we also provide lunch for the children who live in the houseboats and attending the school on the bank of Chao-Phya River. The lunch consists of:

- Can concentrated soymilk diluted with water.
- Thai dishes using Kaset Protein in the preparation.

SLIDE 71, 72, 73, 74, 75

Provide lunch for 265 school children of 12 - 17 year of age at the School of Wat Prasrimahathad for 10 days.

The result of feeding is quite satisfactory since the acceptability was very good. Price per meal for this school is $ 0.09. Protein content is approximate 30 gm./meal.

SLIDE 76, 77, 78

Sometimes we arrange the demonstrations in different schools, in the public (such as during Thai Products Exhibition Week being held last June) and many other places. The demonstration is on the preparation of food in Thai dietary pattern using this new protein food product such as this Kaset Protein as main raw material.

SLIDE 79, 80

Fish, mussel and other aquatic animals are also main source of protein but there are lots of troubles concerning handling and transportation. Besides Marine, in a very near future, our institute will work also on Kainum (Green Algae) together with Mung, Soy & other.

THIS IS HOW THAILAND CLOSES THE PROTEIN GAP

I thank you all for attending this lecture and I must emphasize that I need suggestions and advices from you.

Last but not least I would like to convey my sincere thank to USDA, USOM and Dr. C. C. Loo who help to start this project and also to all of my prof. who taught me and gave me the foundation for the work.

กล่าวนำ

ท่านประธาน นักวิทยาศาสตร์ผู้ทรงเกียรติทั้งหลาย ข้าพเจ้าในนามของสถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร มหาวิทยาลัยเกษตรศาสตร์ ขอขอบพระคุณทุกท่านที่ได้กรุณาให้เกียรติมาฟังและให้โอกาสแก่ข้าพเจ้าได้มาพูดถึงส่วนหนึ่งของผลงานที่ผ่านมาแล้วในปีนี้ ที่นำมาเรียนชี้แจงในวันนี้ก็เพื่อที่จะขอทราบคำแนะนำเพิ่มเติม เพื่อจะได้นำไปใช้ให้เป็นผลแก่ประเทศของข้าพเจ้า และของกลุ่มประเทศที่กำลังพัฒนาอยู่ในแถบเดียวกันนั้น ข้าพเจ้าต้องขอขอบพระคุณล่วงหน้าไว้ ณ ที่นี้ด้วย

การบรรยายนี้จะเป็นการบรรยายประกอบสไลด์ เพราะข้าพเจ้าถือว่า ภาพหนึ่ง ๆ ดีกว่าคำพูดหรือคำบรรยายหลาย ๆ ร้อยหน้ากระดาษ

รูปที่ 1,2

ผลงานนี้ถ้ามีส่วนดีอยู่บ้าง ข้าพเจ้าขอน้อมมอบให้แก่ U.C. Davis และ Professor ทุกท่านใน Dept. of Food Science & Technology ถ้าปราศจากวิทยาการที่ข้าพเจ้าได้รับมาในตอนศึกษา ข้าพเจ้าคงขาดความสามารถที่จะทำให้ผลงานนี้เกิดขึ้น และธรรมเนียมไทยเรานั้นถือว่า ครูบาอาจารย์เป็นบิดามารดาคนที่สองของเรา

รูปที่ 3

ประเทศไทยเป็นประเทศในกลุ่มเอเชียอาคเนย์ และแหล่งที่ตั้งนั้นก็คือ แหลมทอง มีประเทศใกล้เคียงที่รวมอยู่ คือ พม่า จีน ลาวเหนือ ลาวใต้ เวียตนามเหนือ เวียตนามใต้ เขมร (ทั้งแดงทั้งขาว) มาเลเซีย และสิงคโปร์ จะเห็นได้ว่าอยู่ในกลุ่มพื้นแผ่นดินที่มีการถูกภัยทางวิถีการเมืองคุกคามอยู่ และนอกจากนั้นก็ยังมีหน้าที่ของตนเองในการที่จะพัฒนาประเทศ

รูปที่ 4

ประเทศไทยมีขนาดเท่ากับรัฐเท็กซัส หรือประเทศสเปญ มีเนื้อที่ ๕๑๔,๐๐๐ ตารางกิโลเมตรและแบ่งออกเป็น ๔ ภาค คือ เหนือ ใต้ กลาง และตะวันออกเฉียงเหนือ

รูปที่ 5 (Problems)

ปัญหาและอุปสรรคที่มีอยู่ในขณะนี้ก็คือ.—

รูปที่ 6, 7, 8, 9, 10

ท่านจะได้เห็นแล้วว่าจากทั้ง 5 ภาพนี้ คือภาพของเด็กในระยะเริ่มจากหย่านม เด็กกำลังโต ก่อนวัยเรียน ในวัยเรียน และผู้ใหญ่ ต่างอยู่ในลักษณะขาดอาหารและเสื่อมปัญญา จึงเป็นปัญหาอันหนึ่งในหลาย ๆ ปัญหาที่ประเทศไทยจะต้องทำในระยะที่กำลังอยู่ในการพัฒนาประเทศนี้

รูปที่ 11 Why

ทำไม ?

ทำไมจึงเป็นเช่นนี้ ?

รูปที่ 12

ประเทศไทยจากผลของการสำรวจในปี 1960 มีประชากร 26,257,916 คน ซึ่งในขณะนั้นจะมีความหนาแน่นเท่ากับความหนาแน่นของประชาชนในโลก คือ 51 คน/1 ตารางกิโลเมตร

1969 จะมี 34 738,000 คน

และคาดว่าในปี 2000 จะมี 70,000,000 คน

รูปที่ 13

ทั้งนี้ เพราะสถิติของครอบครัวไทยนั้น 1 บวก 1 เท่ากับ 6

มีอัตราแห่งการเกิดถึง 32%

รูปที่ 14, 15, 16, 17

แสดงผลิตผลทางเกษตร โดยเฉพาะธัญญพืช

ในปี 1966	มีข้าว	11.975,000 ตัน
	ข้าวโพด	1.122,400 ตัน
	แป้งมันสำปะหลัง	742,000 ตัน
	ถั่วเขียว	131,800 ตัน

รูปที่ 18, 19

แสดงรายได้ของประชากร

ในปี 1966 รายได้ถัวเฉลี่ยของคนไทยนั้นมีเพียง 2,499. บาท หรือเท่ากับ $ 120/ ปี ซึ่งอาจจะแยกออกไปได้ดังนี้.—

ต่ำกว่า $ 150/ ปี	48.4 %	รายได้ต่ำ
150— 300	20.8 %	
300— 600	19.5 %	
600— 900	5.7 %	
900—1,200	2.4 %	รายได้ปานกลาง
1,200—1,500	1 0 %	
1,400—1,800	0.7 %	
1,800—2,400	0.6 %	
2,400—3,000	0.3 %	รายได้สูง
สูงกว่า—3,000	0.6 %	

รูปที่ 20

จากสถิติจะเห็นว่าคนไทยเรานั้นใช้รายได้ที่มีอยู่เป็นค่าอาหารเสียประมาณ 46.4 %

จากรายได้เพียง $ 120/ปี หรือ $ 10/ เดือน

เป็นค่าอาหารประมาณ $ 5/ เดือน

คนไทยบริโภคข้าวประมาณวันละ 400 กรัม ฉะนั้น เดือนหนึ่งจะเป็นข้าวประมาณ 12 กก. หรือ $ 2/ เดือน

อีก $ 3 ที่เหลือจะหาโปรตีนได้จากที่ใดเมื่อความต้องการของโปรตีนนั้นไม่อาจจะมีการแบ่ง ชั้นวรรณะ เชื้อชาติ หรือความจน ความมีของคนเราได้

รูปที่ 21

จากการเปลี่ยนแปลงในเรื่องค่าครองชีพของคนไทย โดยเทียบเอาปี 1969 เท่ากับ 100 นับระยะเวลาเพียง 3 ปี ค่าอาหารมีราคาสูงขึ้นถึง 20 % แต่ตามสถิติอีกนั่นแหละในระยะ 6 ปีที่ผ่านมานี้ รายได้ของคนไทยเราเกือบจะไม่ได้เพิ่มขึ้นเลย นี่ก็เป็นอุปสรรคอันหนึ่ง

รูปที่ 22

ปัญหาอีกอันหนึ่งคือระบบแห่งการกินของคนไทยจะเห็นว่าส่วนใหญ่เป็นพวกธัญญพืช และมีเนื้อสัตว์น้อย และอยู่ในลักษณะผสมสิ่งละอันพันละน้อย คืออย่างโน้นบ้างอย่างนี้บ้าง ซึ่งอาหารไทยบางอย่างมีองค์ประกอบถึง 20 ชนิด และส่วนมากเป็นเช่นนั้น

รูปที่ 23

เด็กไทย เด็กอเมริกัน ในระยะที่ยังบริโภคน้ำนมจากมารดาอยู่นั้น การเจริญเติบโตของเด็กไม่ผิดกัน แต่หลังจากที่เริ่มรับประทานอาหารจากภายนอก น้ำหนักจะเริ่มเปลี่ยนไป

รูปที่ 24. 25

เด็กชาย — หญิง — อเมริกัน — ไทย — เวียตนาม มีการเจริญเติบโตผิดกัน และนี่ถือได้ว่าเนื่องจากการให้อาหาร ระบบแห่งการกิน และคุณค่าของอาหารที่บริโภค (ทั้งนี้ ย่อมขึ้นอยู่กับรายได้ซึ่งเป็นองค์ประกอบหรือปัจจัยที่จะได้อาหารมา)

รูปที่ 26, 27

นี่แหละคือช่องว่างของโปรตีนที่ขาดอยู่สำหรับประเทศไทย และประเทศไทยจะอุดช่องโหว่ในเรื่องนี้ได้อย่างไร เรื่องนี้ทางมหาวิทยาลัยเกษตรศาสตร์ โดยสถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร จึงได้รับหน้าที่อันมีเกียรตินี้

รูปที่ 28

โดยสามัญสำนึก เรามักจะนึกถึงอาหารโปรตีนแต่เฉพาะในเรื่องที่ได้มาจากสัตว์ แต่ถ้าพิจารณาถึงผลที่มีอยู่ในสภาพของประเทศไทยแล้วก็ยากที่จะทำได้ เพราะสัตว์มีราคาสูง และการส่งเสริมย่อมจะกินระยะเวลานาน อีกทั้งมีอีกหลายแฟคเตอร์ที่เข้ามาพัวพัน และอาจจะช้าเกินไปเมื่ออัตราเกิดของประเทศไทยสูงถึง 3.2 %

รูปที่ 29

ด้วยเหตุนี้ทางสถาบันค้นคว้าและพัฒนาผลิตภัณฑ์อาหาร มหาวิทยาลัยเกษตรศาสตร์จึงมีเป้าหมายในการค้นคว้าดังนี้.—

1. ผลิตอาหารที่มีราคาต่ำ
2. อยู่ในระบบแห่งการกิน
3. มีคุณค่าทางโภชนาการสูง
4. ใช้วัตถุดิบภายในประเทศ

รูปที่ 30

จากเป้าหมายดังกล่าว ทางเราจึงได้จัดพิธีสมรสขึ้นโดยร่วมกันระหว่าง Food Science and Technology กับทาง Nutrition โดยแบ่งหน้าที่กันว่าทางฝ่ายเจ้าบ่าวจะต้องผลิตอาหาร คือทำหน้าที่แสวงหา และทางฝ่ายเจ้าสาว จะต้องนำอาหารนั้นไปทำการเลี้ยงดูลูกเต้าให้มีความอุดมสมบูรณ์ยิ่ง ๆ ขึ้น นี่แหละคือการร่วมมือกันระหว่างสองหน่วยงานนี้

รูปที่ 31

ก่อนอื่นก็ต้องมีการพิจารณาถึงวัตถุดิบที่มีภายในประเทศที่มีอยู่ เช่น ถั่วเขียว ซึ่งเป็นวัตถุดิบที่ใช้อยู่ในประเทศ มีการเพาะปลูกอยู่แล้ว มีโรงงานอุตสาหกรรมที่ใช้ถั่วเขียวเป็นวัตถุดิบเพื่อทำวุ้นเส้นและแป้ง ในถั่วเขียวจะมีโปรตีนอยู่ประมาณ 20 % และในขณะนี้ไม่ได้ใช้ให้เกิดประโยชน์ 1/5 ของ 340 ล้านบาท ได้ทิ้งไปโดยเปล่าประโยชน์

ถั่วเหลืองอยู่ในโครงการการเพาะปลูก ซึ่งเป็นวัตถุดิบมีอนาคตที่ไกลมากทั้งในด้านของน้ำมันและแหล่งโปรตีนราคาถูก

ปลาหน้าดิน และพวกหอย ซึ่งอาจจะขยายพันธุ์ได้ง่ายถ้าทำ

รูปที่ 32

การทำผลิตภัณฑ์ใหม่นี้ต้องสนองความต้องการของผู้บริโภค ทั้งนี้ต้องพิจารณาถึง

- ท้องถิ่น
- วัย
- ชั้นของคน

รูปที่ 33, 34, 35

ได้มีการทำน้ำนมถั่วเหลืองลักษณะดื่มทันที และในลักษณะทำเป็น Sterilized evaporated soymilk

ทั้งนี้ เพื่อขจัดปัญหาในเรื่องการเก็บ — การขนส่ง

วิธีที่ทำนั้นใช้แบบของ Mysore และของ Cornell รวมกัน นับว่าได้ผลดีทั้งในด้านยอมรับและราคา สำหรับเรื่องราคานี้สำหรับประเทศไทยราคาต่ำกว่าน้ำนมถั่วถึง 80 % ราคาลิตรละประมาณ 5—6 เซนต์ แต่น้ำนมวัวราคาถึง 20—25 เซนต์

รูปที่ 36, 37

รูปการแสดงการทำ. Full-Fat Soy Flour ซึ่งใช้เป็นวัตถุดิบในการทำอาหารหลายอย่าง ทั้งนี้ใช้วิธีการของ USDA (Peoria) ผลแห่งการวิเคราะห์ตามตารางแนบท้ายรายงานนี้ (PER = 2.22, NARC Casein 2.50)

รูปที่ 38, 39, 40, 41, 42

เป็นการทำคุ๊กกี้โดยใช้ Full fat soy flour ซึ่งในด้านการยอมรับนับว่าได้ผลดีมากราคาถูก ผลแห่งการวิเคราะห์อยู่ที่ตารางแบบท้าย (PER = 2.56, ANRC Casein 2.50)

รูปที่ 43, 44, 45, 46

เป็นการทำ Kaset Protein Noodle โดยใช้ Defatted soy flour, Local wheat และการเติมแต่ง Amino Acid

รูปที่ 47, 48, 49, 50, 51

การทำ Texture Kaset Protein หรือที่เรียกว่า Meatless Meat ในเรื่องนี้ได้ทดลองทำมาหลาย Formula ด้วย จากผลของการวิเคราะห์พอจะสรุปได้ดังนี้.—

KP.	(Kaset Texture Protein)		No. 9	PER = 2.14
KP.	,,	,,	No. 10	PER = 2.21
KP.	,,	,,	No. 11	PER = 1.95
ANRC (Casein)				PER = 2.50

จากผลแห่งการวิเคราะห์ที่ได้รับมานี้ ทำให้ได้ความคิดที่จะแก้ไขดัดแปลงให้ดีขึ้น ทำให้มีการทดลองทำเรื่อยมาจนขณะนี้ถึง KP. 15 และมีการทำเกี่ยวกับการใช้ Fermented fish flavour และการทำ KMPC (Kaset Marine Protein Concentrate) ซึ่ง PER สูงถึง 3.06

รูปที่ 52

จากการเปรียบเทียบ Animal Protein และ KP. ในประเทศไทยพอสรุปได้ดังนี้.

	ราคาสด/1000 กรัม	100 กรัมของโปรตีน
หมู	$ 1.25	$ 0.625
เนื้อ	$ 1.24	$ 0.620
ไก่	$ 0.80	$ 0.533
Kaset Protein (60%)	$ 0.70	$ 0.116

รูปที่ 53

เพื่อ Improve ในเรื่อง Texture ในระยะหลังนี้จึงมีการผสมระหว่างโปรตีนจาก Mung bean และโปรตีนจาก Soy bean ซึ่งทำให้เกิด KP. 15 ซึ่งจากการทดลองปรากฏผลในด้าน Texture ดีขึ้นมากและมีผลทางด้านรสและอื่น ๆ ดีขึ้น

รูปที่ 54

สรุปผลทางด้านคุณค่าทางโภชนาการของตัวอย่างอาหารที่ผลิตขึ้นมีดังนี้.--

	PER
Kaset Marine Protein Concentrate	3.10
Cookie Soy Flour	2.39
Baby Food Powder (No. 17)	2.16
Kaset Full Fat Soy Flour	2.03
Baby Food Powder (No. 18)	2.54
ANRC Casein	2.50

ในการเตรียมอาหารนี้แล้วแต่กลุ่มชนและท้องถิ่นซึ่งอาศัยระบบการปรุงแต่งเป็นเกณฑ์ ในขณะนี้ได้ทดลองไว้พอสรุปได้ดังนี้.—

รูปที่ 55, 56, 57, 58, 59, 60, 61, 62,

ในการเลี้ยงเด็กอายุระหว่าง 3-5 ขวบ ที่ทางภาคเหนือ-ตะวันออกเฉียงเหนือ จำนวน 2500 คน (เริ่มแต่ปี 1968)

รูปที่ 63, 64, 65

ในการจัดอาหารกลางวันให้แก่เด็กอายุระหว่าง 7—10 ขวบ ที่โรงเรียนพิบูลอุปถัมภ์ ซึ่งอยู่ห่างจาก Institute ไปประมาณ 5 ไมล์ จำนวน 80 คน โดยจัดอาหารกลางวันในราคา 1.— บาท (5 เซ็นต์) มี

น้ำนมถั่วเหลือง

ข้าว

กับข้าว

ขนม

โปรตีนในมื้อนี้จะมีประมาณ 20—25 กรัม เด็กกลุ่มนี้ค่อนข้างจน บางคนไม่ได้รับประทานอาหารเช้ามา ได้มีการเลี้ยงต่อเนื่องมาปีนี้เป็นปีที่ 3 โดยจัดอาหารออกเป็น 15 รายการ และหมุนเวียน

จากผลหลังจากการเลี้ยงในระยะปีเศษให้หลัง ปรากฏว่าน้ำหนักของเด็กที่เลี้ยงโดยแบบดังกล่าวมีน้ำหนักที่เพิ่มขึ้น ถ้าเปรียบเทียบกับเด็กที่รับประทานโดยปกติแล้ว น้ำหนักจะสูงกว่า 3 เท่า

รูปที่ 66, 67, 68, 69, 70

การจัดอาหารทดลองเลี้ยงแก่เด็กชาวเรือ (พ่อแม่มีเรือต่างบ้านเรือน ขนาด 50 ตารางฟุต จะเอาลูกมาเข้ากินนอนที่โรงเรียนนี้ มีอยู่ประมาณ 4—5 แห่งตามบริเวณแม่น้ำเจ้าพระยา)

ได้เลี้ยงเด็ก 400 คน เพื่อทดสอบการยอมรับอาหารประเภทดังกล่าว

— ใช้น้ำนมถั่วเหลืองเข้มข้นบรรจุกระป๋องแล้วเติมน้ำ

— ให้อาหารชนิดเกษตรโปรตีนปรุงแต่งตามระบบแห่งการบริโภค

รูปที่ 71, 72, 73, 74, 75

การจัดอาหารกลางวันแก่เด็กนักเรียนอายุ 12—17 จำนวน 265 คน ระยะเวลา 10 วัน ที่โรงเรียนวัดพระศรีมหาธาตุ

ผลปรากฏว่าเด็กยอมรับและราคาใน 1 มื้อ สำหรับเด็กรุ่นนี้มี Protein content 30 กรัม/ มื้อ **ราคามื้อละ** $ 0.09

รูปที่ 76, 77, 78

ในบางครั้งได้มีการ Demonstration ให้แก่ประชาชนเพื่อให้ได้ทราบเช่น ในระหว่าง Thai Product week ในเดือน June และตามโรงเรียนฝึกหัดครู และที่อื่น ๆ

รูปที่ 79, 80

รูปหอย—ปลา—ไข่น้ำ—อัลยี่

ปลา—หอย เป็นแหล่งโปรตีนเช่นเดียวกัน แต่นอกจากจะมีปัญหาเกี่ยวกับเรื่อง Handling & Transportation.

ขอขอบพระคุณทุกท่านที่ได้มาฟังการบรรยายนี้และขอเน้นอีกหนึ่งว่า ข้าพเจ้าพร้อมเสมอที่จะรับข้อคิดและข้อแนะนำ ขอขอบพระคุณล่วงหน้าในความปรารถนาดีของทุก ๆ ท่านที่ช่วยมาเป็นกำลังใจในเรื่องนี้

เว้นเสียมิได้ที่จะขอบพระคุณ USDA USOM และ Dr. C.C. Loo ซึ่งได้เริ่มโครงการนี้มาด้วยกันในระยะแรก ตลอดจน Prof. ของข้าพเจ้าทุกคนได้ปูพื้นฐานให้ความรู้แก่ข้าพเจ้าอันเป็นเบื้องต้นที่ให้ความสำเร็จในเรื่องนี้.

CHIANGMAI
LUMPOON
THAILAND
AYUTTHAYA
BANGKOK
HUAHIN
PRACHUAB
CAMBODIA
CHUMPHON
PHUKET
SONGKHLA
HAAD YAI
PENANG

INSTITUTE OF FOOD RESEARCH AND PRODUCT DEVELOPMENT

KASETSART UNIVERSITY

STRATEGIES TO COMBAT MALNUTRITION

by

*Aaron M. Altschul**

I wish to deal today with malnutrition which is income-dependent. But much of what I will say can apply as well to deficiency-caused malnutrition which is not income-dependent.

I will not dwell on the seriousness of malnutrition as a world problem -- this is self evident. So is the fact that the principle reason is poverty. Nor is it necessary to point out to this audience that malnutrition is not a simple matter. It is usually an admixture of not having enough food together with inadequate balance of nutrients. Nor is food alone the issue: the state of infection, for example, has a role. Nutrition is one factor in the complex ecology of the human and his well-being.

The major problem facing hungry people is to get enough food. But calories are not enough: the food must be balanced with all nutrients. The best solution is to have sufficient income to be able to fulfill all needs. Many societies have reached this point; but many millions of people are far away from this goal. This discussion then is an inquiry into the properties of low-cost solutions that would make adequate nutrition available to many more poor people.

Nations and cultures differ in their culinary habits and desires for kinds of food. And they differ in how much they pay for their meals. Consider only the proportion of animal protein in diets and its variations among nations. Clearly a major difference in the food bill amongst peoples and nations is in their cost of protein. Animal protein is much more expensive than protein from plant sources.

The entire question of world food supply hinges on the model of protein usage to be selected. If it is the affluent model of Western Europe and the U.S., then obviously the total food supply will be much less than for a model in which expensive protein foods are a minor proportion of the diet.

Special Assistant to the Secretary of Agriculture for Nutrition Improvement, speaking at the Institute of Food Science and Marketing founding celebration, April 27, 1970, Cornell University.

It is not possible to divorce considerations of the type of protein eaten from calorie adequacy. If too much is spent on more expensive protein foods, there may not be enough left for all the calories needed. Conversely, calorie inadequacy might be remedied if less need be spent on protein foods.

Let us start the discussion with an example of an efficient food operation

One such example is the feeding of monogastric animals in pens. There, the cheapest sources of calories and proteins are put together; the deficiencies are titrated with synthetic nutrients, amino acids and special protein concentrates. Here we are dealing not with INDIVIDUAL NUTRIENTS BUT WITH A SYSTEM OF NUTRIENTS. But for humans no such efficiency is attained, either by the affluent or the poor. For the affluent there is a surfeit of nutrients. This is not generally a serious problem except when it results in obesity; it is primarily an economic problem. For the poor, whose major sources of food are cereal grains, interspersed with poor quality calorie sources such as roots and minor quantities of good protein, most of the protein which they receive from the cereal grains is inefficiently used because the amino acid composition is not optimal.

If we wish to maximize the caloric intake at low levels of income, then it becomes necessary to increase the efficiency of the utilization of the foods. Let us discuss ways of improving the efficiency of food utilization for humans and then cite some examples from both foreign and domestic food programs. The basic principle is to try to develop the concept of a food system under conditions of free individual choice. One approach is to modify free choice by education so that the individual selects a good diet and maximizes the efficiency of his foods. Another approach is to modify the foods so that under the conditions of free choice presently existing more of the diet constitutes a food system. These two approaches are not inconsistent and, in fact, supplement one the other. I should like to concentrate on the latter approach -- that of modifying the foods. And, of course, such a discussion is most appropriate for the events of today. There are three general approaches:

I. PRIMARY INTERVENTION

By far the broadest range of possibilities for improvement lies with cereals and cereal products. Cereals can be made into complete foods. They can carry the vitamin and mineral supplements, or practically all of them; they can be fortified to maximize the protein impact of their own proteins. This can be done

either by addition of amino acids or of protein concentrates or with a mixture of the two. Plants can be bred to improve the protein impact of their seeds. This is notably true for corn where it is possible that high lysine corn will revolutionalize the efficiency of achieving good nutrition in those countries where corn is a major food staple.

It isn't even necessary to stop with cereals. A major effort is now under consideration for the fortification of mandioca flour by addition of soy protein isolate.

II. INSTITUTIONAL FEEDING

Institutional feeding offers the opportunity of maximizing nutrition at lowest cost because under such conditions there is a reduction in free individual choice. This idea suggests optimum solutions in such institutions as hospitals, school feeding programs, work feeding programs, and others.

III. SECONDARY INTERVENTION

These are interventions designed to fulfill specific needs of certain groups or to take advántage of certain food habits. Among these are cheaper foods for vulnerables such as infants. Animal analogues provide cheaper nutrition than the more expensive products and therefore stretch the food budget dollar. Another approach is to take advantage of certain habits and improve the foods. An example of this would be nutritious beverages based on the soft drink model.

In all of these interventions, the objective is to guarantee balanced diets and not leave the matter to chance. While a complete food system for humans will rarely be attained, if only becouse of the need for esthetics, these interventions will make it possible to approach this goal more closely and more often. It should be realized that there is no panacea -- that a number of different interventions may be necessary. And it also should be clear that there is a dynamic to interventions. There must be surveillance and evaluation and adjustment of interventions, as necessary.

EXAMPLES OF INNOVATIONS IN FOREIGN FOOD PROGRAMS

The following are some examples of innovative efforts abroad; we are involved in some of these, others we are watching with a great deal of interest.

Three major field tests (financed by the Agency of International Development) are now underway to demonstrate and adapt fortification principles to the

three major cereal varieties: wheat in Tunisia, rice in Thailand, and corn in Guatemala. A fourth major effort on fortification of mandioca flour with isolated soy protein is being organized for Brazil. The purpose of these demonstrations is three-fold:

(a) To work out the logistics and the limitations of fortification of these major sources of food with amino acids and/or protein concentrates, vitamins, and minerals,

(b) To determine the role of nutrition in the complex mixture of health and well-being of the communities involved (There is no intention to test the nutritional effects of fortification PER SE; there have been sufficient laboratory and clinical demonstrations of the improvement in the protein value of these products when they are supplemented with amino acids or protein concentrates. The issue is the effect of such improvement under real-life conditions.),

(c) Finally, to provide a basis for interaction between foreign and domestic technologies so as to allow local science and technology to put its own stamp on these efforts and take over the expansion of this program within the country itself.

Other examples of fortification are the shipment of 5 million pounds of lysine-fortified bulgur by the United States to Nigeria in February 1970 and the decision of the Indian government to fortify its atta with peanut flour. Commercial examples of these efforts are the fortification of Modern Bread in India with minerals, vitamins and lysine and the marketing of a precooked corn flour made from high lysine corn (Ricarepa) by CPC International, Inc., in Colombia.

School lunch programs are popular in many parts of the world. In some instances there is the effort to combine innovation with the institutional aspect. In Japan, for example, one-third of the bread in the school lunch is fortified with lysine and vitamins. Extensive use has been made of CSM (a low cost product containing 20% high quality protein) in institutional programs where it can be better used there than in individual homes. There are also maternal and child feeding centers where it is possible to use foods that might not be readily manageable in homes. The same is true for preschool feeding and care centers.

Examples of secondary interventions are the development and marketing of

infant and children foods such as Incaparana in Guatemala and Colombia, Duryea (a baby food containing high lysine corn, soy flour and milk) in Colombia and various soy-milk mixtures, such as Solein in Brazil and Bal Amul in India.

An interesting development is the impending availability of nutritious beverages based on the soft-drink model. The first was Vitasoy, a soy beverage being sold in Hong Kong. Several new ones are in early stages of development: Saci, a caramel-flavored soy beverage marketed by Coca-Cola in Brazil and Puma, a soy beverage marketed by D'Aguire Brothers in Georgetown, Guyana. Several companies are interested in developing carbonated protein beverages which would presumably be more attractive.

There is also considerable effort being expended in studying the potential for blending textured oilseed protein in meat products. General Mills has a contract with the Agency for International Development for such a study in Pakistan, Archer Daniels Midland is doing the same kind of a study in Thailand, and there are plans to conduct such a marketing study in India.

EXAMPLES FROM DOMESTIC FOOD PROGRAMS

The primary effort in the U.S. food programs is to increase available income for food expenditures. This is being done by expanding the food stamp program and by liberalizing terms for obtaining these stamps. In some counties there are commodity distribution programs. Expenditures on U.S. food programs rose to $1.5 billion this year and are contemplated to be about $2.5 billion next year. In addition to these efforts, there is increasing activity in testing innovation and engineered foods for their role in eliminating malnutrition.

Fortified foods of various sorts are being distributed and tested. For example our food distribution program is now including macaroni: either fortified with soy or milk protein or as a new high-protein corn-soy macaroni. Pillsbury, under contract with the Office of Economic Opportunity, has been market-testing an iron-vitamin-lysine fortified flour in Chicago. Other groups in the food industry have been looking at means for fortifying wheat products with iron and vitamins. Several completely fortified products of wheat flour and corn flour are being tested for inclusion in the commodity distribution program.

Modifications in the conceptions of the school lunch are in the offing. There is a trend towards considering the nutrient composition of the school lunch -- of being sure that this objective is being served rather than defining school lunch solely in terms of specific foods.

solely in terms of specific foods. This permits a greater flexibility in the inclusion of foods and may make it possible for certain engineered foods to be served in school lunches where they offer an economic advantage. The ultimate would be computer programming of nutrients and foods in school lunch and other school feeding programs.

The Department of Agriculture provides special foods for pregnant, lactating women and infants. This began as a distribution of specific foods for these risk categories. In recent months tests were started to substitute a certificate program which will enable the mothers and infants to obtain foods available on the grocery shelf.

Nutritious beverages based on the soft drink model have not yet appeared in the United States. But several commercial companies are looking at this matter seriously and are watching the experiences in foreign countries with a great deal of interest.

The inclusion of textured soy products into the general food economy is well underway. The pressure to include these kinds of foods in institutional food programs will build up as economies gained by so doing can be demonstrated.

COST OF FOOD IMPROVEMENTS

Let us consider how these food improvements might be financed. The food improvements, which I have discussed, can be put into two categories: those in which the foods are improved at an increased cost and those where nutrition is maintained but the cost is lowered because of the inclusion of lower cost analogues. While eventually as a result of a greater awareness of nutrition, it may be possible to induce people to pay more for better nutrition, such a provision will do very little now for the lowest income groups. In one way or another there must probably be a government subsidy, at least initially, to allow the lowest income people to take advantage of the better nutrition. This subsidy can be justified as a social investment in the quality and well-being of its people just as governments now subsidize education. For the second class of foods which involve analogues, no subsidy should be required. The government, however, can help introduction of these lower cost foods, if it so desires, by modification of existing regulatory practices to permit orderly and responsible innovation.

Much of what I have described is new, is in test stage, is in the initial stage of development. Yet enough is visible to provide a glimpse of what is in

store. New technologies are available, new options are available, a greater flexibility exists for providing lower cost solutions that take into account nutrition and acceptability. Problems which were insurmountable five years ago don't quite appear so impossible of solution now. We might compare the food situation with the changes in life expectancy in this century.

Even at the relatively low per capita incomes prevailing in most of the developing countries, life expectancies in these countries are far greater than life expectancies were in our own country and in Western Europe at equivalent levels of development. In 1914 our life expectancy was 50 years at a time when we attained a GNP/capita of over $1,000. In India the same life expectancy is attained in 1970 at GNP/capita of under $200. Advances in medicine made it possible to reduce mortality at much lower costs and made available benefits not even achievable earlier in this century in Europe and the United States. There is a lesson here for adaptation of modern food science to the needs of developing countries.

It is possible now to conceive of the elimination of malnutrition as a disease of poverty. This option makes it necessary for governments to decide whether nutrition deserves special consideration in view of the new technologies that now exist. Indeed no responsible government can afford to overlook the available possibilities. Miscalculation by attachment to the classical food concepts may become an invitation to disaster.

ASSESSMENT OF PROTEIN NUTRITION BY URINALYSIS

by

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The problem of meeting the protein requirements of population groups in developing countries has aroused world wide interest. Concerted efforts are being made in different parts of the world towards improving existing sources of protein and finding new sources of protein. However, before effective measures can be undertaken, it is essential to gauge the prevalence and extent of protein deficiency in the vulnerable groups of the population concerned.

There are various methods available for the assessment of nutritional status of a community. Biochemical tests form an important component and the range of biochemical tests that can be used for assessing protein nutrition is considerable. However, there are many factors which impose limitations on the collection of samples, and the methods employed for their analysis. Blood and urine specimens are commonly collected and analysed. It is not often easy to obtain samples of blood especially from children for any meaningful investigation. Because of certain cultural factors and ignorance, even adults are not keen to have samples of blood drawn from them. Moreover trained personnel are required for the collection of blood.

On the contrary it is much easier to obtain urine samples from children and adults alike. Urine as one of the easily available body fluids has been extensively studied from early times. The study of the composition of normal urine helps in the understanding of the various metabolic processes that take place in the body. Quantitative data on the composition of urine allow comparison between normal and malnourished individuals. Urinanalysis facilitates the assessment of the nutritional status of an individual and of the adequacy of the intake of various essential nutrients. Further it permits the assessment of the adequacy of protein intake and also to a certain extent in assessing the quality of the protein consumed. Standard methods are available for measuring various nitrogenous constituent

in the urine and these can be rapidly and easily performed. This paper summarises the basis of some of the determinations made on urine for assessing protein nutrition.

URINARY NITROGEN

The output of nitrogenous substances in the urine has long been known to vary with the nitrogen intake (Folin, 1905). For adult population groups consuming a mixed diet and maintained in nitrogen equilibrium the daily excretion of urinary nitrogen is a good estimate of protein intake. Urea may account for about 80 - 90% of the total nitrogen in a normal diet. In protein deficiency the total urinary nitrogen excretion is low and the amount of urea nitrogen, both absolute and relative is reduced. Urea may account for only 50% of the total nitrogen. As total nitrogen output decreases with decreasing intake, the proportion of urea nitrogen falls, because the so called 'endogenous' nitrogen remains constant. Therefore in principle the ratio of urea N/total N on a single sample of urine can be used to give essentially the same information as measurement of the total nitrogen output in a 24 hour collection (Waterlow, 1969).

Platt (1954) measured the urinary excretion of urea of children and lactating women of different nutritional and socio-economic conditions and found the ratio of urea N/total N to be markedly lower in the groups with poorer nutrition

Powell, Plough and Baker (1961) reported that the ratio of total urinary nitrogen to creatinine correlated well with the protein intakes measured in a dietary survey. With spot samples of urine the total nitrogen or urea nitrogen may be related to creatinine. These measurements of the output and partition of urinary nitrogen may give indirect information about the state of protein nutrition. The ratio of urea to creatinine in fasting urine samples also bears a direct relationship to the protein metabolic level of the individual. The urea/creatinine nitrogen ratio is an approximate index of dietary protein related to muscle protein stores. Although a 24 hour collection period probably gives more reliable results a 3 - 4 hour collection period has been found to be adequate (Dugdale and Edkin, 1964).

Scrimshaw, Young, Schwartz et. al. (1966), used urinary nitrogen as a measure of protein utilisation. Their study indicated that a simple measure of urinary nitrogen might provide a satisfactory method for evaluating adequacy of proteins for humans.

URINARY CREATININE

mass or lean body mass. The creatinine coefficient (creatinine excretion mg/24 hrs/kg body weight) has been used as an index of the relative amount of muscle in an individual. Arroyave and Wilson (1961) proposed that to relate creatinine excretion to body length rather that to weight provides a more sensitive index of the loss of muscle mass- since variations in fat deposits affect the latter. Every individual has a characteristic creatine-creatinine turnover dependent in a general way on the amount of functioning muscle tissue. The creatinine coefficient has also been used as an index of nutritional status in children (Talbot, 1938; Stearns, Newman, McKinely et. al., 1958; Arroyave and Wilson, 1961).

The measurement of creatinine output is in fact of great value in the assessment of protein nutrition. It gives information about one of the most important reservoirs of protein in the body. Skeletal muscle forms about 25% of the body weight in infants against 45% in adults. Standard, Wills and Waterlow (1959) showed a statistical correlation between changes in creatinine excretion and in muscle mass, as estimated from skinfold thickness and limb circumference.

Muscle is perhaps the tissue most severely affected by protein depletion. For this reason the size of the muscle mass is one of the most valuable indicators of the state of protein nutrition in man. The muscle mass can be estimated by measuring the urinary creatinine output. Low creatinine excretion reflects a reduction in muscle mass, both absolute and in relation to body weight. A three hour collection of urine gives the same result a 24 hour collection.

HYDROXYPROLINE/CREATININE INDEX

Hydroxyproline peptides are excreted in the urine as a by product of collagen metabolism. Hydroxyproline excretion is a measure of the turnover rate of collagen. The amount of hydroxyproline excreted is closely related to the rate of growth. Whitehead (1965) related the amount of hydroxyproline to that of creatinine in random specimens of urine and this gives the hydroxyproline ratio. In normal children the ratio of hydroxyproline excretion decreases with increasing age, as the rate of growth falls off, while that of creatinine increases. Whitehead found the reduction in hydroxyproline index in malmourished children was statistically related to the weight deficit. Picou, Alleyne and Seakins (1965) found the hydroxyproline excretion of protein depleted infants was lower than that of normal children with optimal growth. Creatinine excretion was also lowered, but only slightly.

It has been suggested that the low excretion of hydroxyproline in the urine reflects a reduction in the turnover rate of collagen. This may be a useful index of early growth failure before there are significant change in body weight.

In the absence of growth there is a reduction in the size of the soluble collagen pool.

URINARY SULFUR/NITROGEN

Urinary sulfur excretion may relate to protein quality. The urinary inorganic sulfate sulfur/nitrogen ratio is a reflection of the quality of the protein ingested. The urinary S/N ratios resemble those of the protein mixture fed (NRC - 1963). Since the urinary S/N ratio may be an approximate indicator of the quality of the protein consumed and the N/creatinine ratio may be an index of the quantity of protein consumed, then: $\frac{N}{\text{creatinine}} \times \frac{S}{N} = \frac{S}{\text{creatinine}}$ with the S/creatinine ratio being an index of both quality and quantity, i.e., analogous to the NDpCal % concept of Platt, Miller and Payne- (1961). Sulfate sulfur/creatinine ratio is a better index of utilizable protein than the nitrogen/creatinine ratio for the same subjects.

It is evident that there are a number of useful tests that can be performed with urine for the assessment of protein nutrition. However, it has to be emphasized, that biochemical determinations do not give an entire picture of the nutritional status of an individual. They merely serve to supplement and complement data obtained by other methods.

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THE IMPORTANCE OF AMINO ACIDS IN HUMAN NUTRITION

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The amino acids form an essential part of human nutrition. They are supplied to the body in the form of plant and animal proteins. The proteins are broken down in the gastro-intestinal tract of the body into the different amino acids with the aid of ferments known as bio-catalysts.

These are reabsorbed through the intestinal wall and conveyed to the cells with the bloodstream. Specific cellular enzymes then cause the body's own proteins to be built up from these amino acids.

Whilst carbohydrates and fats are the energy suppliers for the body, the nutrient proteins can be considered as components of the organism. It is, however, of general importance for nutrition that carbohydrates, fats and proteins exist in balanced proportions since the synthesis of body proteins from amino acids needs energy which is generated by the breaking down of carbohydrates and fats. If the body does not receive sufficient energy the amino acids are used as a source of energy and thus diverted from their actual function. Conversely, however, a scarcity of protein cannot be evened out by doses of carbohydrates and fats, however great the quantities.

Nowadays 22 different amino acids are known which occur as direct hydrolysis products of proteins. W.C. Rose has shown that the protein components of human nutrition can be completely replaced by a mixture of these 22 synthetic amino acids. He also found, based upon the work of Abderhalden, that not all amino acids have the same importance to nutrition. Only eight amino acids are indispensable to man and must be supplied to him extraneously, i.e. with his food (essential amino acids).

In Table 1 the essential amino acids for man and for some animals are indicated.

Table 1

Essential amino acids	Man	Rat	Broiler	Pig
Tryptophane	+	+	+	+
Phenylalanine	+	+	+	+
Leucine	+	+	+	+
Isoleucine	+	+	+	+
Threonine	+	+	+	+
Methionine	+	+	+	+
Lysine	+	+	+	+
Valine	+	+	+	+
Histidine	±	+	+	+
Arginine	±	+	+	+
Proline	-	-	-	-
Alanine	-	-	-	-

The remaining amino acids (non-essential amino acids) can be synthesised by the body from non-specific nitrogen sources and metabolites of the carbohydrate and fat metabolism or from the essential amino acids.

It is difficult however to make a clear distinction between essential and non-essential amino acids as some of them occupy a middle position. Thus, for example, methionine can, to a certain extent, be replaced by cystine and phenylalanine by tyrosine. Histidine and arginine are not considered as belonging to the essential amino acids, although histidine is vital for the young, growing body, whilst arginine is of great importance in parenteral nutrition as it renders the infusion solutions more compatible. Amongst the non-essential amino acids proline and alanine occupy a special position as a positive nitrogen balance is reached more easily when they are present than when other, non-essential acids such as glycine are present.

It is therefore more convenient to classify the various amino acids in a row whose extremes are, on the one hand, the strictly essential amino acids such as lysine and threonine and on the other the non-essential amino acids like glutamic acid which are synthesised quickly by various means. In the middle would then be the "semi-

essential" amino acids such as histidine, arginine, proline and alanine[2]. Several research groups have carried out examinations to determine the absolute human requirement for the different essential amino acids. Very difficult and time-consuming experiments are necessary to find out the requirement figures. One method is to use the nitrogen balance as a basis, i.e. for each amino acid an amount is determined at which there is a balance between the quantity of nitrogen absorbed and excreted. Another way is to examine the amino acid level in the blood serum. Thus, when the dosage of an amino acid is below the requirement level the content of this amino acid in the serum is very slight. If the oral dosage of this amino acid is gradually increased, the concentration in the serum remains constantly low, whilst the content of all other amino acids decreases. Only when the requirement has been exceeded does the content of this amino acid in the serum rise sharply. If the quantity of this amino acid provided is plotted against its concentration in the serum we have two straight lines of different gradient whose meeting point gives the minimum requirement[3].

The outstanding work of Rose[1] resulted in him being the first to find the essential amino acid requirements for human beings. These values are given in Table 2.

Table 2

The essential amino acid requirement of the adult

L-AS	Daily supply in g. minimum	safe intake
L-isoleucine	0.70	1.40
L-leucine	1.10	2.20
L-lysine	0.80	1.60
L-methionine	1.10	2.20
L-phenylalanine	1.10	2.20
L-threonine	0.50	1.00
L-Tryptophane	0.25	0.50
L-valine	0.80	1.60

Later on other research groups carried out experimental work on the requirement figures[7] and arrived at similar results.

Table 3

Essential amino acid requirement of human beings related respectively to Tryptophan = 1 as the amino acid present in the smallest quantity

Amino acid	Rose[1)]	Rose[4)] rev.	Longen-[3)] ecker	Hegstedt[5)]	Winitz[6)]	FAO[7)]
Isoleucine	2.8	3.1	4.5	3.3	3.4	3.0
Leucine	4.4	3.4	6.8	4.3	5.4	3.4
Lysine	3.2	2.4	5.2	3.3	4.0	3.0
Methionine[+]	4.4	4.8	-	4.2	-	-
Methionine[++]	-	-	5.5	-	3.4	3.0
Methionine[+++]	0.8	1.8	-	1.2	2.6	1.6
Phenylalanine'	4.4	-	-	-	-	-
Phenylalanine''	-	4.4	8.0	-	9.7	4.0
Phenylalanine'''	1.2	1.2	-	1.6	2.6	2.0
Threonine	2.0	2.0	3.0	2.2	3.4	2.0
Tryptophane	1.0	1.0	1.0	1.0	1.0	1.0
Valine	3.2	3.6	3.0	3.7	3.9	3.6

+) Met in the absence of Cys = summary supply of needs of Met + Cys

++) Met + Cys

+++) Met in the presence of Cys = Met not replaceable by Cys

') Phe requirement in the absence of Tyr

'') Phe + Tyr

''') Phe in the presence of Tyr = Phe not replaceable by Tyr

From the various results the FAO has drawn up tentative requirement figures for human beings which are reproduced in the last column of Table 3. On the basis of these figures it goes on to calculate the composition of an ideal protein for humans. This protein contains the essential amino acids in the quantities required respectively. This gives it a biological value of 100, that is, from 100 g. of this protein 100 g. of body protein are produced. Natural proteins, however, differ to a greater or lesser extent from this ideal protein. Here, the quality of the protein is determined by that essential amino acid which shows the lowest content compared to the ideal protein. This amino acid is called the limiting amino acid because it restricts the utilization of the protein.

Example:

The ideal protein for humans contains, inter alia,

10.8 g. methionine + cystine / 100 g. crude protein

12.4 g. lysine / 100 g. crude protein

3.1 g. tryptophane / 100 g. crude protein

Soya meal contains

7.6 g. methionine + cystine / 100 g. crude protein

15.3 g. lysine / 100 g. crude protein

3.3 g. tryptophane / 100 g. crude protein

In relation to the ideal protein the amount of lysine and tryptophane in soja meal protein is adequate, whilst the methionine + cystine content is too low. This makes methionine the limiting amino acid. The value of the protein can only be obtained to the extent to which methionine + cystine are present, irrespective of the content of all the other essential amino acids.

If we now compare these figures with the percentages in the ideal protein we reach a chemical score of 70% for methionine + cystine $(\frac{7.6}{10.8} \cdot 100)$. Soja protein can thus only be utilized to 70%.

In Table 4 the composition of the FAO reference protein is given and compared with the proteins in cow's milk, chicken eggs and plant proteins[7].

Table 4

Amino acid composition of proteins in g. A.A. per 100 g. protein

Amino acid	FAO	Cow's milk	Chicken egg	Vegeta bles	Leg. fruit	Rice
Isoleucine	4.2	6.4	6.6	3.68	5.82	3.3
Leucine	4.8	9.9	8.8	5.79	7.94	6.1
Lysine	4.2	7.8	6.4	5.26	6.63	2.8
Total arom. amino acids	5.6	10.0	10.0	4.74	8.84	6.7
Phenylalanine	2.8	4.9	5.8	3.16	5.19	3.5
Tyrosine	2.8	5.1	4.2	1.58	3.65	3.2
Total sulphur-cont. A.A.	4.2	3.3	5.5	2.63	2.21	2.26

Methionine	2.2	2.4	2.4	1.05	1.13	1.3
Cystine	2.0	0.9	3.1	1.58	1.08	0.96
Threonine	2.8	4.6	5.1	3.68	3.92	2.8
Tryptophane	1.4	1.4	1.6	1.05	0.86	0.76
Valine	4.2	6.9	7.3	4.21	5.73	4.9

In plant proteins the limiting amino acid is methionine. And, in addition, rice shows a considerable lack of lysine and tryptophane. The chemical score of these proteins in the body, related to the ideal protein for vegetables, leguminous fruits and rice, is 62, 52.5 and 54% respectively.

All figures show here indicate the minimum requirement of human beings for the - individual amino acids and are only valid for adults. The requirement figures for children and ageing persons differ considerably from the above values.

In relation to the reference protein of FAO the total protein requirement per day adn per 1 kg. body weight is as follows (Table 5)

Table 5

Protein requirement	
Age (years)	g. per kg. body weight per day
1-3	1.06
4-6	0.97
7-9	0.92
10-12	0.86
13-15	0.84
16-19	0.77
Adults	0.71

This additional requirement however is not the same for all amino acids. It is found on the contrary that methionine itself has to play a significant role in the synthesis of the body's own proteins. This applies both to children and ageing persons[10, 11]. In this respect Hegstedt[12] carried out quantitative investigations which are reproduced in Table 6.

Table 6

Additional essential amino acid requirement at an N retention of 0.5 g. per day in human beings. Given as a percentage of the requirement, for an even N balance.

Isoleucine	310	Leucine	357
Lysine	321	Methionine	493
Phenylalanine	213	Threonine	465
Tryptophane	160	Valine	161

These results are used today throughout the world chiefly for parenteral nutrition. The infusion solutions containing concentrations of amino acids suitable for human requirements have achieved great success in the clinic. Thus for example, a patient in Australia had 9/10 of his intestine removed and mucous membrane from the rest, so that the patient was incapable of feeding himself orally. He was therefore fed parenterally for 7 months with infusion solutions and even gained weight during this time. When the mucous membrane had formed again the infusion solutions were discontinued and the patient could be fed orally again. It is also possible to feed orally with a mixture of synthetic amino acids adapted to the purpose and this is already in practical application. Winitz developed a chemically defined diet of amino acids, fats and carbohydrates which was originally intended as nutrition for astronauts but has already entered the field of medicine.

Experiments are being commenced at the moment to improve natural food by adding synthetic amino acids. No doubt they will contribute together with other methods to improving the world food situation and to alleviating the problem of undernourishment.

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PUTTING THE PRODUCT WHERE IT COUNTS

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With the vast array of highly specialized scientific talent which has been organized to fight the battle of world nutrition, we of International Flavours & Fragrances do not wish to place our relatively minor role out of context. The lions share of the effort is directed at creating well balanced high protein food systems out of low cost locally available materials.

This is the major role - IFFs total effort consists only in working with these already developed systems, creating compatible flavors which will give them optimum palatibility to those specific people the system was designed to nourish.

Though when compared to the total effort our role is small, we believe that it is vital. A new food may have maximum food value but unless its taste is acceptable and it reaches the stomach, the practical food value is zero. Since these new high protein systems often have inherent flavor problems of their own, our job is to mask the problem and provide a flavor acceptable to the target group.

The rather formidable product development task is your job - we just help you to put your product inside - where it counts!

CRJ/lc
October 21, 1970

HIGH NUTRITION-LOW COST FOODS: THEIR IMPACT IN DEVELOPING COUNTRIES

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By far the most constructive recommendations for averting the nutrition crisis of the developing countries has been the report submitted in July 1967 to the Economic and Social Council of the United Nations entitled INTERNATIONAL ACTION TO AVERT THE IMPENDING PROTEIN CRISIS.

A large number of programs and thousands of people are engaged in the survival problem. This alone makes the evaluation of the impact of the programs most difficult. If there is to be a measurable amount of success in these programs, attempts must be made to evaluate both the short and long term impact of the programs and to put emphasis on the successful ones and discard those of little value.

This paper reports some interim findings of attempts to market high nutrition low cost foods in the developing countries. The permanent successes have been extremely few. The League for International Food Education has been conducting a survey largely in the developing countries to help determine the reasons for success or failure.

In Tables I and II are indicated a number of foods which have achieved some volume (I) and (II) which are at an evaluate stage. Table III indicates U.S. AID incentive grants to food industry companies for developing high nutrition low cost foods in developing countries.

AMONG THE FACTORS IDENTIFIED AS DESIRABLE FOR A SUCCESSFUL AND CONTINUING ENTERPRISE WERE:

PRODUCT ATTRIBUTES.

--High nutritive value.

--Product so designed as to really meet local acceptability requirements.

--Food should, as much as possible, resemble a traditional accepted product with respect to taste, texture, odor, etc. (Example: VITA-BEAN (Soymilk), now produced as a sterilized product sold in Tetra Pak containers, but formerly made fresh at home and consumed daily as made.)

--Long shelf life, unaffected by severe climatic conditions; preferably no refrigeration requirement.

--Easy handling and storage.

--No requirements for additional preparation.

MARKETING CONSIDERATIONS.

--Product ready availability needed.

--Taste acceptance, packaging and price should preferably appeal to ALL segments of the population in order to achieve a volume of business that can support a private enterprise.

--Sustained advertising needed.

--Education as to product merits needed.

--Product must be low-cost in relation to income.

--Food design problems must be solved on a culture by culture basis; no universal answers, only many local ones.

--Commercial marketing know-how geared to large scale production may sometimes be needed.

--Product should be designed to invite repeated buying.

--Consumers must have some money as a medium of exchange.

--Dogged persistence and patience needed.

PRODUCTION REQUIREMENTS.

--Private industry production is preferable.

--Distribution of ingredients and finished product must be such as to permit movement from surplus food areas to scarcity areas.

--Adequate processing facilities are needed.

--Food ingredients should be in-country available.

INSTITUTIONAL SUPPORT.

--Very desirable to incorporate in-school feeding and other institutional programs.

--Support by government nutrition and medical agencies essential.

--Support by food technology and nutrition institutions essential.

INTERDISCIPLINARY APPROACH.

--A major element in success is the simultaneous three-fold approach of the nutritionist, food technologist, and the marketing expert.

AMONG THE FACTORS LISTED AS OBSTACLES OR RESPONSIBLE FOR FAILURE OF SUCH FOODS TO SUCCEED WERE:

--Price of food too high.

--Lack of cooperation from national authorities.

--Unwillingness of consumers to pay for nutritional advantages.

--Duties, government regulations and government red tape.

--Unstable currency.

--Inability to obtain local financing.

--Public apathy.

--Political interference.

--Product resembled a low-cost common product and prestige identity was not established.

--Package was attacked by insects and rodents.

--Product has poor shelf life.

--Product had one or more defective organoleptic properties.

--A food product with a poverty image will be poorly accepted.

--New food products must be pre-sold on a status basis.

--Archaic business practices hinder new product acceptance.

--Interest rates on capital, needed for establishing a food industry, in some developing countries may run between 25-30%. It is thus necessary to bring in capital from areas where the cost of the money is less.

--Basic food ingredients, such as soybeans, may cost several times as much in the developing countries as in the U.S.A. because of poor farming and poor yields.

--The users of basic food crops may need to supply field service to insure the presence of a continuing supply of the crop.

Most of the early attempts at formulating high nutrition, low cost foods resulted in rather rudimentary ingredient mixtures, only a little way removed from modern day complete animal feed formulations. Now, there is a new trend toward "second generation", more sophisticated food products, such as beverages, pasta products, biscuits, confections, and snacks. Realization has gradually come that certain food items carry an aura of status which seems to be universally sought by people.

It has also become increasingly clear that if new types of high nutrition foods are to achieve commercial success, effective advertising and marketing procedures must be applied. This is another way of saying that ways must be found to communicate with people and change their deeply ingrained eating habits--at least to some extent. This is a most difficult task in rural areas where communication of any kind is hard to achieve.

Dramatic progress has been made in producing improved varieties of corn, rice, and cottonseed. In the case of corn, it is now possible to obtain greatly improved protein quality and substantial improvement in protein content; in the case of glandless cottonseed, there is at hand the prospect of non-toxic high protein cottonseed flour for human use. Wheat and rice varieties producing greatly increased yields are already being effectively used in the developing world. Further genetic selection may well lead to protein quality improvement in both rice and wheat, along with improved yields.

Not only will these improvements result in better basic food crops, but in turn such nutritionally improved crops will make easier and less expensive the formulation of low cost high nutrition foods.

Basic food fortification is another recent trend, where, at a minimum cost, needed amino acids, minerals and vitamins can be added to a widely used basic food such as wheat flour, corn or rice, with little or no change in the organoleptic properties. Thus, virtually no demand is made to learn a new food habit. In this way, the cost burden imposed by advertising may be minimized. Several large scale feasibility studies on fortification are now underway in developing countries.

In many cases, pre-existing unfavorable factors may clearly indicate that a food enterprise for profit is not yet feasible. In such cases, government and voluntary agency programs dispensing local or donated foods will be (as it has been) indispensable. It is to be hoped, however, that while the donation programs continue, the recipient country will organize itself on a national basis to provide a favorable climate for private food enterprises to develop. These can and should supply low cost high nutrition foods for those most in need.

Table IV indicates the volumes of CSM (corn-soy-milk), non-fat dried milk solids, and WSB (wheat-soy-blend) that have been donated by the United States to developing countries under PL 480 Title II. It will be observed, using some estimated figures for 1970, that 7.18 billion pounds of non-fat dry milk solids will have been shipped by the end of 1970, 1.07 billion pounds of CSM, and 17.2 million pounds of WSB. Data for shipments of milk powder date back to 1955, CSM to 1967, and WSB to 1969. There can be no reasonable doubt that these shipments have been of great value, especially for maintaining the health of children.

The development of sucessful high nutrition low cost food enterprises continues to be slow and frustrating. Nevertheless, some relatively new factors can now be identified which seem to indicate better prospects in the future than in the past

for marketing sucessful high nutrition low cost foods in the developing countries. Among these are:

--The considerably reduced cost of key nutrients for fortifying basic foods (i.e., amino acids, vitamins and minerals).

--Increased recognition by responsible government agencies of the permanent crippling effects of malnutrition, with an increased willingness for improved priority for food industry development.

--The growing involvement of important food industries from the developed countries in launching food enterprises in the less developed countries.

--The proliferation of nutrition and food technology research and teaching institutions in the developing world which can now supply some of the necessary home-grown technology.

--The increasingly sophisticated food processing, marketing and nutrition knowledge and support provided by UNICEF, WHO, FAO, USDA, and U.S. AID, the development agencies of other governments, and the voluntary organizations such as CARE, PEACE CORPS, VITA, L.I.F.E., the voluntary church agencies, etc.

--The development of high yielding strains of rice and wheat, as well as improvement in the protein quality and content of basic widely grown crops such as corn.

--The prospect of new sources of relatively low cost protein such as petro protein and fish protein concentrate, which can eventually be used to fortify acceptable foods.

It is obvious from these tables that criteria must be established for measuring the impact of these projects. Now is no time for empty promises, false hopes and false publicity programs, for they won't fill hungry bellies. Give-away programs are hopeless as a long-term solution. For years individuals, associated in any way with food production, have been considered as being in a very low prestige vocation. For those who go to bed hungry every night and finally die of starvation the Science of Survival is an elite profession. We are surviving the chemical, antibiotic, atomic and space ages. There is the technical "know-how" for Science of Survival but "how-do" is the unsolved problem of today.

It has been impossible to obtain data on all of the high nutrition low cost foods. If you have information which should be included in any of the tables, it will be appreciated if you will send such information to

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Table I-a

HIGH NUTRITION-LOW COST FOODS WHICH HAVE ACHIEVED SOME VOLUME

PRODUCT	MADE BY	PRODUCT TYPE	PERCENT PROTEIN
BAL AHAR	GOVERNMENT OF INDIA	BLENDED FOOD	22.0
CEREALINA	CPC INTERNATIONAL BRAZIL	WEANING FOOD	20.0
FORTIFIED ATTA	FLOUR MILLS INDIA	FLOUR	13.5
GOLDEN ELBOW MACARONI	GENERAL FOODS USA	MACARONI	20.0
INCAPARINA	CENTRAL DISTRIBUIDORA CIA LTD GUATEMALA	CEREAL BLEND	27.0
KUPAGANI BISCUITS	PYOTT LTD SOUTH AFRICA	BISCUIT	7.9
LECHE ALIM	UNIVERSITY OF CHILE CHILE	CEREAL	27.0

Table I-b

HIGH NUTRITION-LOW COST FOODS WHICH HAVE ACHIEVED SOME VOLUME

PRODUCT	MADE BY	PRODUCT TYPE	PERCENT PROTEIN
MODERN BREAD	COMMERCIAL BAKERIES INDIA	BREAD	9-10
PL	INSTITUTO NACIONAL DE NUTRITION VENEZUELA	BEVERAGE	27.0
PRONUTRO	FOOD CORPORATION LTD SOUTH AFRICA	CEREAL AND SOUP	22.0
PUMA	DIH LTD GUYANA	BEVERAGE	2
SUPERAMINE	FAO/WHO/UNICEF WITH ALGERIAN GOVERNMENT	INFANT FOOD	20.9
VITA BEAN	YEO HIAP SENG LTD SINGAPORE	BEVERAGE	--
VITALIA	INSTITUTO DE INVESTIGACIONS TECNOLOGICAS, COLOMBIA	MACARONI	17.8
YOO HOO	YOO HOO BEVERAGE COMPANY USA	BEVERAGE	3.3

TABLE II

HIGH NUTRITION-LOW COST FOODS AT EVALUATION STAGE

PRODUCT	MADE BY	PRODUCT TYPE	MARKETING STATUS
BEVERAGE BASE	INSTITUTE OF TECHNOLOGY ISRAEL	BEVERAGE	NO MARKET TESTING
DURYEA	CPC INTERNATIONAL COLOMBIA	INFANT AND CHILDREN'S FOOD	CONSUMER TESTING
FORTIFIED RICE	KYOWA HAKKO KOGYO, LTD JAPAN	RICE	EARLY FEASIBILITY TESTING IN INSTITUTIONAL FEEDING
NEW ZEALAND WHOLE MILK BISCUIT	FOODTOWN SUPERMARKETS, LTD NEW ZEALAND	WATER CONFECTION	PILOT PLANT PRODUCTION
PROVESOL	INSTITUTO DE INVESTIGACIONES TECNOLOGICAS, COLOMBIA	BEVERAGE	ON TEST
RICAREPA	CPC INTERNATIONAL COLOMBIA	FLOUR	CONSUMER TESTING
SOLEIN	LATICINIOS MOCOCA BRAZIL	BEVERAGE	SOME INSTITUTIONAL MARKETING
SOY MILK	SWIFT AND COMPANY USA	BEVERAGE	INITIAL FEASIBILITY TESTING

TABLE III

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT INCENTIVE GRANTS

FIRM	PRODUCT	COUNTRY
ARCHER DANIELS MIDLAND	TEXTURED VEGETABLE PROTEIN	THAILAND
DORR-OLIVER	70% PROTEIN COTTONSEED FLOUR CONCENTRATE	INDIA
GENERAL FOODS	CORN PASTA	BRAZIL
GENERAL MILLS	OIL SEED MEAT EXTENDERS	PAKISTAN
INTERNATIONAL MULTIFOODS	PROTEIN FORTIFIED FLOUR	TUNISIA
MONSANTO	PUMA BEVERAGE	BRAZIL
NABISCO	FORTIFIED CRACKERS	VENEZUELA
PILLSBURY	PROTEIN BEVERAGE POWDER	EL SALVADOR
SWIFT & COMPANY	VEGETABLE PROTEIN EXTENDERS	INDIA, BRAZIL

TABLE IV

FOODS DONATED BY U.S. GOVERNMENT*

PRODUCT	TOTAL VOLUME (IN MILLION POUNDS, ESTIMATED)	1970 (IN MILLION POUNDS, ESTIMATED)
NON-FAT DRY MILK	7,180	299
C-S-M (CORN-SOY-MILK)	1,007	293
W-S-B (WHEAT-SOY-BLEND)	17.2	11.2

*DATA FROM U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT, WASHINGTON, D.C.

REFERENCES TO PAPER ENTITLED
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THAILAND, ITS ENVIRONMENT AND ITS PEOPLE

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Thailand is a typical example of a country situated in a complex tropical environment. Although only three and a half times the area of the state of Michigan, Thailand possesses an extreme diversity of terrain. The country is made up of only three basic physiographic types--the highlands, plains of thin alluvium over rock, and the low alluvial plains. However, within these basic physiographic types is a variety of topographic and terrain features. There are low land and terrace paddies, dikes, levees, meander scars and ox bow lakes, canals and irrigation ditches, meandering streams, swamps, sink holes, termite mounds, sharp ridges and rounded hills, and a multitude of vegetation types which include tropical rain forests, dry evergreen forests, savannah and mangrove.

Its coastal areas range from white sandy beaches conducive to resort development, to vast areas of mud flats and labyrinthian tangles of mangrove. Only a few isolated coastal areas are rocky. Inland there are broad areas of virtually flat rice fields, some dotted sparingly with trees and termite mounds. A vast lowland region covering some 45,000 sq. kms. stretches from the Gulf to the mountains in the north. This region consists primarily of rice fields cut by sluggish, wildely meandering streams and rivers, and numerous canals and irrigation systems. In the rainy season this region, the Central Plain, is virtually a large fresh water lake dotted by numerous coconut palms and houses on stilts.

Immediately surrounding the Central Plain low hills punctuated by isolated groups of mountains rise sharply out of the deep alluvium. To the north and west of the plain is a mountainous region which borders Burma and Laos. Northern Thailand consists generally of a series of North-South trending parallel ridges, some of which rise to 6-7000 feet as individual peaks, although most of the mountains do not exceed the 3-5000 foot level. Nevertheless, the terrain presents a rather formidable environment. Meandering rivers flow through wide intermontane basins, in places cutting deeply incised gorges. The mountains bordering Burma are generally high and rugged, through which streams have cut deep canyons and narrow valleys. It is not possible to generalize concerning the vegetative cover of the region as it varies greatly in kind and density throughout. The valleys and portions of the

more accessible mountain areas are heavily cultivated.

Northeastern Thailand is a structural basin forming a plateau region covering more than 150,000 square kilometers. It consists primarily of rolling terrain dotted here and there by low hills. Large areas are flooded seasonally by sluggish meandering rivers, the largest of which drains southeastward across the basin. Meander scars, seasonal ox-bow lakes, and other small lakes are not uncommon. The Mekong River borders the entire Northeast on the north and east and is a controlling factor in the lives of millions within its immediate and adjacent environs. The marginal areas of the plateau on the west and south are marked by mountains, some quite rugged, which only at a few points rise above 4000 feet. The plateau is heavily cultivated and only in the mountain areas and in isolated areas of the plateau proper can heavy forests be found. A great diversity of crops are grown in the northeast which bear heavily on the country's economy.

The southeast peninsula, known properly as Eastern Thailand, encompasses a variety of topography, ranging from muddy estuaries and low coastal plains, to dissceted uplands, rolling hills and mountains which are similar to those bordering the Northeast plateau. These extend the full length of the Thai-Cambodian border. Some of the mountains reach an altitude of 5400 feet. Large areas are diversely cultivated, but equally large areas, near the border, are densely forested.

The western peninsula, or Southern Thailand, also possesses a great diversity of terrain. There is a continuation of the mountain range from the north which borders Burma, while isolated hills and mountains rise sharply out of the alluvial plains. The alluvial plains lie east of the mountains and constitute the bulk of the area in the south. Streams flowing from the mountains onto the plains overflow their banks with monotonous regularity in the rainy season. Many mangrove swamps are prevalent along much of the western coast of the peninsula, and in the far south in the tin mining area of the west coast, rocky seascapes hiding sandy coves are common. The mountains are densely forested, and the plains, as usual, are heavily cultivated. Huge tropical rain forests dominated the terrain on the Malaysian border.

Thailand lies in the monsoonal belt, over which during the months of May thru October westerly winds bring almost daily rains. Most of the country receives 50-100 inches of rain during this period; however, areas in the shadow of mountains may receive less, and areas on the windward side may receive double that amount. Very little rain falls during the six month dry season. Streams and canals evaporate and vast arid-like areas develop on the dry, sun-baked clays and sandy loams. Mean

temperatures actually vary little. Daytime highs in the low to mid-90 s are common; nighttime tempeatures in the mid to high 70 s or low 80 s are normal. In December and January temperatures in the uplands and mountains occasionally drop to the 40 s, or even 30 s, but in the lowland areas it is uncommon for temperatures to go below 60 degrees. During the months of March and April, isolated areas may suffer above 100 degree weather.

Thus it is an outdoor world for the majority of the people. An outdoor existence of eating and sleeping, work and play, living and dying. It is not possible, of course, to generalize on the living and eating habits of a population of over 35 million people. It goes without saying that the mode of living varies with the local environment, but Thailand is an agrarian country and the lowland and plateau people live very much the same existence. The Northern hilltribes represent an extreme although in reality their eating habits are only a variation of the normal. The city dwellers represent another extreme, but not nearly so great in diet as in housing.

In the more isolated regions of Thailand particularly within the hilltribes of Northern Thailand, breast milk is a child's primary diet for the first 18 months. At one month pre-chewed glutinous rice is added to the diet along with mashed banana of a specific variety an occasion. Weaning is frequently determined by birth of another child. At this point in his young life the older child is displaced to more or less fend for himself. He is generally cared for by a close relative and is forced to turn to a quasi-adult diet of sticky rice or rice soup with a small amount of meat or vegetable. If the family diet is only sticky rice and chili paste, as sometimes happens, the child has only sticky rice.

The remainder of the family including children other than infants eat fried beef, chicken, pork, or fish. Chili paste is often used as a flavor in rice. The paste is composed of peppers, onions, garlic, salt and dried fish or shrimp. Eggs are either not liked or considered a luxury as generally they must be purchased at a market. Dairy products are neither available nor liked. Vegetables cultivated or gathered from froest or hedgerow are very popular and are eaten boiled or fried with small amounts of fruit. The term vegetable by Western definition is a rather loose one, and over 70 varieties are common. Fruit is common but not generally eaten in large quantities by the hilltribes, although over 40 varieties are common to Thailand.

Although meat is seldom a part of the hilltribes' meal, pork is the most common. Squirrels, birds, wild goat, deer and monkey may be part of the meal. In

some tribes corn is used because not enough rice can be grown. The two may be boiled together, flavored with salt, with pork or chicken added.

The source of fat is from foods fried in rendered pork fat. Butter is not available--and would not be eaten even if it were. Coconut is a source of fat and is regarded as a sweat meat--eaten raw or roasted when young. The older coconut is made into sweat meats or cakes. All varieties of rice are preferred "polished" (overmilled), though there is some use of home--husked rice. Whether it is done with knowledge of its beneficial results is not totally known. Glutinous rice is soaked overnight in water, strained and steamed for 20-30 minutes. When children have an infection or fever all protein is restricted because it is believed to be harmful.

The tribes live on the tops of hills, near streams or on slopes depending on the custom of the tribe. The houses vary in size, but may consist of 3 or 4 rooms, one of which is a bedroom. Five to ten people per house is common. Lighting is generally by torch only.

In the lowland areas of the north particulary near the more populated villages or cities, the basic diet is somewhat more substantial. It includes both common and glutinous rice, curries (including those made of tree flowers) without coconut cream, river fish (small), raw meat with herbs and peppers, vegetables, and some varieties of insects and grubs. Of course economy is a factor which controls variations of the basic diet. However, even in the low income families, most own or work enough land where high protein crops could be cultivated. Soy beans are not a part of the staple diet, although a fermented condiment called "Thua Nau", literally "rotten bean", is eaten with sticky rice.

In the Northeast the diet is more varied. Of course rice is eaten with every meal, but though there are considerable number of buffaloes, oxen, and pigs, the average villager may eat meat only twice a week. The poorer families eat meat rarely if ever. Rabbits are a source of ready meat, but the idea has not caught on. Poultry is eaten as frequently as once a week by nearly everyone. Birds are eaten whenever they can be caught. Eggs are eaten by a large percentage of the people at least once a week, but nearly 25% do not eat them at all. Fish is very important and is usually eaten in one meal a day. Frogs and snails are rainy season treats as are fresh water shrimps and crabs. Silk worms play a dual role, the obvious one and as an appetizer with rice mixed with fermented fish. Bread is seldom eaten. No milk is consumed except tinned or powdered.

Outside of cities a very few families have electricity. Torches or

kerosene lamps are commonly used. Candles are considered too expensive. Lighting, of course, has a lot to do with how evenings are spent. Furniture is basic, ranging from virtually none to a few chairs, tables or cupboards. The family commonly sleeps in one room on bamboo floor mats or mattresses. Mosquito nets are a status symbol, but are seldom used because of both cost and trouble. Cooking is done on charcoal burners or wood between rocks; however, an amazing percentage cook on an open fire in a hole. Statistics show that approximately 15% have access to a sewing machine. Washing is done at a well or stream and most everyone has some form of soap, though some in isolated areas do not. It is further estimated that 95% of the Northeast dwellers have no toilet facilities at all, nor desire any as their absence bears no relation to income level or village status.

Water is a perennial and ubiquitous problem. It is usually a case of feast or famine. For several months of the rainy season there is too much and the land is flooded. During the dry seasons many inhabitants must purchase or walk great distances to obtain the basic needs for daily existence. Reservoir and flood control projects and drilling and community water projects are providing a degree of relief to many in the Northeast.

The following is an excellent account of the daily routine in a small village and provides a good insight to village life which may be considered "typical" for a very large percentage of low land living Thais. The paper from which it was taken is reproduced here virtually in its entirety.

Bang Chan is situated in the rice-producing area of central Thailand, about 20 miles by road northeast of Bangkok. The community, scattered over an area of approximately 5 sq. mi., had a population in 1954 of approximately 1700, divided among 336 households. About 60 per cent of the households were made up of independent families, parents with unmarried children, with an average family size of 5.7 persons. The community was defined simply by the clientele which patronized Wat Bang Chan, the Buddhist monastery and place for religious exercises, and the one primary school in the village situated on the grounds of the wat. Within the area of the community lived a small minority of Thai Moslems who patronized a mosque and school just outside Bang Chan. The few Chinese in the village were considered as part of the Thai-Buddhist community. Information to be presented on food habits refers primarily to habits of the Buddhist majority.

A road, connecting Bangkok and Minburi, the nearest market town, ran through one edge of the village. Within the community, one went by boat on the network of canals during the wet season, and during the dry season, on foot along the

dikes or across fields. Some adults in Bang Chan had never been to Bangkok, though almost all had visited Minburi, about 3 mi. away. When travel by boat was possible, boat vendors brought fresh produce and staples. They often extended credit and also accepted items such as fresh fish, fruit, and eggs on a barter basis, thus providing an outlet for small amounts of home products.

ANNUAL CYCLE OF ACTIVITIES

Basic to an understanding of food habits in Bang Chan is a knowledge of the annual cycle of activities. The main occupation of 80 per cent of the families was rice farming. Though there were clear differences in socio-economic status, the daily lives of the people were much alike: whether owners of land or renters, whether farming large or small plots, rich and poor worked in the fields at the same tasks and produced or gathered much of their food.

The tropical monsoon climate, together with the overflowing Chao Phraya River, provided natural conditions for raising a single crop of wet rice. From late May to November, during the hot wet season, the land was prepared, seed beds grown, seedlings transplanted and the lush, green rice fields grew. Despite availability of fish and greens in the canal, highest cash outlays for family food occurred in the transplanting season. Increased energy needs for work, cash onhand from sale of the previous year's crop, vendors accessible because of high water, and the convenience of purchased foods--all probably contributed to this situation.

Early varieties of rice began to mature in November, and harvesting continued throughout the cooler, dry season to early February. Hours of work were even longer during harvest than transplanting. The crop must be brought in while enough water remained in the canals so that sheaves could be moved and buyers could still come for the paddy (unhusked rice). Every daylight hour was used for field work, and threshing continued far into the night. At this time, too, many varieties of fish matured, and some family members fished night after night. School vacations were scheduled during the heavy work seasons of transplanting and harvest, so that older children might work in the fields and younger ones help care for babies and toddlers, who were never taken to the flooded fields. School-age children could also help fish, cook, gather food for the family and grass for the buffalo. Cooperative harvesting was common, but those with larger fields to harvest often hired neighbors, both men and women, as temporary helpers.

For most households in Bang Chan, sale of surplus rice was the main source of income. For some, sale of other home-produced foods, such as eggs or

fruit, and of fish and wild greens obtained from the canals augmented the cash income. A few turned to other labor, such as canal digging, when farm work was slack.

When the crop was in, most people rested, fished, and prepared for big ceremonies demanding organized work. Ponds were drained, and the fish on the muddhy bottom caught. Cash expenditures for food, which had declined progressively since the beginning of the rive year, reached a minimum, chiefly because people had ample time to fish.

During the hot, dry, post-harvest season, festivities and ceremonies dominated the village scene. Some of these, such as weddings, rites to honor a teacher, and pre-ordination feasts, were held at home, with many members of the community participating. Others, such as cremations and ordinations, took place at the wat (temple). Food played an important role in all of these affairs. Such occasions provided opportunity to "make merit" and add to one's prestige, as did the regular offering of food to the priests, throughout the year.

Though the beginning of Buddhist Lent in July marked the official end of the season of festivities, their number declined sharply in later May when the rains came, and the rice year began once again.

HOME SITES AND HOUSES

Since the canals provided the chief means of local transportation for much of the year and also supplied water for many household uses, houses were built near the canal. Even though home sites were mounded up to a level of 2 or 3 ft. above that of the fields, water might cover the mound at the peak of the rainy season. Many houses were built on stilts to avoid flooding when the water level was high.

Depending on the resources of the family, houses were built of either thatch or wood, roofed with thatch, galvanized iron, or occasionally, tile. Split bamboo or matting might be used for dividing walls, if the house had more than one room. Wooden flooring was usual. In simpler thatched houses with dirt floors, one or more low wooden platforms were built for sitting and sleeping, and water buffalo might be sheltered under the same roof with the family.

In the larger houses, the kitchen was usually a small separate room with a wooden floor and at least one window for ventilation. In smaller houses, especially those with an earthen floor, food preparation was carried on in one corner of the main room. Here the "fireplace" might be simply a mound of clay on the ground, with clay stove on top of it. In houses with a wooden floor, the "fireplace" would

be a low table or wooden case with sides built up several inches, and filled with clay, On this stood the clay stove, beside which hot pans and pots were set when removed from the fire. Firewood was kept nearby. Most families also had a portable charcoal stove for auxiliary use for outdoor cooking or when traveling by boat.

In many kitchens, clean dishes were placed upside down on a slatted wooden rack. A free-standing ventilated cupboard or "food safe" was the other common item of furniture. At its best, this was screened and the legs ant-proofed, but relatively few families had such well constructed food safes. Families often kept leftover cooked foods in a basket or covered with large dishes on a tray. Fish and sugar must be kept away from ants, but cooked rice, which did not attract them, could be left anywhere out of reach of dogs. A large jar or oil can held raw rice while salt, fermented fish, shrimp paste, and fishsoy were stored in smaller jars or bottles, usually covered. Dried food materials, such as onions, garlic, chili peppers, and other seasonings, might be hung from the roof in a basket. Paddy (unhusked rice) was usually kept in a large bin of matting or wood.

In a few homes, a clay water jar stood in the kitchen or nearby, but more often foods were washed, and cooking water obtained at the canal or fish pond. Rainwater, collected and stored in jars, was preferred for drinking, but in the dry season families had to resort to water from the canal or fishpond for drinking as well as food preparation. There were no deep wells in the area.

Some garbage was fed to animals; the remainder was not burned or buried, but was thrown either into the canal or elsewhere.

MEAL PATTERNS AND TYPICAL THAI DISHES

Food was commonly prepared twice a day, in the morning and late afternoon. The meal pattern was the same for breakfast and dinner, with rice being the principal item in every meal. In Thai, the general term meaning "to eat" is translated literally "to eat rice," and all food items are divided into two classes: rice and "with rice."

Breakfast preparation was begun early if food was to be offered to the priests, but family members might eat at various times during the morning: the husband before or after he went to the field; older children, before school time; babies and small children, when someone had time to feed them; and so on. Preparation of supper might be started anytime after 2:30 P.M. Family members more often ate together at the evening meal then at breakfast. Except during heavy work seasons, adults often ate just the two principal meals, but small children ate whenever hungry.

The homemaker, or older daughter if there were one, was usually responsible for meal preparation, but all members of the family who were old enough to help, learned to cook. A girl or boy could cook rice "as soon as he could lift the rice pot," i.e. at six or so; by age twelve, he could prepare a creditable meal. Committees of school children, ages seven to fourteen years, cooking a special meal on the school grounds, prepared a variety of dishes with ease, thus giving evidence of the home experience these children had had.

Responsibility for food preparation increased with age up to about fifteen years, after which the young people joined other able-bodied family members in field work during the busy seasons.

The principal processes used in food preparation were cutting food into bite-size pieces, pounding spices and flavoring materials, grating coconut, straining, boiling, and sautiing in a small amount of fat. The kitchen had no oven. A stick or metal support over the fire was sometimes used to roast fish of appropriate size of field rats. Bananas might be baked in the skin on a rack over the fire.

PREPARATION AND SERVICE OF MEALS

To help the reader visualize meal preparation and service in a village home, we will first describe breakfast preparation in one household. By 5:15 A.M., the fire had been lighted. Using a tin can, the twelve-year-old daughter measured rice into the clay rice pot. She took it to the canal, washed the rice twice, then covered it with an excess of water and put it on the fire. About 25 min. later, the mother removed the cover, stirred the rice once, then replaced the cover, allowing the rice to cook a little longer before she drained off the excess water. A little of the rice water was set aside for the baby, the rest was poured into the dog's dish. The rice left from the previous evening meal was added to the rice pot, which was then put back on the stove for a few minutes.

Meantime, dried chili peppers had been soaked in water, and the mother crushed and pounded them in the mortar with some onion, garlic, shrimp paste, and salt. The varied seasonings used liberally in Thai cookery are pounded fresh for each meal.

The daughter drained the water from a coconut into the dog's dish and split the coconut in half. Seated on a low wooden stool she deftly grated the coconut meat by pushing each half over a toothed iron scraper which was attached to one end of the stool. With a coconut shell dipper, she added a little water to the grated coconut, worked and squeezed the mass in her fingers, then poured the milky water through a fiber strainer into a kettle. She added successive portions

of water and squeezed the grated coconut several more times, thus obtaining almost three times the original weight of coconut as "coconut milk".

By this time, the rice had been taken from the stove, a few sticks of wood were added to the fire, and the kettle of coconut milk was put on the heat at about 6:15 A.M. Twenty minutes later, the pounded seasonings were added, with a spoonful of palm sugar, and the cooking continued. Lastly, swamp cabbage, which the daughter had gathered from the canal, and dried salted fish were put into the pot.

At 6:50 A.M., the curry was taken from the fire bowls of rice and of curry were then arranged on a tray for the small boy to take to the landing to be offered to two priests who would shortly pass that way. While the mother nursed the baby, the older daughter set out bowls of rice for the other school-age children and herself. A bowl of curry, with a spoon for serving, was placed in the center where all could reach it.

Each one had a spoonful of curry beside his rice. To take more than that at one time would appear greedy. Enough rice for a bite was pressed together with the fingers of the right hand, so that grains would not be scattered as they were conveyed to the mouth. The curry was eaten by touching one side of the rice ball to it.

When the baby had finished nursing, the mother mixed rice water with some rice in a bowl and fed it to him. He was too young to have the highly seasoned curry. The older children rinsed their bowls and turned them upside down to dry, put some rice and curry into a tiered lunch pail, and were off to school in their small boat. The mother had her breakfast later, when the father returned from doing early chores. A small amount of rice was left over from the meal preparation were scraped through a gap in the floor boards, to be snatched up by the chickens.

"WITH-RICE" DISHES

In Bang Chan, three or four "with rice" dishes were usually prepared during the day, but the number and kind varied in different families and according to season. Fish was second in importance to rice, but the typical "with rice" preparation, whether "hot" or mild, contained more than one food item in addition to a variety of spices and flavoring materials. One or two of the "with rice" dishes would usually be "hot," i.e., highly seasoned with fresh or dried chili peppers. Curries belong to this category, but may be designated as either "hot" or "sour." The latter have crushed tamarind added, but contain less chili and spices. Vegetables, if used, were added when the cooking was nearly finished.

A hot sauce, nam prik, made of shrimp paste, chili, garlic, and other spices ground to a smooth consistency in a mortar and then mixed with lime juice, sugar, and salt or fishsoy, was called by one informant the everyday food of the villagers. When vegetables were eaten raw or cooked without seasoning, nam prik was always served with them. If the poor man had nothing else to eat with his rice, nam prik would make it more palatable.

Mild dishes included panned vegetables; meat or eggs cooked with small amount of fat and a variety of spices and condiments (including black pepper but not chili); fish, roasted or boiled; vegetables cooked in coconut milk or water without seasoning, or served raw.

Judging both from meals prepared in the eleven households studied and from the school children's records, some protein-rich food, usually fish, was generally eaten at each meal, but the amounts per person might be small. Some children had no vegetables, and only about one-fourth of the vegetables mentioned in the children's records were green or yellow. Except for the occasional use of pineapple or unripe papaya in curries, fruits were not included in meals, but were eaten by many children as snacks.

SNACKS

Between-meal snacks might be any available leftover food, fruits, or items bought from a vendor. Most school children ate snacks, which were usually different from foods eaten at a regular meal. Fruits and "desserts" were commonly eaten, although a variety of other foods, not a part of the usual Thai meal, were also listed. One could tell fairly well from the children's records what the vendors, who appeared on the school grounds daily, offered for sale on a given day. Some influence of temperature was apparent; thus ices and syrup over shaved ice were eaten more often during the hot dry season, and cooked foods, such as fried Chinese noodles, appeared primarily in cool weather. Seasonal fruits might be picked from the home garden, and items such as lotus seeds were gathered wherever the children found them. Some children carried food to school, but many ate no regular lunch.

The number of snacks recorded by individual children did not, however, appear to be related to whether or not they had eaten lunch. For example, among the 76 children who provided 24-hr. food records during May 1953, the average number of snacks recorded by the 39 children who ate a regular lunch and the 37 who did not, was about the same, i.e. a little over three per child.

SOURCES OF FOOD

HOME PRODUCTION, STORAGE, AND PRESERVATION

Rice. Although nearly a third of the households owned a home rice mill, undermilled or home-pounded rice was not widely used. Information on this point was obtained for 333 of 336 "kitchen-unit" households in the village. Of these, 4 consumed home-milled rice only, 51 used home-milled rice in major part, 78 in minor part, and 199 not at all. Most families took paddy to the mill when water in the canal was high enough so that it could be transported by boat. No family in Bang Chan used rice polishings for human food.

Fish. Next to rice, fish constituted the most abundant food in the diet in Bang Chan. Either fresh or preserved, they were available throughout the year. During heavy work seasons, many families purchased fish from vendors. Every house had a pond, from which fish were taken as needed, sometimes--for convenience--several at a time, to be kept alive in a large pot near the house. By draining the pond, fish were harvested. Those caught in excess of immediate needs were preserved for later use. Larger ones were commonly salted and dried; smaller ones were preserved as fermented fish. Small shrimp, which were caught in quantity during only about three weeks in February, were made into shrimp paste, an essential ingredient of Thai "hot" dishes. The liquid drained off from the mixture of fish or shrimp and salt in the first stage of preparing fermented fish or shrimp paste was used by some villagers to prepare fishsoy, a common condiment.

Eggs. Chickens were raised by about 90 per cent of the families, and over 70 per cent owned ten or more. Only 37 per cent of the households had ducks, and only 13 per cent had ten or more. Most of the eggs produced were sold.

Fresh Foods Other Than Fish. Production and use of meat was inhibited by Buddhist tenets which forbade the taking of life. Killing of poultry, fish, and so on, was tolerated among the relatively young, but was considered unsuitable to the aged who should be preoccupied with living virtuously. Vendors sold meat, such as water buffalo and pork, as well as fish. Actual butchering was done by Moslems or Chinese who did not object.

Since many villagers were unwilling to slaughter water buffaloes, even when they became aged and useless, such animals which had died of old age or disease were not, however, regarded by Thai Buddhists in Bang Chan as unfit for human consumption, but Moslems were forbidden to eat them. Some Moslems reported offering dead animals to Buddhists in barter for other materials. In 1955, only five householders in Bang Chan raised hogs, and four of these had one or two only. Moslems

ate no pork.

Poultry was not commonly used for food, it was the poor man's "feast" food suitable for guests. Various wild creatures were used for food. Eels, frogs, turtle, cobra, and other snakes were used for curry, some for special parties for men. Field rats, available all year, were roasted.

Vegetables and Fruit. Although kitchen-gardening had been encouraged by the Thai government, vegetables and fruit were grown in Bang Chan to a limited extent only. Every family had some sort of kitchen garden, but seasonings and chili were more commonly grown than vegetables and fruit.

In a typical farm garden in Bang Chan, one would find bananas and a number of plants used for seasoning curry, such as various kinds of chilies, lemonagrass, bergamot, of which both rind and leaves are used, and galangal. Both sweet and holy basil were commonly grown. Some families grew one or more varieties of gourds and of eggplant, perhaps training them over a tree or trellis. The inflorescence of the banana was also used as a vegetable. Leafy vegetables were not commonly cultivated, but some families grew phak kached (Neptunia prostrata), a green water plant, in gardens staked out at the edge of the canal or in a pool. Some had trees with edible leaves. Swamp cabbage, which grew wild along the edge of the canals, was the most common green leafy vegetable. In addition to bananas, a few families grew guava, jujube, star gooseberry, Manila tamarind, mango, and pineapple.

Increased home production of fruit and vegetables would in many cases require increasing the size of the home site by purchase, mounding, or both. Ordinarily, increased land for the kitchen garden was obtained only at the expense of some of the rice land. Water-ways, however, were public areas; and any convenient wide spot might be selected as a private garden, marked off with stakes.

FOOD PURCHASES AND CASH EXPENDITURES

Relatively few foods were purchased, but some of these, such as onion, garlic, limes, tamarind, coconut, and palm sugar; were so frequently used that without cash to buy them, villagers would have considered their diet monotonous. If their own supply of fresh and dried chilies, fishsoy, and shrimp paste was inadequate, these too would be bought. Other foods less commonly produced in Bang Chan were purchased for variety; for example, eggplant and white radish were bought by more than half the families that participated in the dietary study. Salted and pickled white radish and pickled bamboo shoots were the only preserved vegetables

purchased and used frequently.

Cash expenditures for food were relatively small, the average cash cost being less than half a baht (a little over 2 cents) per capita per day. Animal foods, being relatively expensive, accounted for more than a third of the cash spent, coconut a little less, vegetable about a fourth. Minor amounts went for palm sugar, fats and oils, spices, and miscellaneous.

THE ACCEPTABILITY OF NEW PROTEIN-RICH FOODS IN THE WAR-AFFECTED AREAS OF NIGERIA.

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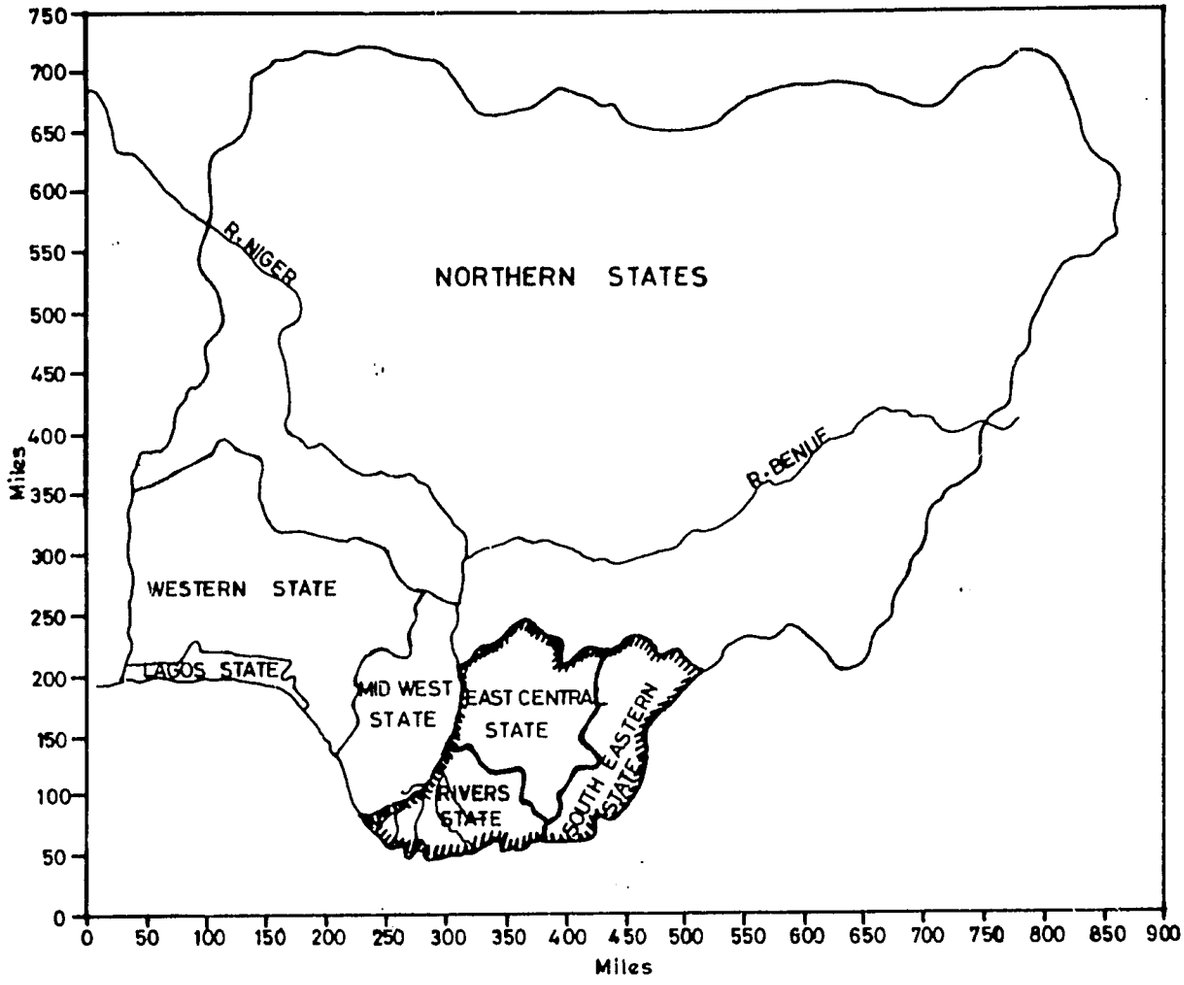
ABSTRACT.

During the recent civil war in Nigeria, some emergency relief foods were introduced into the war-affected areas of Nigeria for the relief of the famine and starvation.

The utilisation of these foods in the hospital for the treatment of severe kwashiorkor cases, the convalescent home and some villages in the state was observed

The new protein-rich foods were not readily accepted because they were unfamiliar. The locally available foods were always preferred.

The steps taken to improve the acceptability of these foods are discussed.



BANIGO E. O. I. AND OMOLOLU A.

FIG.I MAP OF NIGERIA SHOWING THE MAJOR WAR-AFFECTED AREAS (RIVERS, EAST-CENTRAL AND SOUTH-EASTERN STATES)

INTRODUCTION.

Nigeria, situated in West Africa, extends from the Gulf of Guinea in the South to the border of the Sahara in the North, covering an area of about 357,000 square miles (Figure I.) It is the most densely populated country in Africa and contains about 56 million people (CENSUS 1962-63). The independent Federation of Nigeria came into being in 1960. In 1967 the 12-state administration of the Federal Republic was established under a Military Rule. The official language is English and there are over 200 vernacular languages.

The civil war which lasted for 30 months (July 1967-January 1970) affected the three Eastern states (former Eastern Region) with a total area of 29,484 square miles and estimated population of 14 million people (Figure I.)

While in advanced countries, much of the food consumed may be imported, it is characteristic of developing countries that patterns of food consumption and production overlap. Therefore the food consumed in any particular part of Nigeria is largely dependent upon food produced in that area. There are no reliable data on the production of foods in Nigeria. Animal protein sources (meat, fish, egg and milk) in the former Eastern Region are limited. So also are plant protein sources (oil seeds and legumes). Starchy roots and tubers (cassava, yam, coco-yam and sweet potato) constitute the major staple food crops. Maize, rice, vegetables, various fruits and oil palm are also grown there.

While the overall energy supply in this area was found to be adequate, that of protein was not (NUTRITION SURVEY 1965). Conditions referred to as pure kwashiorkor (COLLIS 1958) and marasmic kwashiorkor (PLATT 1958) have been reported in certain parts of the former Eastern Region before the civil war.

In order to relieve the famine and starvation in the war-striken areas, several humanitarian organisations the world-over supplied massive quantities of various foods. This paper reports a study on the use of these foods and their acceptability in two health centres in the Rivers State capital and some villages, a few months after the cessation of hostilities.

Man, is by nature, very conservative and will resist any change in his food habits. The formulation of new 'complete' foods has been successful in clinical treatment of severe malnutrition cases (CANTOR AND ROBERTS 1967; PARMAN 1968). However, the well planned but expensive promotion which is needed for the

introduction of new protein-rich foods, if they are to be readily accepted by those for whom they are intended, has often been neglected especially in times of famine, disaster or starvation.

MATERIALS.

The emergency relief (protein-rich) foods available during this study are given in Table I.

Table I. Relief (protein-rich) foods available.

Common or trade names	Protein Content %	Components of products.
Yellow corn meal	7.95[a]	degermed milled corn, enriched and fortified with Calcium and Vitamin A
Bulgur wheat	12.4[a]	completely cooked, dried and cracked wheat grain.
Rolled oats	12.1[b]	flaked oat meal.
C. S. M. (Corn-Soya-milk)	20.0[c]	precooked corn meal 68%, toasted soy flour 25%, non-fat dry milk 5%, vita mins and minerals added 2%.
Farex	14.2[c]	three cereals, minerals and vitamins blended and cooked.
P.K.F.M. (Post Kwashiorkor Food Mixture)	19.9[d]	precooked high protein mixture formu lated as follows: maize meal 40%, fu fat soy flour 38%, dried skim milk 5' Sucrose 15%, vitamin mineral mixture 2%, added vanilla flavour.
K Mix II (Kwashiorkor Mixture II)	22.4[d]	Casein, skim milk powder and sucrose mixed in the ratio 3 : 5 : 10 parts b weight.
Dried skim milk	28.9[e]	milk.
Canned chicken	N. E.	Shredded dry pack chicken cooked reac to serve.
Emergency food pack	N. E.	dried cake and soup blocks.
Stockfish	N. E.	Norwegian dried cods.
Salted fish	N. E.	dried salted fish.

Source: a AACC Protein-enriched cereal foods for world needs St. Paul Minn. 55104, 1969.

b McCance R. A. and Widdowson E.M. The composition of Foods H M. S. O. London, 1960.

c Supplied by manufacturer.

d Calculated.

e FAO - USDHEW Food Composition Table for use in Africa 1968

THE NIGER HOSPITAL, DIOBU, PORT HARCOURT AND THE EGBUNINE CONVALESCENT HOME, PORT HARCOURT.

There were 35 and 450 patients at the hospital for treating kwashiorkor cases and convalescent home respectively. These were mostly in the age group 0 - 15 years. They were placed on high protein diets prepared either entirely with emergency relief foods or in combination with locally available foods.

The preparation, cooking and presentation of various dishes of new protein-rich foods were observed. These dishes may be classified as Beverages (or drinks), Porridges (or pap), Foofoo, Jollof, Soup (or stew) and Fried products. This classification is given in Table 2.

Table 2. Classification of new protein-rich foods according to dishes.

Beverages (or drinks)	Porridges (or pap, gruels)	Foofoo	Jollof	Soup (or stew)	Fried products
Dried skim Milk	Yellow corn meal.	Yellow corn meal.	Bulgur wheat.	Stockfish Salted fish.	Wheat flour Yellow corn meal.
K Mix II	C. S. M.	C. S. M.	C. S. M.		
P.K.F.M.	Rolled oats				
	Farex				
	Bulgur wheat				

BEVERAGES These are low viscosity liquids with a high water content (usually over 90%), prepared by mixing the protein foods with water (boiled and cooled recommended)

Most traditional beverages are fermented cereal alcoholic products for example pitto and burukutu.

PORRIDGES The moisture content of these is about 90%. These are prepared by mixing the mate ial with boiling water until the desired consistency is obtained. Alternatively the porridge may be boiled under stirring. Sugar and milk may be added. The most important porridge of this area is Ogi, a fermented cereal product.

FOOFOO These preparations are distinct from porridges in that the product can be formed into balls which do not flow under gravity. The moisture content is of the order of 65 - 80%.

The material is stirred into boiling water to give a semi-solid product. It is then cooked for about 10 minutes and served with a highly seasoned soup containing meat or fish and leafy vegetables. Foofoo in this area is usually a fermented cassava product or pounded yam or plantain.

JOLLOF The nearest Western food equivalent is risitto. These are similar to foofoo in moisture content (65 - 80%)

The material is cooked with sufficient water until very soft. Fat or oil, spices, meat or fish are added and then thoroughly mixed. It is served alone as a complete dish. Traditionally, jollof is prepared either with rice or in combination with beans.

SOUP (or stew) The African soup unlike its Western equivalent is highly seasoned and contains meat, fish, leafy vegetables and other codiments. Usually served with foofoo.

FRIED PRODUCTS (puff-puff, pancake)

The material is stirred into the required amount of water until the desired consistency is obtained. It is fried in oil or fat. The popular traditional fried products are akara (beans cake) and mosa (banana mixed with maize meal).

The weight of food given to a selected number of patients and their plate wastes were determined. Additionally each patient's assessment of every dish served in terms of taste, flavour, appeal (colour) and overall acceptability was obtained.

The % waste of some dishes and the patients assessment are given in Table 3

Table 3. % Waste and patients' evaluation of some dishes.

Names of dish	Waste %	Patients' evaluation.
Bulgur Jollof (with butter oil)	50.5	Colour unattractive, not tasty.
Bulgur Jollof (with palm oil)	24.2	Improved colour, more acceptable taste.
Bulgur Gruel	64.8	Colour uninviting, too dark, not delicious, product unfamiliar.
C. S. M. Jollof	40-60	Not delicious, texture too smooth, dish unfamiliar.
C.S.M. Porridge	40-70	Not tasty, unfamiliar
Rice and Beans Jollof	-	Delicious, very acceptable.
Milk drink	14-50	At times too watery, milk is associated with frequent stool.
Stockfish	35	Not allowed to cook properly, hard to chew.

The dishes in Table 2 have been prepared in accordance with the existing cooking practice of the locality. The results show that the % waste recorded for some of these dishes are high (Table 3). The % waste of Bulgur Jollof (with butter oil), Bulgur Jollof (with palm oil) and Rice and Beans Jollof are 50%, 24% and none in that order. There is a correlation between % waste and acceptability of the product. The more attractive and tasty the product is, the smaller the % waste.

The % waste recorded for C. S. M. Porridge, milk drink and Bulgur Gruel are 40-70%, 14-50% and 65%. These dishes do not appear to be very acceptable. It was thought possible that the people's unfamiliarity with the products may account for this. Here a particular dish was unacceptable for example Bulgur Gruel, it was substituted with another one.

Some modifications in the preparation of the dishes were effected. For instance butter oil was replaced with palm oil in Bulgur Jollof and the % waste dropped from 50% to 24% (Table 3). Bulgur Jollof was replaced with Rice and Bulgur

Jollof. The modified dishes appeared acceptable.

FIELD STUDY IN VILLAGES AND HOMES.

Anothe aspect that was studied in the field was the use of these foods by the local people.

The foods were given out at Distribution Centres and the amounts given were meant to last for a week for the family. Follow ups were done to the homes of the recipients to find out how the foods were used and advice given on their preparation.

In the studies carried out in the villages and homes it was interesting to find that the preparation of the foods accepted, had been adapted to the normal food habits and pattern of the people whilst those foods that could not be cooked in the traditional way were not acceptable.

C. S. M. This was made and accepted as a Foofoo (See Table 2), but not as a porridge or gruel. It became known all over the area as American 'GARI' and used as a substitute for 'gari' prepared from cassava.

BULGUR WHEAT - This was prepared in the homes as Rice - by boiling and eaten with vegetable soup. It was regarded as a poor substitute for rice and to conceal its colour and hardness was prepared either mixed with rice or cooked as Jollof (See Table 2).

Bulgur gruel was never seen prepared in the homes.

Bulgur wheat was described by the local people as unmilled rice, because of its high bran content.

STOCKFISH This was well accepted. After thorough soaking (usually overnight), it was cooked in a soup with vegetables, tomatoes, onions and spices. The soup accompanied the foofoo (made with C. S. M. or local gari) and rice or bulgur wheat.

GENERAL DISCUSSION.

All the new protein-rich foods introducted into the war-affected areas were of a higher protein content than existing staple foods (starchy roots and tubers). The protein content of the emergency relief foods is of the order of 8 - 30% (Table I), starchy roots and tubers 0.9 - 6% (FAO 1968). Food habits are difficult to change. Yellow corn meal and C. S. M. were used exclusively to prepare foofoo (Table 2). If however, gari (a cassava product) was available, it was rather preferred. Stockfish and salted fish were acceptable. These are well known in this area having been in use prior to the civil war. Given a choice between new

high protein and already familiar low protein foods, the latter was always preferred.

In the introduction of new products into an area, the following factors seem very important for acceptability:

1. Food habits - Here C. S. M. was accepted as a 'foofoo' or American 'gari' but not as a gruel or porridge as recommended by the makers.
2. Taste - For instance milk was not readily accepted because the taste was unfamiliar to the local people.
3. Colour - The yellow maize used in C. S. M. caused some problem in those areas where gari had always been white. In areas where the traditional gari had always been yellow (due to preparation with palm oil) C. S. M. was readily acceptable.
4. Cooking practices and available cooking utensils. In the preparation of these foods no new utensils or cooking practice should be needed. This latter aspect is receiving attention in this Unit.

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PROTEIN MALNUTRITION IS STARVATION

by

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An important question which should be asked by food industrialists, would-be nutrition educators, public health administrators, and by policy makers, is how widespread is "protein malnutrition". Although most nutritionists refer not to "protein malnutrition", but to "protein-calorie malnutrition", it is my impression that too frequently the calorie component of the term "protein-calorie malnutrition" is given only lip service.

Sukhatme (1970) had this to say :

> "..... the widespread incidence of protein deficiency in India today is mostly the result of inadequate quantity of food".

In other words the point was made that protein malnutrition is mostly the result of starvation. He went on to say,

> ..... "We must conclude that children's needs for protein can bet met by a diet based on cereals and pulses, such as those normally eaten by adults, provided they take enough of it".

Gopalan (1970), in discussing whether or not the hypothesis that marasmus is due to predominent calorie deficiency, while kwashiorkor is the result of predominent protein deficiency, said :

> "I feel that, in view of the accumulating evidence from different parts of the world, our earlier concepts regarding the pathogenesis of kwashiorkor and marasmus need reappraisal. Such reappraisal will not be a mere academic exercise but will have far-reaching practical implications".

Gopalan considered that the main bottleneck in the dietary situation of both syndromes is calorie inadequacy.

Both these views, which are based on practical experience, seem to

indicate that nutrition educators may be in error when they teach that children need special protein-rich foods. From a theoretical point of view also, there appears to be no basis for holding the view that children need such foods. Breast milk, in which about 7 percent of the calories are derived from protein, is not notable as a food rich in protein. It is recognised, of course, that not every dietary mixture of proteins has a biological value approaching that of milk-protein. But even so, it seems hardly likely that weaning foods need be especially rich in proteins.

Although many people believe the contrary, there is actually no support from the Recommendations of the Joint WHO/FAO Committee on Protein Requirements (1965) for the notion that children need special protein-rich foods. It is certainly true that these recommendations indicate that protein needs per unit of body weight are higher in children than in adults, for example, comparable figures are 1.5 g protein per kilograms of body weight for children, and 1.0 g/kg for adults. But the fact that children also require more energy per unit of body weight than adults is frequently overlooked. Given adequate quantities the same foods will meet the protein and energy needs of both child and adult equally well. It can be argued too, on psychosocial, and even on economic grounds, that it may be undesirable to encourage dietetically a child elite group.

It seems possible that too much attention can be focussed by planning authorities on protein and protein-rich foods as a means of combating malnutrition in children, if the real problems of "inadequate quantity of food" is neglected.

There is a case for producing more conventional protein-rich foods, but there are more important reasons for doing this than to combat malnutrition. For example, livestock can help considerably to buffer fluctuations in the production of basic food crops such as cereals and tubers. Also the presence of livestock helps to add interest to the environment and to provide aesthetically satisfying employment for people. Finally, animal products can add variety to diets that may otherwise tend to be monotonous.

"Protein-calorie malnutrition" is identical in every sense to "starvation". One might well ask why do nutritionists continue to talk about "protein-calorie malnutrition", when what is really meant is "starvation". The use of

the correct word is not a mere quibble, but has far-reaching practical implications because it can be understood by all: decision makers, educators, and food industrialists.

As Gopalan (1970) indicates, if we re-focuss our attention on "inadequate quantity of food" as the main problem, this will have far-reaching policy implications. There are two which appear to be relevant to the Seminar on Protein Food Promotion:

1. A relatively low priority should be given to the production and promotion of semi- and non-conventional protein-rich foods.
2. A high priority should be given to the production, and especially to the equable distribution, of basic foods and to conventional protective foods such as leafy greens.

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Role of Commercial Sector

SCIENTIFIC SUPPORT OF PROTEIN PROJECTS

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1. INTRODUCTION

The protein nutrition situation in The Netherlands is quite different from that in many developing countries. For the time being, the protein nutrition in our country would seem to be sufficient. However, the introduction of some industrially developed new protein preparations was a reason for the Minister of Public Health to request the Public Health Council in 1967 to advise on the possibilities of the development of new (i.e. non-conventional) protein foods and to draw up tentative guidelines for authorities and industry for the evaluation of these foods.

Being a member of the Committee which was formed for this purpose, I would like to tell something of the experience gained from the investigations made on the subject and of the discussions which have resulted in tentative guidelines (9).

In these guidelines, the new protein products have been subdivided in various categories according to the origin of basic material and production methods applied. In this way the requirements which should be recommended, and which will have to be worked out later into food law regulations, could be more differentiated as circumstances may require.

2. CATEGORIES OF PROTEIN FOOD PRODUCTS

2.1. Products which are mostly variations of and do not actually differ much from long-established food products for human consumption, the process of their industrial manufacture being comparable to that of average household preparations (cooking, roasting, etc.). To this category belong dried soups and instant meals.

2.2. Long established food products having undergone some technological treatment during the manufacturing process not comparable with household preparations, e.g. extraction with organic solvents, extrusion cooking or autoclaving, or additions which might change the character of the product, such as various types of fish proteins, soya protein, etc.

2.3. Protein products prepared from ingredients previously not used for human consumption, e.g. proteins from oilseed press-cakes, leaf proteins, etc.

2.4. Protein products prepared by microbiological fermentation of wastage from the chemical and agricultural industries, such as food yeasts from molasses, brewer's yeast, yeast from the potato or maize starch industry, yeast from the paper industry, etc.

2.5. Protein products prepared by fermentation of hydrocarbons (n-paraffins, gas-oil).

2.6. Protein products prepared by cultivation of different organisms on synthetic media, e.g. different types of algae.

2.7. Synthetic or semi-synthetic amino acids.

As the products mentioned under 2.2. up to and including 2.7 are in some ways different from the human foods being used until now, an evaluation of these products is necessary. With our present knowledge a safe evaluation can be given when the following aspects are taken into account.

3. ASPECTS FOR THE EVALUATION

In assessing tentative guidelines for the evaluation of new protein foods different aspects will have to be considered, viz.

a. nutritional value
b. potential toxicity
c. microbiological conditions
d. chemical composition and purity
e. functionality
f. nomenclature and labelling

In the following paragraphs some examples will be given of studies concerning the evaluation of protein foods which have been carried out in recent years.

4. NUTRITIONAL VALUE

4.1. Determination of nutritional value

As these new products are meant to replace conventional products or to improve the protein nutrition, it is necessary to judge their protein nutri-

tional value which cannot be indicated by a single figure. The nutritional value depends mainly on the contents of the essential amino acids, their ratio and the biological availability. These may differ appreciably from protein to protein.

Essentially, two methods are used for assessing the nutritional value of proteins: the chemical analysis of the essential amino acids (chemical score) and the biological evaluation, using experimental animals, e.g. rats (nettprotein utilization (NPU), protein efficiency ratio (PER)) and determination of limiting amno acid(s).

Both chemical and biological data are needed to obtain sufficient information about the value of a product.

From the chemically determined composition of a protein the NPU can be predicted, see table 1. In this table the biological values determined by rat assays and the chemical score are given for mixtures of brown beans and maize.

Table 1. Comparison of calculated chemical score and biological value determined in rats

Protein mixtures			
brown beans %	maize %	chemical score	biological value
100		37	36
80	20	49	44
60	40	63	61
40	60	74	78
20	80	67	75
	100	53	67

Taking into account the inaccuracy of the biological method, the results of the biological determinations are mostly fairly well in agreement with the calculated values. If not, the cause should be sought for in digestibility, availability, etc.

4.2. Choice of protein

Before starting a protein project it is useful to ascertain that a product has indeed a good nutritional value. This was demonstrated in the following project.

In West-Africa an improvement in protein nutrition was expected by the cultivation of vegetables in the gardens of the inhabitants. For this purpose, the endemic cassava plant was chosen, the leaves of which are known to have a high protein content (8.4%). To evaluate the nutritional value the amino acid composition and the NPU were determined; the latter in rats (8). The amino acid composition is given in table 2.

Table 2. Amino acid composition in g/16 g N of cassava leaf protein in comparison with whole egg protein (4)

Essential amino acids	Cassava leaf	Whole egg protein
Isoleucine	4.6	5.6
Leucine	7.8	8.5
Lysine	5.4	7.0
Methionine	1.7)	3.3)
Cystine	0.86 } 2.6	2.4 } 5.7
Tyrosine	3.6	4.2
Phenylalanine	5.2	5.8
Threonine	4.3	5.2
Tryptophane	0.59	1.6
Valine	5.9	7.3

The amino acid composition of the cassava protein seems to be comparable with that of many other plant protein, the S-containing amino acid and tryptophane being the limiting ones.

From table 3 is observed that the NPU of cassava leaf protein is extremely low as a result of low digestibility. If methionine is added the NPU may be improved but still amounts to only half of that of casein and fish protein.

Table 3. Net protein utilization, digestibility and biological value cassava leaf protein (4), as compared with milk and fish

	NPU	D	BV
Cassava leaf	5	32	16
Cassava leaf + methionine	32	45	71
Milk	75	86	87
Fish	68	87	77

To prove these findings in rats, experiments were also carried out in human subjects. The nitrogen retention was determined in 5 subjects on European diets in which approximately 30% of the protein was replaced by cassava leaf protein. Actually, nitrogen retention was about 10% lower than that of the control diets.

In another experiment, the proline and total amino acid concentrations in the blood serum were determined after ingestion of a cassava leaf meal of 500 g (40 g protein) or 500 ml skimmed milk (13), cf. fig. 1.

In this figure it is shown that there is hardly any increase in proline or & amino acid nitrogen in the blood serum of a subject after ingestion of about 40 g of leaf protein. The ingestion of milk gives a good response.

These experiments have made it clear that cassava leaf protein is not a good protein source and that the efforts spent on this project could have been put to better use.

In another project the problem was of a quite different nature. Proposed by U.N.-agencies, it concerned cultivation of large quantities of broad beans (Vicia faba), containing approximately 20% of protein. In Iran in particular the scheme might produce good results as this type of beans is used in various local dishes. Upon the completion of a large irrigation system, extension of this cultivation was possible.

It is known that broad beans may cause a disease, a hymolytic syndrome, called favism. In Europe, only few people are sentitive to this disease. In the Mediterranean and Middle East regions, however, it is more common and seems to be related to a hereditary enzyme deficiency of glucose-6-phosphatase-dehydrogenase. The highest percentage of people susceptible to it was found just in the districts where the cultivation of broad

beans had the best possibilities. Needless to say that such projects are not very encouraging for the improvement of protein nutrition. Of course there are still many fields of interest in which research work can be carried out, for example developing by selection a race of broad beans not containing any toxic factors or designing technological processes eliminating these factors. Most probably it will take years to attain satisfactory results.

4.3. Heat processing

For densely populated regions with urbanization and industrial development, different types of protein projects will be chosen. Here, industrial products with good keeping qualities and convenient to use will be preferred to improvement of agricultural produce. Often, a heating process such as pasteurization, sterilization, etc. is used for preservation purposes. If this is done accurately the nutritional value will not decrease too much. The extent of loss depends on the composition of the food product, heating time and temperature and is, as far as is known, caused by a Maillard reaction of some essential amino acids and sugar compounds. In this reaction, the amino acid is changed into a form unavailable for the synthesis of protein in the body, cf. fig. 2.

Although loss of nutritional value with moderate heating is not easily demonstrated, the possible harm caused by the compounds of a Maillard reaction is not known. In an investigation carried out in connection with bifidus factors, an unexpected effect of heating could be observed.

When feeding babies with pooled human milk, a difference was noted between non-heated milk and milk sterilized by heating, cf. fig. 3, in which a comparison of feces from a baby fed respectively with heated and non heated pooled human milk (7) is given.

During the period that the baby was fed with heated human milk, a higher lysine and cadaverine content was present in the feces than in the period of non-heated milk feeding. It is believed that these substances ar formed from non-available lysine products by bacterial metabolism. Although this is, perhaps, not a serious problem, the cadaverine production should be avoided, if possible.

In another investigation it could be demonstrated that sometimes the composition of the product plays a role in the effect of heating on the nutritional value, cf. table 4 (15).

Table 4. Heating of luncheon meat with different rind contents

Heating	7½% rind		15% rind	
	NPU	% cystine g/16 g N	NPU	% cystine g/16 g N
None	78	1.0	76	1.0
Household process	74	1.0	75	1.0
Heated at 110°C	75	1.0	73	0.9
Heated at 125°C	75	1.0	68	0.8

In this heating process, which is often used in industry, some loss of nutritional value is observed, especially when the rind content is high. A comprehensive review on this subject is given by de Groot (3).

4.4. Alkaline treatment

In protein evaluation studies carried out with isolated soya protein, various products were investigated. The NPU values appeared to be much lower than could be expected from the amino acid composition. In this respect it should be noted that all products had undergone an alkaline extraction process (5), during which process lysinoalanine or lanthionine may have been formed, cf. fig. 4.

In Fig. 5 (left) the formation of lysinoalanine as a result of the alkaline treatment of soya proteins has been set out at various temperatures. Moreover the changes in lysine, methionine and cystine are given, while the right hand side represents the changes in NPU and true digestibility. All treatments were carried out at pH = 12.2 for 4 hours.

In later studies a decrease in growth of rats could be established by the addition of 0.2% isolated lysinoalanine to an adequate diet (Ottenheym, 12). So far, no chronic toxicity studies have been carried out with this substance.

It is clear that processes during which lysinoalanine is formed should be avoided as long as nothing is known with regard to possible hazards to health.

A comparable loss of nutritional value was observed in a preparation of groundnut protein, in which the aflatoxin was inactivated (de Groot, 4), cf. table 5.

Table 5. Nutritive quality of groundnut oil meal (untreated) and groundnut protein (aflatoxin eliminated)

	groundnut oil meal	groundnut protein isolated
NPU	50	35
TD	93	97
BV	54	36

The low quality of the isolated protein may perhaps be ascribed to the low content of cystine.

In evaluating the protein nutritional value of the conventional products the processing factors are the main criteria.

If non-conventional basic material is used, as is mentioned in categories 2.4., 2.5. and 2.6., not only the criteria with regard to nutritional value, but also potential toxic factors, have to be investigated and, if necessary, eliminated (e.g. gossypol from cotton seed protein). Toxicological studies will have to be carried out on the same lines as those required for the allowance of food additives.

5. POTENTIAL TOXIC FACTORS IN NOVEL PROTEIN PRODUCTS

An important aspect in evaluating protein products is the possible potential toxicity, especially in the non-conventional food products. Governments and industry cannot permit themselves to start or to stimulate expensive nutrition projects with non-conventional food products from the categories 2.4., 2.5. and 2.6. without having done adequate toxicological studies beforehand.

The Central Institute for Nutrition and food Research TNO has gathered a lot of experience in this field concerning single cell proteins (6), particularly with Candida yeast proteins from gas-oil and n-paraffins. In the toxicological evaluation acute, sub-chronic and chronic studies with rats, mice, chickens, dogs and swine were performed. Cancerogenecity and reproduction were studied in long-term experiments.

After about 8 years of study and the investigation of several hundreds of samples of different batches it has become clear that good new protein products

can be manufactured. These products have to be used in animal feed stuffs, for it has been found that all single cell proteins have a rather high nucleic acid content which gives rise to an increase of uric acid levels in blood serum, if fed to human subjects in larger quantities. This being undesirable, elimination of part of the nucleic acids will be necessary.

An extensive description of the toxicological studies to be carried out in animals and human subjects is given in the afore mentioned guidelines (9).

Oser (11) too, gives some directives for the toxicological evaluation of novel food products, e.g. some advice on the number of animals to be used in chronic studies, observations to be made and the frequency of these various criteria. A scheme for a multigeneration test with regard to reproduction and lactation is also described.

Even when the toxicological studies with laboratory animals are satisfactory, there is still a lot of work to be done. If the product is mainly to be used in animal husbandry, efficiency studies are important. In chickens, hatchability and fertility studies are necessary, in other animals reproduction tests have to be carried out. If a product is also intended for human consumption further studies in human subjects are desirable. Biochemical criteria may give a clear insight into the metabolism of new products in comparison with the conventional ones.

6. MICROBIOLOGICAL CONDITIONS

The formation of a list of recommendations with regard to the microbiological standards to which all types of new products should come up, cannot be realized, while one for agricultural or fermented products has to be considered as quite impossible. The following requirements, which are identical to those recommended for conventional instant food, are proposed for the various industrial instant food products which are used without further culinary preparation (e.g. cooking, proper heating, etc.).

Table 6. Microbiological requirements for instant food protein products (10)

Total aerobic count per 1 g	<100.000
Total numbers of aerobic sporebearing bacteria per 1 g	virtually identical total aerobic counts
Total anaerobic count per 1 g	< 10.000
Differential enterobacteriogramme	
Salmonella, Edwardsiella, Arizona and Shigella per 25 g	not detectable
Escherichia coli per 10 g	not detectable
Enterobacteriaceae per 0.1 g	not detectable
Sulfite-reducing Clostridia per 1 g	< 100
Bacillus cereus per 1 g	< 100
Staphylococcus aureus per 1 g	not detectable
Lancefield group D streptococci per 1 g	< 100

7. CHEMICAL COMPOSITION

In assessing the nutritive value of a protein containing product it is necessary to know its overall composition and content of other nutrients. This is of special interest when the product is to be used as a main item of food in a diet (e.g. humanized milk for babies) or even is the sole source of food, as is often the case in weaning foods. The composition data may give indications concerning the raw material. The mineral content of a fish flour of whole fish is much higher than of a flour of fish fillets; the ash content of isolated fish protein (IFP) is even lower. Such figures are indications for further requirements as for instance the maximum flour content.

New products to be used for human consumption should have optimum nutrient levels (vitamins and trace elements).

In a project for the improvement of the protein nutrition of babies and infants calories are usually as important as proteins. The calories may be provided either by fats or carbohydrates. If fats are incorporated the industrial tendency is to make use of fats with a high percentage of saturated triglycerides. However, with the present knowledge of fat metabolism and the development of atherosclerosis, it is recommended to use fats with a rather high percentage of linoleic acid. In this respect attention must be drawn to the linoleic acid content of protein rich formulas for the feeding of babies. Butter fat as the sole

source of fat is unsuitable for this reason (14).

If weaning foods containing a high quantity of starch are used for baby and infant nutrition, the problem is how to provide sufficient calories in an acceptable amount of food. To this end an enzyme treatment may be applied which would hydrolyze the starch and make the product more soluble (1).

Another possibility is to make use of a new cooking process, called extrusion cooking (2). Before applying this technique with success careful study of process conditions will be necessary to avoid losses of protein nutritional value.

In case amino acids are used for the fortification of proteins, directives with regard to the purity of the amino acids should be given.

8. FUNCTIONAL EVALUATION

A variety of functions can be attributed to proteins. As far as is known, there is no relation between nutritional value and technological properties of a certain protein product. A new protein product being prepared for the purpose of better gelatination, emulsification, formation of foam or other special properties, should be evaluated in quite a different way. For these preparations the usual requirements for food additives are recommended.

9. NOMENCLATURE AND LABELLING

The nomenclature of novel products is mainly a problem of the Food Law Authorities with regard to honesty in trade and commerce and serves as a guarantee for the housewife. As a matter of fact a minced meat product of 100% meat is not the same as one being an imitation containing soya protein. Proper labelling may protect the consumers and the industry against undesired falsifications.

10. SUMMARY

A description is given of some basic principles for the scientific evaluation of new protein food products.

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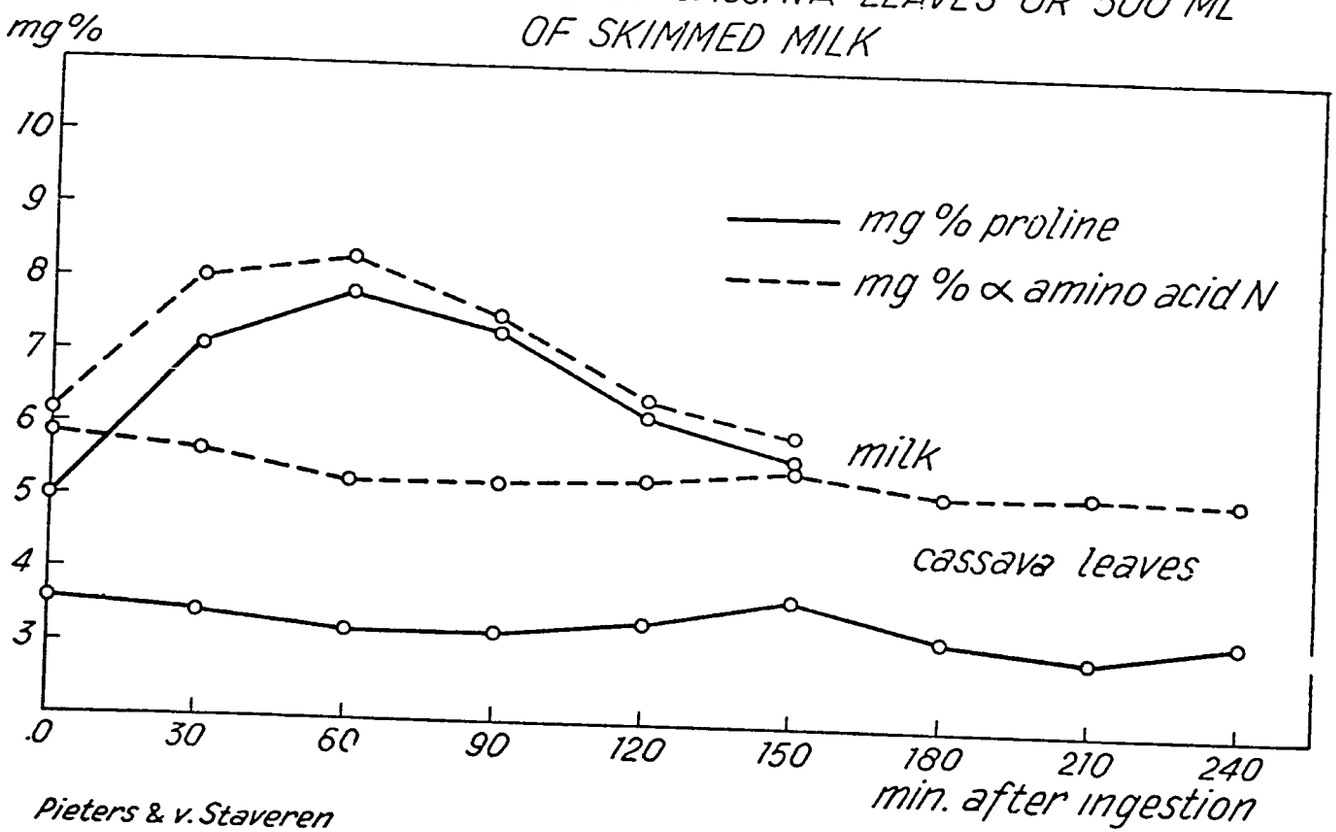
1. TOTAL AMINO ACID N AND PROLINE IN BLOOD SERUM AFTER INGESTION OF 500 G OF CASSAVA LEAVES OR 500 ML OF SKIMMED MILK



Pieters & v. Staveren
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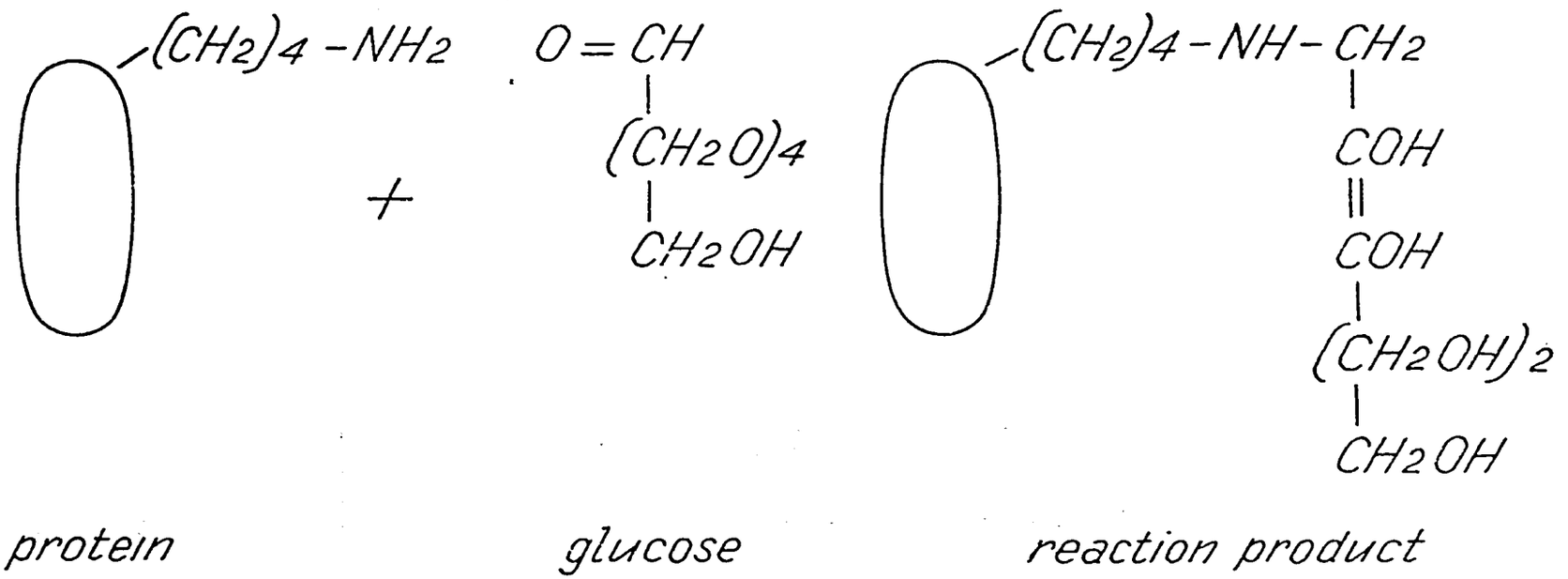
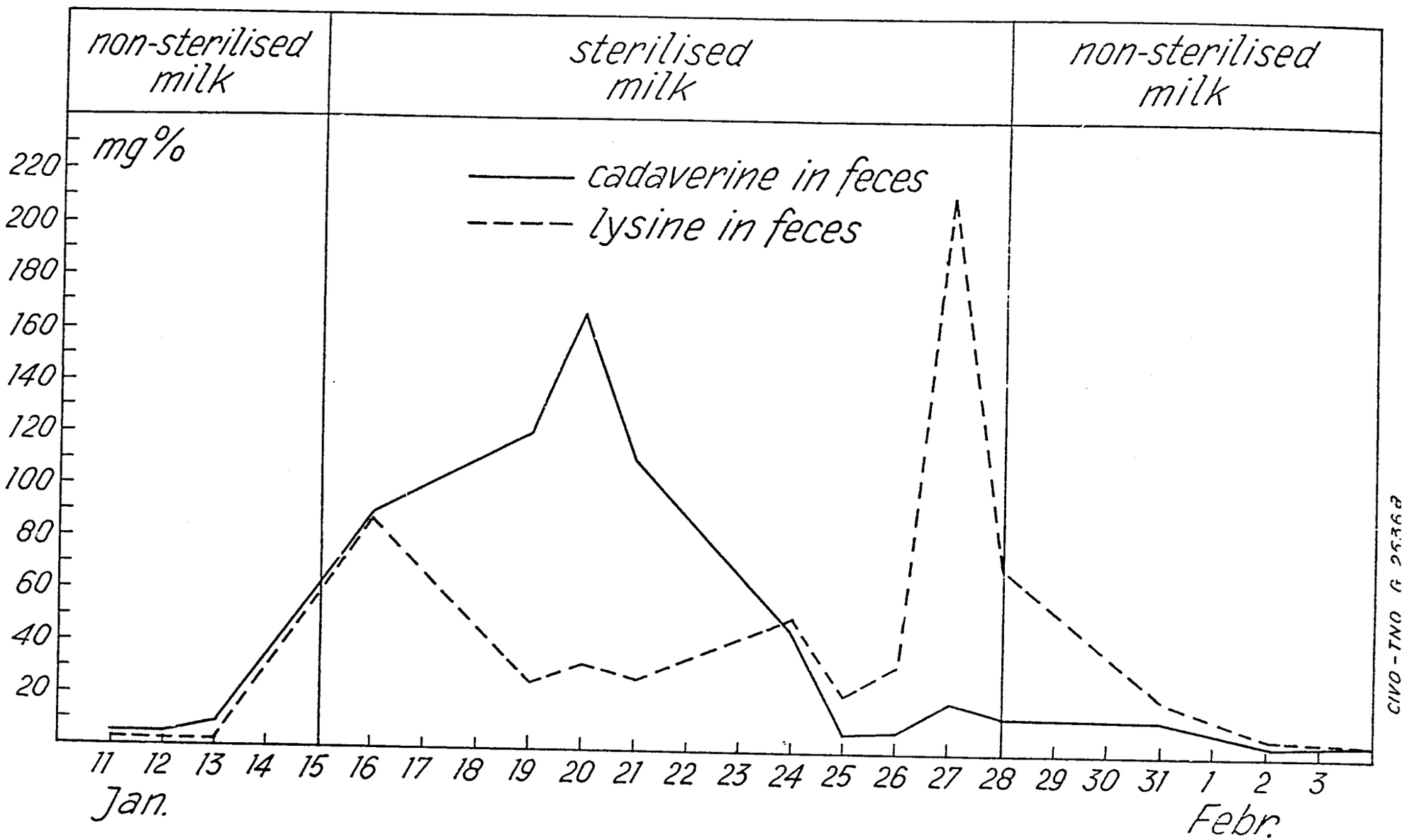
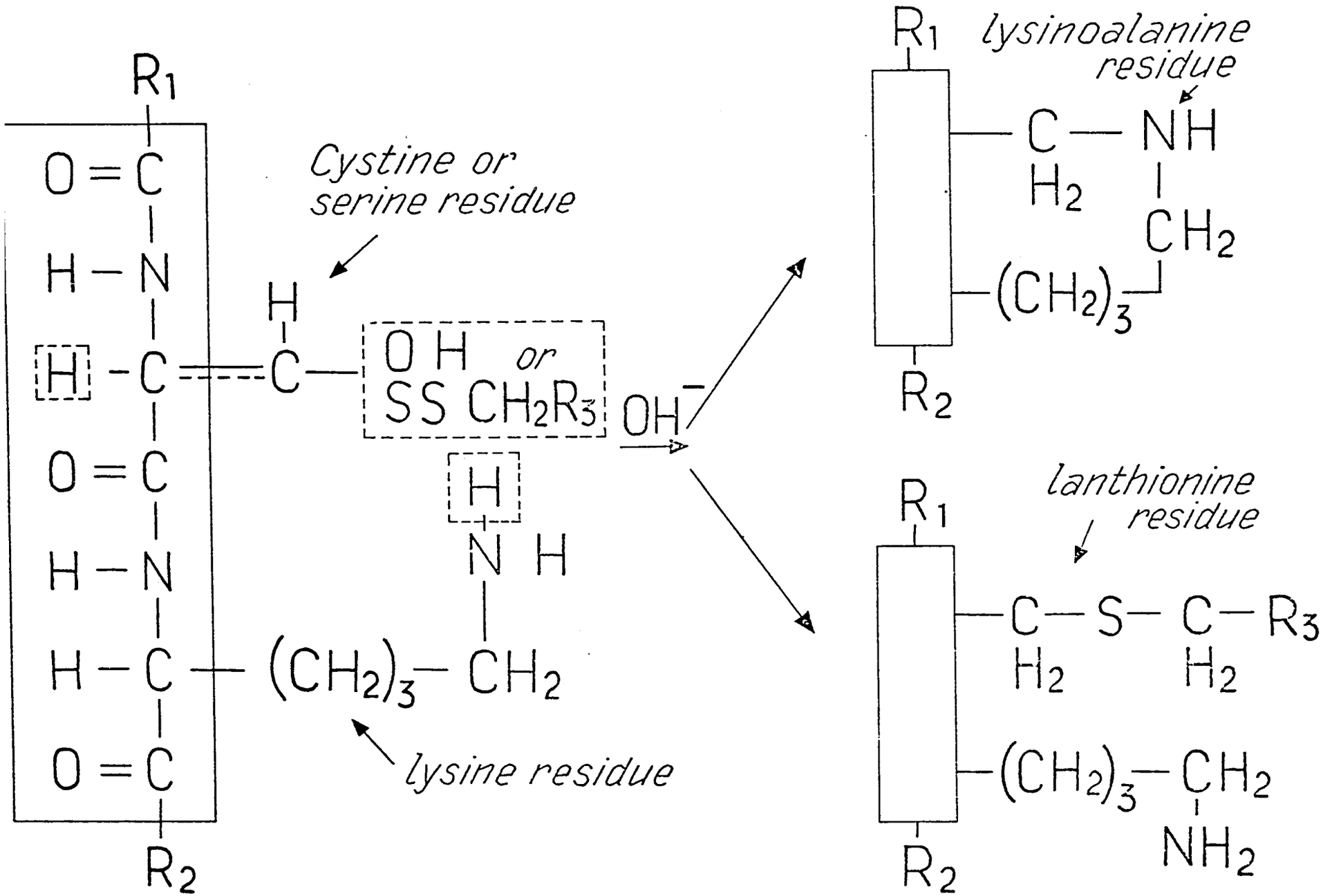


Fig. 2 Maillard reaction of proteins with glucose

CIVO - TNO G 2083

Fig. 3 LYSINE AND CADAVERINE PRODUCTION FROM HEATED AND NON-HEATED POOLED HUMAN MILK





1. Formation of lysinoalanine and lanthionine during alkaline treatment of proteins.

CIVO-TNO G 2615

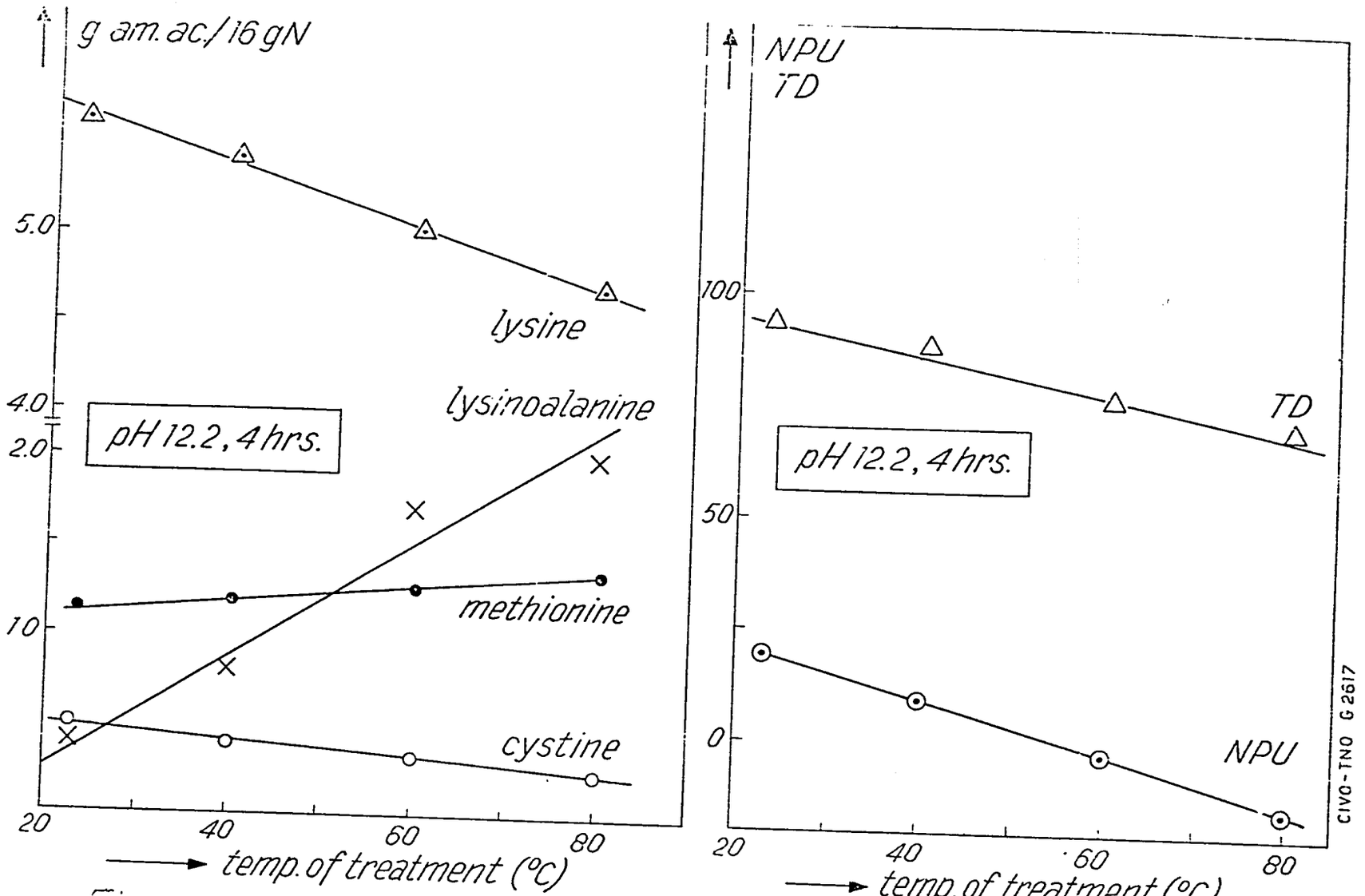


Fig. 5. Effect of temperature at alkaline treatment on amino acids and nutritive value of soy protein

September 1970

THE 800TH LIFE

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In a remarkable new book entitled, FUTURE SHOCK, the author, Alvin Toffler dramatically describes the significance and the sensitivity of the times in which we live.

> "It has been observed, for example, that if the last 50,000 years of man's existence were divided into lifetimes of approximately sixty-two years each, there have been about 800 such lifetimes. Of these 800, fully 650 were spent in caves. Only during the last 70 lifetimes has it been possible to communicate effectively from one lifetime to another - - as writing made it possible to do. Only during the last 6 lifetimes did masses of men ever see a printed word. Only during the last 4 has it been possible to measure time with any precision. Only in the last 2 has anyone anywhere used an electric motor. And the overwhelming majority of all the material goods we use in daily life today have been developed with the present, the 800th, lifetime."

How exciting to realize that in our lifetime we are seeing more creativity, more productivity, more genuis than in all other lifetimes put together! What a challenging, absorbing time in which to live our lives and that is really the subject of my talk - our lives - your's and mine.

Because no matter what else transpires in the world, no matter what anyone else is doing, in the final analysis the meaning of the 800th life is what we do with our own lives.

The past year has been rich in personal experiences for me. It has given me the incredible opportunity to visit school lunch programs almost a half a world apart. From the banks of the frozen Tannana River and the little Indian village of Minto, near the Arctic Circle in Alaska, to the native village of Santa Maria in the State of Santa Caterina in the vast cattle ranching area in the south of Brazil. These two communities are nearly 13,000 miles - more than half a world - apart, extremes in geography, different in language, in culture and in background and yet my single most predominent memory of these experiences would be of their likeness, not of their difference.

Whether we were stepping from our tiny chartered plane onto the frozen soil of Alaska, and being greeted by Ski-do's and excited upturned faces and wide brown eyes of Indian children in Minto, or whether we were stepping from a similar chartered plane onto the windy air strip on the high mountain-surrounded plateau of Santa Maria to look into more expectant upturned faces and wide brown eyes, the problems and the needs were the same. The problems were those of hungry children. The problems were those of mind and body. The problems were those of infusing fuel into the body to make possible an infusion of knowledge into the brain. Whether a teacher in Alaska or whether a teacher in Brazil, the faith in education was the same, the realization that only through the hard work of learning could children gain the magic key which would unlock them from the poverty and the privation of their tiny villages and release them into the vast world beyond.

In Alaska, in the south of Brazil, in the south of Chicago, or the north of Atlanta, the bodies and minds of children function alike. They must have food in order to learn.

One of the most memorable moments in these thousands of miles of travel came toward the end of a very long day in Santa Maria. After a full schedule of activities, we had attended a gala town reception in the evening to formally establish a new chapter of the Brazilian School Food Service Association. The meeting had had its sentimental moments for me when a children's choir sang "Brother John" to me in English; we finally adjourned at approximately 10 30 in the evening for cocktails and dinner. (The Brazilians seem never to sleep. I don't know how they do it, they are perhaps the most vigorous people I have ever known.) Finally, after dinner at an hour approaching midnight a gentleman from the dinner party approached me and asked me if, as one of the many toasts which would be given during the evening, I planned a toast to our Astronauts. As it happened this dinner party was being given during the month of November when the mission of Apollo 12 was actually underway and upon that very day our Astronauts were walking on the face of the moon. I had avoided like the plague any comment that might sound like bragging on behalf of the great colossus of the north and I replied that I had not planned to give such a toast. The Brazilians were fascinated by our space program and the gentleman was astonished by my reply. As a matter of fact he said, "Well, a toast to them simply must be given; if you will not give it, I will." Naturally, I did not want a Brazilian gentleman to stand in front of this group and say that

this idiot North Americano refuses to toast his own countrymen, so I replied, yes, under the circumstances, I would give such a toast. I had a few moments to collect my thoughts and to confer with my interpreter who was sitting at my side to make sure he understood the words I wished to use. When it came my turn I gave the following toast:

I said, first of all, "I toast the courage of my countrymen who walk upon the face of the moon tonight, and secondly, I toast the accumulated knowledge of mankind that has made this feat possible. Third, and most of all, I toast the concept of commitment. The fact that our nation and our people set a goal, determined to reach it, committed the resources and the willpower and the energy necessary to do the job, and did the job. Now, we in our nation have made a similiar commitment - that there shall be no hungry children in our country - we have the resources, we have the know-how and we have the determination - we are going to do this also.

Further, Brazil is a vast nation also with great resources and know-how and determination and I urge you to join with us in this commitment."

I might add in passing, that my interperter, who is a very mischievous rascal by the name of Renato Xavier, was absolutely fascinated with the word "commitment" and I am sure it has become a permanent part of his vocabulary. As we would walk down a village street in the evening and Renato would see some sweet young thing walking by, he would grin at me and say, "Ah, Dr. John, I think that is my commitment for tonight." I am inclined to think that Renato achieved a high degree of success in his commitments, perhaps primarily because he knew exactly to what he was committed.

I wonder if we in school food service are as clear in our commitment? I think we in school food service have accepted compromise, inadequacy and half-way measures. I think we have accepted the concept of hunger by degree. From its very inception in 1946 and for twenty-two years thereafter the school lunch program was based upon the concepts of nutrition by convenience and hunger by degree. We might refer to it as a spare rib psychology - we gave a youngster to stick to his ribs what the farmer could spare.

We had lived with hunger by degree so long that we grew to accept it. We testified to the House and Senate Agriculture Committees in terms of the amount of money we would need just to meet increased student enrollment from year to year - and consequently stand still; we testified in terms of the amount of money we would need to lower the price of a lunch by only a few pennies and thus bring a few more children than last year within the magic circle of American boys and girls who had food in their empty bellies. We continued to look backward, we continued to use as our frame of reference, as our measuring stick, that which had been done in the past and to applaud ourselves from any minimal improvement. To our shame, we accepted hunger by degree, perhaps because we ourselves had sufficient to eat.

And then came the most revolutionary development in school food service in a generation - not new technology, not a new administrative structure, not a scientific breakthrough, but a new voice, a new perspective, a new concern for the well-being of children - - a new Chairman of the House Education and Labor Committee. Congressman Carl Perkins of Kentucky was not looking back - - he was looking ahead. He did not ask

what we did last year, he asked rather what we were going to do this year. Hunger by degree is abhorrent to Carl Perkins; his message is loud and clear: there is to be no child in America who needs a lunch and does not receive it; there is to be no child who needs a breakfast and doesn't receive it; there is to be no hungry child in America.

The attitude of the Congress of the United States toward child feeding programs has changed dramatically and has changed rapidly to such a point that, in my judgement, most school administrators and even many school food service leaders have not caught up. We have now the finest opportunity since Chief Massasoit provided a good, hot lunch for the Plymouth settlers on Thanksgiving Day in 1621 to rid our land of hunger. We must not let such an opportunity slip through our hands.

In the 800th life of recorded human history, in this year of our Lord 1970, in this year of your life and mine, there is a new day for school food service. In the entire history of the school lunch program - - from 1946 to 1969 - - the total Federal contribution was approximately 3.5 billion dollars. In the present year of 1970 alone the Federal involvement in child feeding programs is just over 1 billion dollars for this one year.

There are other remarkable accomplishments that mark this as a new day in school food service. The breakfast program has come of age, is being recognized as perhaps the finest nutritional contribution ever made to the learning process and bulwarked by a 50 Million dollar grant. For the first time in history we have had the courage to say that matching funds for the Federal dollar shall not come alone from the nickels and dimes of the children, but also from State-matching funds. For the first

time in history we have had the courage to say - - as an official commitment by the national government of this nation - - that there shall be a school food service program available - - whether he wishes to use it or not - - to every child in this nation and in every school in our far-flung network of education for all. As a matter of priority, we have established a federal guideline for the provision of free or reduced price meals. Any child coming from a family of four with an income not exceeding $3720 per year is automatically eligible.

Enormous progress has been made and is being made, but by no stretch of the imagination may we consider the job done. We are still thinking in terms of hunger by degree; we are still circumscribing our vision of school food service to a world already a generation past. We must not permit an arbitrary figure of permissiveness to placate our concern for a child whose father earns $3725 per year and is thereby designated by law to be well-fed. In a world that is literally coming apart at the seams because of innovation, ingenuity and the determination to provide enough for all, we cannot permit our concept of feeding the hungry to be totally defined by one-half cup of this or two ounces of that, to be programmed exclusively in terms of 11:45 in the morning. The Type A lunch was never intended to be more than a basic minimum. It must no longer be permitted to act as a container which totally encompasses our thoughts. We must not be satisfied until we have met the dire needs and equisite opportunities of training parents, breakfasting infants, or nuturing oldsters.

Let us think and act and move in a manner befitting the world of the 800th life. Let us realize that we exist in times of such transience that unless we comprehend, compensate and change, the bewildering fracture of society around us can actually cause the mind to boggle. We become confused, maladjusted, disoriented from our surroundings and, consequently, unable to work effectively in evermore strange and foreign surroundings. The situation is similar to that experienced by a man who travels in a far country. Customs and mores are different, sights and sounds are different, language communication is impossible. The foreigner feels disembodied, cut-off from all that is familiar to him, and very possibly sustained only by the assurance that he will one day return to homeland, loved ones and those deep roots of recognition which give him security. In the kaleidoscopic world of the 70's there is no returning to safe norms and pleasant pastures and quiet shelters of familiarity and recognition. We travel a road with no turning; we play a game which has neither time-outs or out-of-bounds; we duel with an explosive weapon called "change" which has no safety catch.

Ninety percent of all scientists who ever lived are alive today. Not only are their creative and feasible ideas flooding society, but also the time lag between creativity and practical application has been cut in shreds as a result of today's instantaneous communicatior A century passed between the time Nicholas Appert discovered how to can food and the time canning became important in the food industry. Appliances introduced in the United States before 1920 - - the vacuum cleaner, the electric range and the refrigerator - - averaged 34 years - - a generation and a half - - between introduction and peak production. On the other hand, such recent appliances as the electric frying pan, television and washer-dryer combination span only eight years between introduction and peak production.

In no way is the acceleration of technological development more dramatically apparent than in the field of transportation. In the year 6,000 B.C. the fastest transporation available to man was the camel caravan averaging eight miles per hour. In 1600 B.C. - - 4400 years later - - the chariot raised the maximum speed to twenty miles per hour. In the 1880's - - about 3500 years later - - with an advanced steam locomotive, man finally reached 100 miles per hour, and now attainable speeds multiply continually with geometric progression. As a result, we have developed a society so transient that this factor alone causes reason to boggle and leads man to feel bewildered and floating directionless. In 1967, for example, 108 million Americans took 360 million trips involving an overnight stay of more than 100 miles from home. These trips accounted for 310 billion passenger miles in one year. These figures have a very personal meaning to me as I travel between 80,000 to 100,000 miles per year in pursuance of my own work.

Other examples have more direct bearing upon school food service. In 1850 only four cities on the face of the earth had a population of 1 million or more; today such cities are commonplace, with the urban population of the earth doubling every eleven years. We can never keep pace with that astonishing development without techniques that are innovative and equally astonishing. Fortunately, tools and resources are keeping pace with change if we will only keep pace with tools and resources. The Investor-Owned Electric and Power Company advises us for example that in the entire history of our country, we have used 18 Trillion killowatt hours of electricity and in the next ten years will use that amount all over again. Modern architecture has developed modular houses

to such a degree of perfection that the owner needs only a screwdriver to rearrange all interior walls to meet his wife's changing fancy (this is progress?) and almost completely modular public buildings have been developed for maximum flexibility. Such buildings are constructed around life-support columns containing plumbing, heating, air-conditioning and elevators. All other parts of the building are modular and can be arranged and rearranged like children's building blocks to meet variegated day-by-day needs.

Mr. U Thant, Secretary General of the United Nations observed at the Second World Food Congress in The Hague that resources no longer limit decisions. "Decisions now make resources - - this is perhaps the most revolutionary change that man has ever known." In the light of Mr. U Thant's dramatic proclamation that decisions now make resources it is time to stop thinking of a economy of scarcity; it is time to stop thinking in terms of hunger by degree. The impact of constant and ever-accelerating change of school food service is virtually immeasurable.

Clearly, if we are to be effective, if we are to meet the needs of this rapidly changing world around us, our thoughts must be modular and flexible. We must make optimum use of the constantly emerging resources around us.

Therefore, I am more convinced than ever that an economic means test for school food service is an economic absurdity, an administrative nightmare and a social disaster.

We shall never put an end to hunger by degree, we shall never rid the

financially-deprived child of the stigma of pauperism, we shall never become an intergal part of the educational system, we shall never develop sound programs of nutrition and nutrition education until we stop being the country store and become a part of the school house! We do not ascertain how much money dad earns before we determine whether to teach a child old arithmetic or new math; we do not inquire into a child's family background to determine whether or not to teach him American history; we do not explore social niceties and proper appearances (thank God!) before we teach a child to read - - we have free, public education available for all and provided by all. And yet at our own convention in Boston I saw a cash register exhibited with flags in the cash register window proclaiming for all to see such personal and humiliating information for any given child as "A. D. C.," "widowed mother," "no father." We must just as well flag the cash register to read, "poor trash," "down-on-their-luck family" or "bastard child." When I remonstrated with the exhibitor about this item of equipment, he replied that it concerned him also, that he tried his best to persuade the supervisor to buy windowless units that silently recorded each lunch or breakfast. The purchaser replied, "No, if I buy a cash register, I want one that looks like a cash register," and proceeded to buy six units with their vicious, tell-tale windows. Such practices in the public schools of a democratic nation are beyond comprehension; indeed they are barbaric!

Why then do we not provide needed food during the school day on the same basis as the remainder of the educational offering? Two reasons are customarily given.

1. We can't afford it.

2. It will ruin the moral fibre of the child.

First of all, we must admit very frankly that such a program will be expensive. We are talking about several billions of dollars. But in what better way could a wealthy nation spend a portion of its vast resources? Food is a top priority item in our family budgets, in our personal expenditures; food is the fuel on which all the balance of life moves and functions and becomes productive of more food and all other products as well. "Food First" should be the motto of any economic planner.

Second, before we become completely occupied with the costs of good nutrition, someone should make a thorough study of the cost of bad nutrition. Most of our best examples at the moment come from international experience with the Agency for International Development. For example, one report from AID states, "a typical worker of southeast Brazil will - - because of improved health and resulting increased average life expectancy - - produce nearly five times as much during his lifetime as the average born in nutritionally-deficient northeast Brazil." The Food and Agriculture organization reports that those countries with lowest per capita daily protein and calorie consumption are also those with lowest productivity. An interesting example was noted during the construction of the Pan American highway. Bodies of workers, weak from lack of proper nutrients, unconsciously protected themselves by avoiding the expenditure of energy. This resulted in apathy, lethargy and lack of initiative - - characteristics frequently attributed to laziness, indolence or other so called "ethnic traits." The disappointing work output of local laborers was quickly remedied with the introduction of three well-balanced daily meals.

Medical costs stemming from malnutrition far surpass the cost of adequate food. A study in Guatemala shows that the cost of 90 days of hospitalization for each

case arising from inadequate nutrition is $600, compared to an annual cost of $7 to $10 to prevent malnutrition in the first place.

But actually we do not need to go to international examples to observe the cost of NOT providing proper nutrition. According to Dr. Jean Mayer, Professor of Nutrition at Harvard and recently head of the White Conference on Food, Nutrition and Health, the United States is spending 60 Billion dollars per year on remedial health. This is just the cost of trying to get people well again after they have already become ill. In the length of time that the National school lunch program has been in existence, this figure has quadrupled, from 20 Billion dollars a year to 60 Billion dollars a year and has improved the health of our nation not one whit. We are still - - just as we were twenty years ago - - 37th in the world for life expectancy for men and 22nd in the world for life expectancy for women. Let us compare these staggering costs of illness with our investment in good health through good nutrition. True, the Federal contribution to the various child feeding programs for the current year is over a Billion dollars, an enormous improvement but still a drop in the bucket compared to what is going down the drain in medical costs. With a universal food service program in the schools of our nation, millions and indeed billions could be subtracted from medical costs by relatively slight additions to our national grocery bill. What a pleasant change this would be

Let us now turn to the second excuse which is commonly given for clinging to the outmoded concept of hunger by degree. We are told that to provide a child such food

as he needs during the school day would attack his moral fibre.

Nearly 10 Billion dollars are expended annually by the Federal government in one form of subsidy or another. We somehow do not worry about the moral fibre of the sheep rancher as a result of the National Wool Act, or the syndicated wheat producer because of the Wheat Agreement, or the sugar beet farmer because of the Sugar Act. Our sleep is untroubled by concern for the moral fibre of the shipping magnate or the airline president. We seem not even to worry about the possibility of socializing the President of the Savings and Loan Association, although all of these activities are heavily subsidized by the government. How absurd to defend on these flimsy grounds the neglect of our children who are here, hungry and helpless through no fault of their own.

The Billion dollar involvement of the Federal government this year in child feeding programs is extremely important but we must not be complacent or be willing to continue to live with the concept of hunger by degree.

Financial inertia has been overcome. There is a basic rule in physics as follows:

> Any mass has inertia. This inertia resists any change in its present state of motion. To affect change it is necessary to introduce an outside force. A body of mass, moving at any speed, requires this force to alter the inertia contained within it.

FORCE = MASS X ACCELERATION

A force has been provided in school food servic which has overcome the inertia of the mass; the rate of acceleration is in our hands.

On a recent Sunday afternoon I watched the rerun of an old movie on television; It was the story of the life and music of Sigmund Romberg. Mr. Romberg closed his long and prolific career (at least in the film) with the song, "When I Grow Too Old To Dream." I had heard the lyrics of that song hundreds of times before and they had held no particular significance for me. But on this occasion (could it be because I was nearing a birthday?) the words really carried a meaning to me. I realized as never before that I was middle-aged and that I really was too old to dream; that is to say, too old to dream fantasies but NOT too old to dream realities. I realized that I was not going to be President of the United States nor a tycoon of industry nor Ambassador to the Court of St. James. I shall not don pith helmet and walking stick to hunt the tiger in India, but I have just helped feed a hungry child there; it is unlikely that I shall write the great American novel, but I may write a word that increases public comprehension and hastens the end of that stalking beast called malnutrition.

What would you have your life be, just in case you too have reached the stage of dreaming realities rather than fantasies? Would you see yourself an instrument of health and well-being for children? Would you see yourself working with people or as a social analyst or as an educational pioneer of your day? You can be any or all of these by creatively dreaming the realities of school food service, by keeping always before you the realization that you serve people, not food. All of this is within your reach TODAY, this exciting day.

The author of these closing words is unknown:

He was going to be all that a mortal could be - - tomorrow.

None would be kinder or braver than he - - tomorrow.

A friend who was troubled and weary, he knew,

On him he would call and see what he could do - - tomorrow.

He thought of the folks he would fill with delight - - tomorrow.

Each morning he stacked up the letters he'd write - - tomorrow.

But as time fled by, from day to day, he hadn't one minute

to stop on his way.

More time I will have to give to others - - tomorrow.

But the fact is, he died and faded from view,

And all that he left when living was through,

Was a mountain of things he intended to do - - tomorrow.

Make your lifetime - - this incredibly exciting 800th lifetime - - a life of DO IT TODAY - - NOT TOMORROW.

PREPARATION OF CHEESE-LIKE SOYBEAN PROTEIN FOOD BY ENZYMATIC TREATMENT

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I. INTRODUCTION

Fermentation foods made from soybeans have long history in Asian countries and many countries, therefore, have their own soybean foods, Chinese soybean cheese in China and tempeh in Indonesia, for example. Especially in Japan, a variety of fermented soybean food have been developed and such foods as miso, shoyu and natto are still essential food for her people.

Soybean protein has the highest nutritive value among vegetable proteins (7, 10). It contains high tryptophane, lysine and threonine which are said to be essential for children's growth. Soybean protein is therefore, well comparable to the proteins of such ideal foods as milk and egg, except for low methionine content. It is well known that soybean is hard to digest as bean itself (1, 8). Because of this poor digestibility, soybean products as mentioned above are prepared by the extraction or isolation of protein, or by fermentation.

In recent years, scientific studies have been made of these traditional foods and also to develop a new fermented food from soybeans. Wai (11, 12) reported the manufacturing method of Chinese soybean cheese by using sodium chloride and a large volume of alcohol. Hesseltine (5, 6) isolated the mold *Rhizopus oligosporus* which produces protease and lipase, but not carbohydrase, from Indonesian tempeh. Applying this mold, he produced a palatable tempeh-like food from the mixture of soybean and other starch materials. Very recently, Hang and Jackson (3, 4) made a soybean cheese from soymilk by the process of addition of lactic starter (*Streptococcus thermophilus*), protein coagulation, draining of whey, and aging.

The authors planned to develop a easy digestible and cheap fermentation food with good flavor, texture-body, and superior keeping quality from soymilk.

Many trials have been made to produce a cheese-like food from soymilk by the usual process of cheese making from cow milk. But the products were not acceptable.

New idea of using protease in the process was successfully applied. The points are as follows:

(1) Use of salt agglutinants instead of rennet to make curd.

(2) Aging mainly by an added protease to shorten the aging time.

(3) Addition of a lactic starter to help aging by the protease and to improve flavor.

The manufacturing procedure of cheese-like soybean protein food was established after repeating preliminary preparations. The procedure is shown in Fig. 1 and Fig. 2. The process consists of two parts. The part 1 is making soymilk from soybeans, protein coagulation (making curd) by a salt agglutinant, washing and pressing the curd to remove carbohydrates and other water soluble components (Fig. 1). The part 2 is the addition of a protease and a lactic starter to the curd, mixing, molding, paraffin coating, and aging at 17±1°C (Fig. 2).

Though the edible products were produced by the procedure, further improvement of the quality was required. The purpose of the present study is to investigate the optimum condition of each step in the procedure to manufacture a excellent cheese-like soybean protein food.

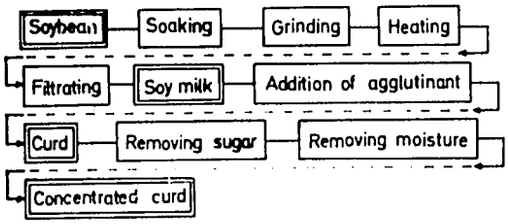


Fig. 1. Flow sheet of making concentrated soybean curd

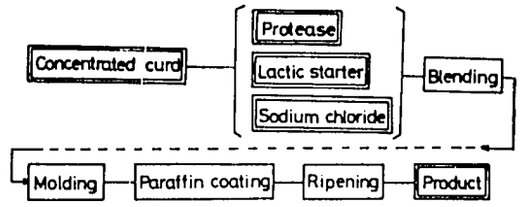


Fig. 2. Flow sheet of preparation of cheese-like soybean protein food

II. OPTIMUM CONDITION FOR EXTRACTING SOYMILK

Experiments were carried out to find out the most efficient and economical conditions for extracting soymilk from soybean with high protein and solids yields.

The important factors affecting upon the extraction were soaking temperature of soybean, soaking time, the amount of water added, and heating time. But in the course of these experiments the soaking temperature was fixed at 20°C.

EXPERIMENTAL

1) Sample

Hawkeye soybean produced in the United States was used. Its composition is as follows:

Moisture:	11.05%
Crude protein:	30.80%
Crude fat:	20.29%
Ash:	4.37%

2) Extraction method

Fifty grams of the soybean was soaked at 20°C, ground by a home mixer for 1 minute, and then heated to boiling. Soymilk was separated from the heated ground mixture by centrifuge for 5 minutes at 4,000 r.p.m.

a. Soaking time: At 20°C, 6, 10 and 15 hours of soaking were tested.

b. Amount of water added: Considering the absorption during soaking and evaporation during heating, 6, 8, 10 and 15 times of water in respect with dry soybean weight were used.

c. Heating time: The ground mixture was heated to boiling and then kept at that temperature for 0, 2 and 10 minutes.

3) Analyses of the soymilk

Following analyses were made on the extracted soymilk.

a. Solids: Drying method at 105°C.

b. Protein: The micro-Kjeldahl method. Nitrogen factor of 5.71 was used.

c. Viscosity: By the Ostwald's viscometer at 25°C.

RESULTS AND DISCUSSION

The results are shown in Table 1, 2 and 3, and Fig. 3, 4 and 5. From the data, the optimum conditions for extracting soymilk from the soybean soaked at 20°C were concluded as follows: soaking time was 15 hours; the amount of water added was 10 times in weight of the dry soybean; and heating time was 2 minutes holding at boiling temperature.

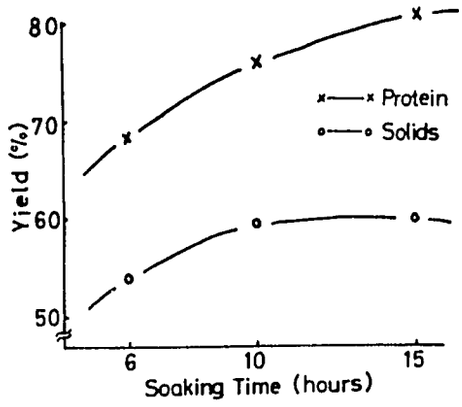


Fig. 3 Effect of soaking time on the yield of solids and protein in soymilk with 10 times of water and 2 minutes heating

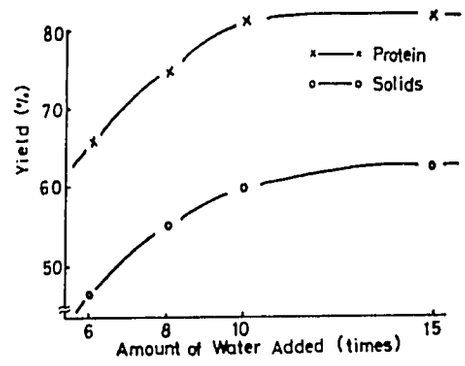


Fig. 4 Effect of the amount of water added on the yield of solids and protein in soymilk of 15 hours soaking, and 2 minutes heating

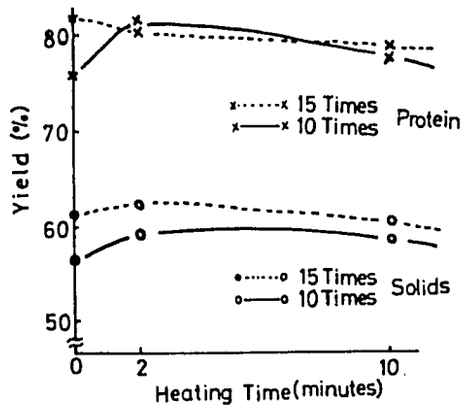


Fig. 5 Effect of heating time on the yield of solids and protein in soymilk of 15 hours soaking, and 10 and 15 times of water added

III. SELECTION OF AGGLUTINANT AND ITS CONCENTRATION

In the preparation of concentrated curd from the soymilk, the selection of an agglutinant important. The texture, taste and yield of the curd are affected by the kind of agglutinant use

Table 1. Effect of the amount of water added and heating time on 6 hours of soaking

The amount of water added	Heating time (min.)	Yield (g)	Solids (%)	Solids yield (%)	Protein (%)	Protein yeild (%)	Viscosity (cp)
6 times	0	233.7	8.29	43.56	3.74	56.76	3.61
	2	216.3	8.72	42.40	3.80	53.37	4.31
	10	22[illegible].7	8.08	41.36	3.51	51.90	5.25
8 times	0	332.3	7.04	52.59	3.28	70.78	2.08
	2	330.2	7.15	53.08	3.26	69.90	2.92
	10	332.0	6.62	49.41	3.03	65.32	3.00
10 times	0	415.3	5.11	47.71	2.32	62.56	1.71
	2	428.2	5.53	53.24	2.45	68.12	1.88
	10	448.1	5.30	53.39	2.38	69.25	2.70
15 times	0	655.2	3.94	58.04	1.67	71.06	1.25
	2	655.8	3.77	55.58	1.65	70.26	1.32
	10	655.3	3.88	57.16	1.66	70.64	1.33

Table 2. Effect of the amount of water added and heating time on 10 hours of soaking

The amount of water added	Heating time (min.)	Yield (g)	Solids (%)	Solids yield (%)	Protein (%)	Protein yield (%)	Viscosity (cp)
6 times	0	215.4	8.85	42.86	3.98	55.67	2.90
	2	231.5	8.88	46.22	4.12	61.93	2.93
	10	211.4	8.42	39.54	3.95	54.22	4.04
8 times	0	328.0	7.18	52.95	3.27	69.65	2.53
	2	330.6	6.92	51.43	3.13	67.19	2.50
	10	327.7	6.91	50.91	3.16	67.24	2.29
10 times	0	424.8	6.13	58.54	2.87	79.17	1.82
	2	434.4	6.08	59.38	2.72	76.73	1.84
	10	437.6	5.81	57.16	2.63	74.73	1.96
15 times	0	656.5	4.10	60.51	1.81	77.16	1.30
	2	662.7	4.18	62.28	1.79	77.03	1.35
	10	643.2	4.30	62.18	1.89	78.94	1.49

Table 3. Effect of the amount of water added and heating time on 15 hours of soaking

The amount of water added	Heating time (min.)	Yield (g)	Solids (%)	Solids yield (%)	Protein (%)	Protein yield (%)	Viscosity (cp)
6 times	0	222.8	9.17	45.93	4.52	65.39	2.57
	2	221.9	9.29	46.35	4.58	65.99	3.57
	10	218.4	8.59	42.18	3.98	56.44	4.70
8 times	0	351.6	6.86	54.23	3.33	76.03	2.47
	2	344.3	7.10	54.96	3.35	74.90	2.58
	10	344.4	6.87	53.19	3.23	72.23	2.78
10 times	0	425.2	5.94	56.78	2.77	76.48	1.75
	2	448.7	5.89	59.42	2.78	81.00	1.73
	10	434.2	5.96	58.18	2.78	78.38	1.87
15 times	0	640.5	4.28	61.63	1.96	81.52	1.40
	2	654.9	4.23	62.28	1.90	80.80	1.42
	10	665.9	4.05	60.63	1.82	78.70	1.50

its concentration and coagulation temperature. Investigations were made to select the most suitable one from four agglutinants, calcium sulfate, calcium chloride and gluconic acid (used in tofu production), and hydrochloric acid.

EXPERIMENTAL

1) Preparation of soymilk

Soymilk extraction was made according to the method described in Chapter II under optimum conditions (15 hours soaking at 20°C, 10 times of water added, kept for 2 minutes at boiling temperature).

2) Preparation of curd

An agglutinant was added into a 50 ml polyethylene centrifugal tube, and then 50 g of hot soymilk was poured into the tube with stirring. The mixed solution was kept for 30 minutes in a constant temperature bath to coagulate the proteins. The coagulation was cut by spatula, and centrifuged for 10 minutes at 2,000 r.p.m. Curd was obtained as the precipitate.

3) Selection of the best agglutinant

Agglutinants and their concentration used in the experiments are shown in Table 4.

Table 4. Kinds of agglutinant and their concentrations

Kinds of agglutinant	Agglutinant concentrations (N) used				
Calcium sulfate	0.025	0.05	0.035	0.04	0.05
Calcium chloride	0.008	0.01	0.015	0.02	
Hydrochloric acid	0.0075	0.0095	0.0115	0.0135	
Gluconic acid	0.006	0.008	0.012	0.016	

4) Optimum temperature of making curd

In order to find the optimum temperature for coagulation, experiments were carried out at 4 different temperatures, 50, 60, 70 and 80°C. The soymilk was heated to 5°C higher than respective experimental temperature before pouring into centrifugal tubes.

5) Analytical methods of the curd

a. Solids: Drying menhod at 105°C.

b. Crude protein: The micro-Kjeldahl method; nitrogen factor: 5.71.

c. Hardness: The Curd Meter obtained from Iio Electric Co. was used. Its raising rate is 1 inch/7 seconds. The diameter of curd knife (contact surface) is 8 mm. Hardness is expressed as grams when the surface of the curd is just broken by the curd knife.

d. Transparency of supernatant: Transmittancy of the supernatant was measured at 440 mμ with 3.5 mm quartz cell by Hitachi Perkn-Elmer UV-Vis Spectrophotometer.

RESULTS AND DISCUSSION

The results are shown in Fig. 6, 7, 8 and 9, and in Table 5, 6, 7 and 8.

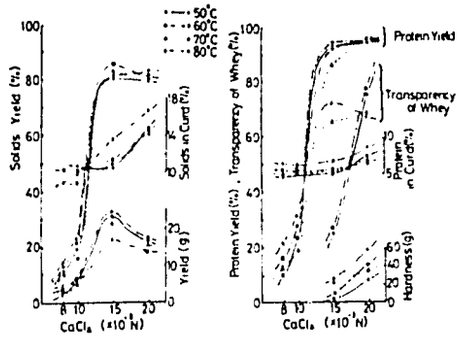


Fig. 6 Effect of calcium chloride on making curd

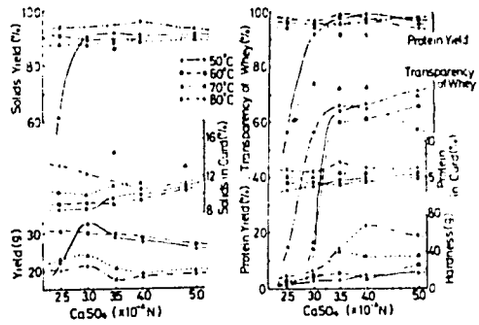


Fig. 7 Effect of calcium sulfate on making curd

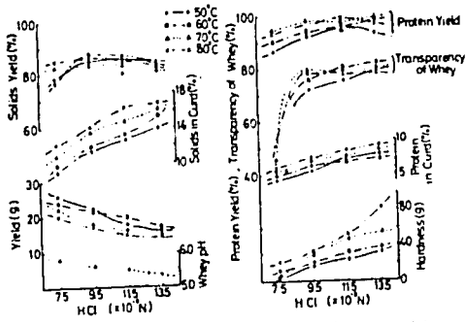


Fig. 8 Effect of hydrochloric acid on making curd

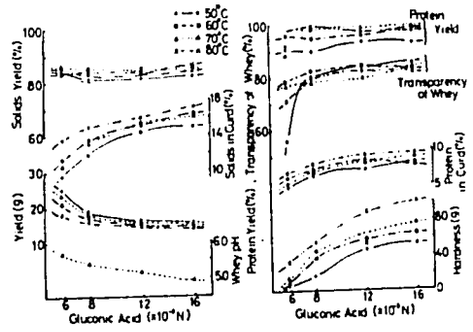


Fig. 9 Effect of gluconic acid on making curd

Table 5. Effect of calcium chloride on making curd

Coagulating temperature	Concent. (N)	Yield of curd (g)	Solids (%)	Solids yield (%)	Protein (%)	Protein yield (%)	Transparency of whey (%)	Hardness of curd (g)
50°C	0.008	2.7	12.35	10.81	4.93	10.00	0	—
	0.01	5.5	10.72	19.24	5.72	23.78	0	—
	0.015	23.3	10.55	80.28	5.25	92.57	25.2	5.5
	0.02	16.3	14.91	79.45	7.65	94.44	73.5	26.3
60°C	0.008	3.7	10.30	12.53	5.60	15.78	0	—
	0.01	6.6	10.25	22.27	5.57	28.02	0	—
	0.015	24.4	11.29	84.98	5.61	93.22	26.7	10.5
	0.02	16.9	14.66	81.15	6.81	94.99	77.8	42.3
70°C	0.008	2.8	10.91	10.69	5.33	11.53	0	—
	0.01	4.8	8.97	15.21	5.25	19.67	0	—
	0.015	21.2	11.13	82.62	5.28	86.59	66.0	23.3
	0.02	15.9	14.24	80.22	7.55	93.97	69.5	37.3
80°C	0.008	4.3	8.97	13.66	6.44	21.68	0	—
	0.01	6.4	9.95	22.35	6.23	30.92	0	—
	0.015	17.0	13.62	81.65	6.97	92.31	72.0	27.4
	0.02	13.7	16.69	83.94	8.87	94.41	68.0	58.4

Table 6. Effect of calcium sulfate on making curd

Coagulating temperature	Concent. (N)	Yield of curd (g)	Solids (%)	Solids yield (%)	Protein (%)	Protein yield (%)	Transparency of whey (%)	Hardness of curd (g)
50°C	0.025	22.5	8.63	62.19	3.45	55.69	0	5.4
	0.03	32.[illegible]	8.63	90.59	3.90	91.71	14.2	8.1
	0.035	29.3	9.75	91.37	4.58	96.15	64.8	8.6
	0.04	27.8	10.17	90.60	4.95	98.79	67.4	13.5
	0.05	25.7	11.01	90.95	5.22	96.59	71.8	16.1
60°C	0.025	30.6	9.28	90.75	4.38	95.94	0	6.0
	0.03	30.3	9.21	89.29	4.38	95.12	16.0	13.9
	0.035	29.5	9.11	86.05	4.29	90.78	60.0	16.2
	0.04	28.9	9.77	90.45	4.62	95.82	61.9	13.4
	0.05	26.4	10.70	90.49	5.15	97.57	65.3	25.1
70°C	0.025	23.0	10.44	87.13	5.13	93.72	0	7.6
	0.03	24.0	10.12	87.76	4.95	93.97	74.4	12.0
	0.035	20.6	11.29	89.59	5.71	94.47	72.0	40.8
	0.04	19.3	11.43	88.86	5.64	95.98	73.7	35.0
	0.05	19.9	13.20	89.69	5.60	96.46	69.0	35.7
80°C	0.025	20.4	13.38	83.41	6.04	97.33	14.2	13.0
	0.03	21.3	12.36	90.23	5.65	95.21	56.5	18.0
	0.035	17.4	14.74	88.66	7.09	98.44	66.3	41.7
	0.04	18.4	10.81	96.32	6.29	91.32	65.0	68.3
	0.05	18.6	11.30	92.51	6.27	93.17	57.1	57.0

Table 7. Effect of hydrochloric acid on making curd

Coagulating temperature	Concent. (N)	Yield of curd (g)	Solids (%)	Solids yield (%)	Protein (%)	Protein yield (%)	Trans-parency of whey (%)	Hardness of curd (g)	pH of whey
50°C	0.0075	25.8	9.02	78.46	4.16	86.25	0	4.0	5.83
	0.0095	22.2	11.40	84.80	5.49	92.07	72.8	16.9	5.60
	0.0115	17.7	12.67	80.09	7.19	96.31	76.2	22.9	5.51
	0.0135	15.7	13.69	83.62	7.51	93.02	79.9	33.4	5.30
60°C	0.0075	23.9	9.81	78.27	4.74	90.14	0	10.0	5.82
	0.0095	22.0	11.90	86.42	6.13	93.73	75.5	20.1	5.60
	0.0115	19.7	13.27	85.83	6.82	94.86	80.9	32.0	5.55
	0.0135	16.5	15.17	83.03	7.34	98.68	82.6	36.4	5.33
70°C	0.0075	22.4	10.95	82.78	5.51	93.97	46.2	5.5	5.74
	0.0095	17.8	13.61	83.50	7.03	97.30	78.8	30.0	5.58
	0.0115	16.2	14.77	83.11	7.65	97.10	79.9	48.0	5.41
	0.0135	14.8	15.96	81.62	8.58	98.99	80.0	53.0	5.28
80°C	0.0075	20.3	12.02	84.22	5.93	93.73	51.0	20.8	5.70
	0.0095	17.7	14.03	85.31	7.24	92.39	78.1	32.6	5.52
	0.0115	15.0	16.28	84.42	8.45	98.84	77.9	51.5	5.40
	0.0135	14.5	16.61	82.68	9.08	96.20	78.0	83.0	5.30

Table 8. Effect of gluconic acid on making curd

Coagulating temperature	Concent. (N)	Yield of curd (g)	Solids (%)	Solids yield (%)	Protein (%)	Protein yield (%)	Transparency of whey (%)	Hardness of curd (g)	pH of whey
50°C	0.006	25.0	9.49	84.83	4.70	90.65	57.0	4.3	5.72
	0.008	18.8	12.03	81.16	6.17	89.81	79.8	15.4	5.45
	0.012	16.3	14.51	81.53	7.01	93.40	84.0	44.1	5.20
	0.016	15.2	15.16	82.82	7.91	93.24	85.3	51.3	4.93
60°C	0.006	21.0	11.29	84.77	5.90	95.59	78.2	9.3	5.62
	0.008	17.4	13.56	84.58	6.99	94.08	82.1	36.5	5.40
	0.012	15.4	15.25	84.18	8.13	96.83	84.2	56.4	5.16
	0.016	14.6	16.42	85.58	7.88	98.94	82.4	63.0	4.93
70°C	0.006	23.3	10.64	85.59	4.78	88.61	77.7	11.0	5.70
	0.008	18.5	13.40	84.92	6.76	98.72	78.8	41.4	5.42
	0.012	15.8	15.46	84.15	7.84	98.35	79.8	54.3	5.17
	0.016	15.2	16.15	84.66	8.75	98.98	84.0	75.0	4.91
80°C	0.006	18.1	13.66	85.24	6.48	93.99	71.6	32.6	5.65
	0.008	16.1	15.09	83.76	7.72	98.77	79.3	53.2	5.40
	0.012	15.2	16.09	84.27	9.04	96.02	83.0	86.7	5.12
	0.016	14.1	17.22	83.71	9.27	98.29	82.1	99.2	4.90

Considering the yields of solids and protein, the optimum concentration of each agglutinant was decided as follows:

$CaCl_2$ .....15×10^{-3}N

$CaSO_4$.....3.5—4.0×10^{-2}N

HCl.....9.5—11.5×10^{-3}N

Gluconic acid .....8—10×10^{-3}N

Optimum temperature was found as 70°C in all agglutinants. This temperature well agrees with the coagulation temperature 70—75°C used in tofu making. With increasing the concentration of the agglutinant and the coagulation temperature, protein yield became higher, and sometimes it reached to as high as 95%. High protein yield, on the other hand, caused poor water binding capacity of the resulted curd. But this tendency is closely related to the kind of agglutinant used. Calcium sulfate produced the curd with relatively high water binding capacity, while hydrochloric acid and gluconic acid formed the curd with less water binding capacity.

When the hardness was below 40 g, the curd was soft, with smooth texture, and showed relatively high water binding capacity. In general, increasing temperature and the concentration of agglutinant produced hard curd. Especially hard curd having coarse texture was obtained with acidic agglutinants.

The transparency of the supernatant solution is a good index of the solid content of the solution. Low transparency indicates high solid content in the supernatant solution, in other words low protein yield, as can be seen in Tables and Figures. The transparency expressed as transmittancy is desirable over 70%. The value of 80% was obtained with acidic agglutinants, and the yield of protein was the best of all.

Calcium sulfate produced the curd of high water binding capacity, soft and smooth texture, and good taste. With this agglutinant, only little changes were observed with the change in

concentration. While other agglutinants produced hard curd at high concentrations. Acidic agglutinants precipitated the curd with undesirable taste and poor texture.

The curd which has small water binding capacity, firm and smooth texture, and good flavor is ideal to produce the products with good keeping quality. But any curd made in this experiment did not satisfy these requirements completely. Calcium sulfate, 0.03--0.04N in the soymilk, however, precipitated fairly good curd at 70°C. The yield of solids with calcium sulfate was the highest among all the agglutinants. In addition the change in yield and other changes were little affected by the concentration of the agglutinant. Calcium sulfate, therefore, is the most suitable agglutinant for the preparation of cheese-like soybean protein food. Calcium chloride is the second best agglutinant.

Nutritionally salt agglutinants are desirable because they can supply Ca^{++} to growing children who need more Ca^{++}. But the curd produced by calcium sulfate had rather high water binding capacity, and some difficulties were experienced to remove water at the dehydration process.

IV. SELECTION OF PROTEOLYTIC ENZYME FOR THE PREPARATION OF CHEESE-LIKE SOYBEAN PROTEIN FOOD

1. Comparison of the activities of 5 proteases against soybean proteins

It is considered that the most important point in processing cheese-like soybean protein food is the selection of proteolytic enzyme to digest soybean proteins. In this study, proteolytic activities of 5 obtainable proteases against soybean proteins were investigated in vitro to examine their suitability to cheese-like food making.

EXPERIMENTAL

Five proteases of different origin; animal, plant, mold, bacteria and actinomycete were used in this experiment (Table 9). Table 10 shows their enzyme unit which was determined by the modified Anson's method at their optimum pH.

Table 9. Enzyme used

Enzyme	Origin
Trypsin (Merk, Chem. grade)	The pancreas
Papain (Nagase Sangyo Co.)	Papaya
Molsin (Seishin Chem. Co.)	*Asp. saitoi* (Contains α-, β-amylase and cellulase)
Bioprase (Nagase Sangyo Co.)	*Bacl. subtilis var Biotecus*
Pronase (Kaken Chem. Co.)	*Streptomyces griseus*

Table 10. Optimum pH and znzyme units of selected proteases

	Trypsin	Papain	Molsin	Bioprase	Pronase
Optimum pH	7.71	5.33*	2.70	7.48	7.38
Enzyme unit PU/g	19.3×10^3	94.7×10^3	76.6×10^3	1225×10^3	457×10^3

* Optimum pH of papain is 5.0, but to prevent casein precipitation, pH 5.33 was used.

Enzyme solution was adjusted to 4 PU/ml. Casein (casein nach Hammersten), unheated soybean protein (defatted, acid precipitated and freeze dried) and heated soybean protein (heated at 110°C for 20 minutes) were used as substrates. The proteolytic activities were determined by the method shown in Fig. 10. Enzyme-substrate reaction was carried out at pH 6.0 for 3, 7, 12 and 24 hours at 25°C. The concentration of substrate solution was 0.6%.

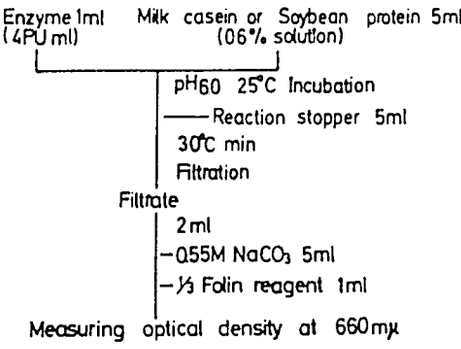


Fig. 10 Experimental method

RESULTS AND DISCUSSION

Table 11 shows the results of measurement of optical densities at 660 mμ. Molsin showed very low proteolytic activity against casein and soybean protein at pH 6.0. Trypsin hardly acted upon both unheated and heated soybean proteins. Bioprase, Pronase and papain showed higher activity than other two enzymes.

Table 11. Comparison of the activities of proteases against casein and soybean proteins

Enzyme	Substrates	Reaction time (hours)			
		3	7	12	24
Trypsin	Casein	0.294	0.498	0.634	0.852
	Unheated soybean proteins	0.004	0.024	0.036	0.044
	Heated soybean proteins	0.016	0.036	0.038	0.044
Papain	Casein	0.506	0.818	0.930	0.930
	Unheated soybean proteins	0.110	0.146	0.168	0.236
	Heated soybean proteins	0.142	0.242	0.222	0.266
Molsin	Casein	0.118	0.208	0.290	0.362
	Unheated soybean proteins	0.042	0.068	0.100	0.128
	Heated soybean proteins	0.038	0.078	0.074	0.098
Bioprase	Casein	0.402	0.666	0.897	1.194
	Unheated soybean proteins	0.120	0.180	0.268	0.328
	Heated soybean proteins	0.224	0.402	0.498	0.622
Pronase	Casein	0.261	0.414	0.566	0.867
	Unheated soybean proteins	0.032	0.096	0.126	0.228
	Heated soybean proteins	0.124	0.274	0.314	0.406

2. Preparation of cheese-like soybean protein food using enzymes

In the experiment of Section 1, the digestion ability of each enzyme on soybean protein was compared in dilute solution. However, in practical manufacturing of cheese-like food, a highly concentrated soybean protein substrate, about 60% moisture, is to be digested by enzymes. In this investigation, cheese-like soybean protein food was prepared using five kinds of protease to see whether the same results as Section 1 can be obtained or not in such a different condition, and to determine their suitability to cheese-like food making.

EXPERIMENTAL

1) Preparation of cheese-like soybean protein food

Cheese-like soybean protein food was prepared by the method explained in Chapter I.

2) Kinds of preparation and the ratio of ingredients

Five different preparations were made using 5 enzymes; trypsin, Molsin, papain, Bioprase, and Pronase with the formula shown in Table 12. Table 13 shows the amount of enzyme used per 860 g of concentrated curd. These amounts correspond to 5,000PU for papain, Bioprase and Pronase, and 15,000PU for trypsin and Molsin because these two enzymes showed very low activities in the previous experiment.

Table 12. Formula of ingredients of preparation

Materials	Weight
Concentrated curd	860 g
Sodium chloride	10 g
Starter	20 g
Unsalted butter	100 g
Sodium citrate	10 g

Table 13. The amount of enzymes

Enzyme	Weight
Trypsin	1000 mg
Papain	750 mg
Molsin	550 mg
Bioprase	12 mg
Pronase	5 mg

3) Development of starter

Mixed culture of *Streptococcus cremoris* and *Streptococcus lactis* (50—50 mixture) was inoculated to a sterilized whole milk culture and incubated at 35°C. Inoculations were repeated to activate lactic acid bacteria, resulting in mother starter. And then, evaporated milk was inoculated with the mother starter and incubated, which was used as main starter. Cultured evaporated milk was used as main starter because a) lactic acid bacteria grew well in evaporated milk, and b) considerable amount of starter could be used without the significant increase of moisture content of final products.

4) Analytical methods of cheese-like food

a. Moisture: Drying method at 105°C.

b. Ash: The ordinary method (ashing at 550°C).

c. Crude fat: The Soxhlet method.

d. Crude protein: The micro-Kjeldahl method (Parnas modified method); nitrogen factor: 5.71.

e. Water soluble protein: Water soluble protein was extracted using homogenizer with

water and extracts were analyzed by the same method as d.

f. Acidity: Water extracted solution was titrated with sodium hydroxide solution. Acidity was shown as lactic acid %.

g. PH: PH meter with glass electrode was used.

RESULTS AND DISCUSSION

Five different cheese-like foods were prepared by the procedures described above and ripened for 28 days at 17.5°C. Changes in pH, acidity, water soluble protein, and water soluble nitrogen/total nitrogen (SN/TN) are shown in Fig. 11, 12, 13 and 14, respectively.

The analytical data of cheese-like food 20 days after preparation, which is considered to be suitable time for ripening are shown in Table 14.

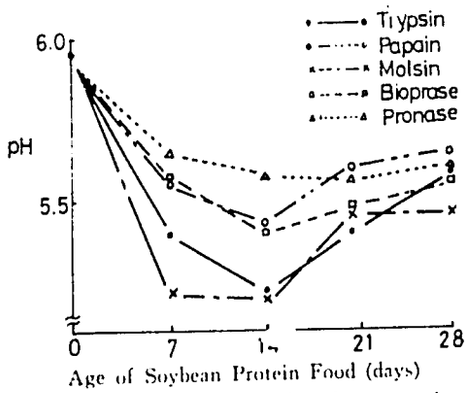


Fig. 11 Changes in pH of soybean protein food during ripening

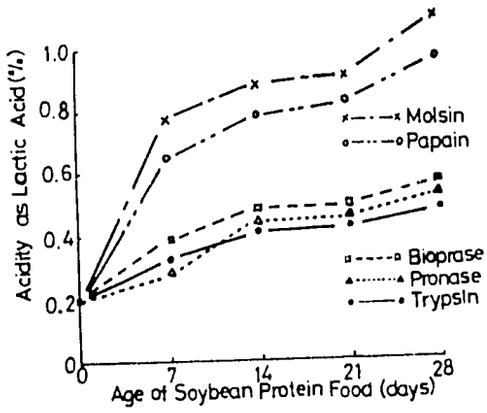


Fig. 12 Changes in acidity in soybean protein food during ripening

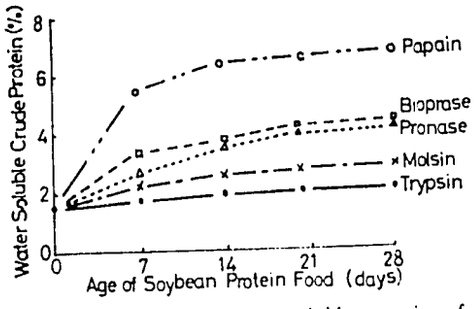


Fig. 13 Changes in water soluble protein of soybean protein food during ripening

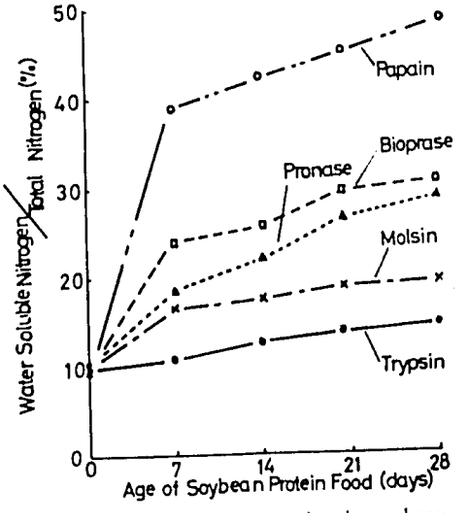


Fig. 14 Protein decomposion in soybean protein food during ripening

Table 14. Analytical data of cheese-like food after 30 days

Enzyme used	Moisture (%)	pH	Acidity (lactic acid %)	Crude fat (%)	Crude protein (%)	Water soluble protein (%)	SN/TN (%)
Trypsin	63.98	5.41	0.44	16.46	14.62	1.97	13.47
Papain	64.01	5.57	0.85	17.71	14.62	6.50	44.46
Molsin	64.35	5.48	0.91	17.85	14.13	2.66	18.81
Bioprase	65.32	5.50	0.52	16.00	14.02	4.15	29.60
Pronase	64.87	5.56	0.48	18.40	14.62	3.81	26.06

As shown in the figures, particularly in Fig. 13 and 14, the digestion ability of enzymes on soybean proteins in the preparation of cheese-like food did not always correspond to that of in vitro study in IV-1, except trypsin. Trypsin showed extremely low digestion ability and did not seem to be suitable for the production of the cheese-like food.

Though the digestion ability of papain was lower than Bioprase and Pronase in the in vitro experiment in IV-1, it showed a extremely high ability in this experiment. The ratio of SN/TN which shows the degree of protein decomposition, reached 38 with papain after a week of ripening. In the same period, Bioprase and Pronase, on the contrary, showed only 24 and 18 respectively.

Oraganoleptic tests (taste and texture) on the products can be summarized as follows:

Trypsin: Even after 4 weeks, it was immature, and had still beanish odor of soybean, but only slight bitter taste. Texture was coarse and gritty.

Papain: SN/TN reached 38 in one week. Though the product was over ripened, it showed extremely smooth texture and desirable taste. Bitter taste first appeared after 3 weeks.

Molsin: It showed fermentation flavor and miso-like taste. Bitter taste was slight.

Pronase: In the first stage of ripening, it had beanish flavor of soybean. But after 4 weeks, the value of SN/TN reached to about 30, and texture became extremely smooth. Taste and flavor were the best among the five products.

Bioprase: This showed similar tendency to Pronase. But it had more bitter taste than Pronase.

The results of the experiments in IV-1 and IV-2 may be summarized as follows:

In the processing of cheese-like soybean protein food, papain was the most suitable among the five enzymes because of the highest digestion ability against soybean proteins. The digestion ability of Molsin was low, and the taste of the products was no good. Trypsin was the most inferior from the stand point of poor digestion ability and the taste of the products.

Considering manufacturing costs, shorter ripening period, lower price of enzyme, and easiness of its obtainment are desirable. Thinking of these factors, papain is considered to be the best enzyme to use for the production of cheese-like food. Pronase and Bioprase are considered to be also applicable enzymes.

V. THE OPTIMUM AMOUNT OF ENZYME

From the results of the experiments in Chapter IV, papain was the best proteolytic enzyme to use in the manufacture of cheese-like food from soybean. The optimum amount of enzyme to be used in the process has not been investigated yet. The length of ripening period and the

quality of the product are influenced by the amount of enzyme used. Generally speaking, the more enzyme is used, the shorter the ripening period and the worse the quality of the products are. The data of repeated trial manufactures indicated that the best ripened cheese-like soybean protein food had the SN/TN value of around 30. Therefore, such amount of enzyme that digests soybean proteins to the SN/TN value 30 in 3 to 4 weeks would be sufficient and enough. To find out the optimum amount of enzyme papain to satisfy the above conditions is the purpose of this experiment.

EXPERIMENTAL

Cheese-like food was prepared by the method explained in Chapter I under the optimum conditions and with the best agglutinant investigated in Chapter II and III. Four preparations using 0.197%, 0.295%, 0.394% and 0.788% of papain (8.42×10^{4} PU/g) in respect of soybean proteins were made. The formula of ingredients is shown in Table 15. Cheese-like foods prepared were ripened for 5 weeks. Analyses were made on moisture, ash, crude fat, crude protein, water soluble protein, pH, and acidity according to the methods mentioned in IV-2. Amino nitrogen was determined by the Van Slyke method.

Table 15. Formula of ingredients of four preparations

	Preparation 1 (0.197%)	Preparation 2 (0.295%)	Preparation 3 (0.394%)	Preparation 4 (0.788%)
Concentrated curd	890 g	890 g	890 g	890 g
Papain	0.467 g	0.701 g	0.934 g	1.868 g
Starter	80 g	80 g	80 g	80 g
Sodium chloride	30 g	30 g	30 g	30 g

RESULTS AND DISCUSSION

The analytical data of the four preparations which differ in concentration of the enzyme; 0.197%, 0.295%, 0.394% and 0.788%, and ripened for 5 weeks are shown in Table 16, 17, 18, and 19.

Changes in pH, acidity, amino nitrogen, and SN/TN during ripening of the four preparations are shown in Fig. 15, 16, 17 and 18. The data indicated that the rate of protein digestion was very rapid in the first 7 days, and then became slower. In the four preparations, papain was used in ratio of 1 : 1.5 : 2 : 4. However, protein decomposition, that is the value of SN/TN was

Table 16. Analytical data of preparation 1 (0.197%)

Ripning period (week)	Moisture (%)	Ash (%)	pH	Acidity (lactic acid %)	Crude fat (%)	Crude protein (%)	Water soluble protein (%)	Amino nitrogen (%)	SN/TN (%)
0	55.61	4.11	6.10	0.17	15.14	21.83	1.84	0.291	8.43
1	55.35	4.22	5.70	0.31	—	21.39	3.36	0.474	15.70
2	54.82	4.18	5.30	0.53	—	21.77	3.91	0.485	17.96
3	55.08	4.14	5.37	0.53	15.44	21.33	4.12	0.502	19.32
4	55.48	—	5.34	0.59	—	21.23	4.33	0.514	20.40
5	54.74	—	5.37	0.58	—	21.60	4.32	0.571	20.00

Table 17. Analytical data of preparation 2 (0.295%)

Ripening period (week)	Moisture (%)	Ash (%)	pH	Acidity (lactic acid %)	Crude fat (%)	Crude protein (%)	Water soluble protein (%)	Amino nitrogen (%)	SN/TN (%)
0	55.61	4.11	6.10	0.17	15.14	21.83	1.84	0.291	8.43
1	55.33	4.19	5.62	0.41	—	21.69	4.38	0.508	20.19
2	54.93	4.12	5.37	0.53	—	21.37	4.65	0.565	21.76
3	55.34	4.19	5.45	0.36	15.36	21.92	5.16	0.640	23.54
4	55.59	—	5.44	0.64	—	21.20	5.16	0.640	24.34
5	54.04	—	5.40	0.69	—	22.15	5.63	0.657	25.42

Table 18. Analytical data of preparation 3 (0.394%)

Ripening period (week)	Moisture (%)	Ash (%)	pH	Acidity (lactic acid %)	Crude fat (%)	Crude protein (%)	Water soluble protein (%)	Amino nitrogen (%)	SN/TN (%)
0	55.61	4.11	6.10	0.17	15.14	21.83	1.84	0.291	8.43
1	55.30	4.21	5.69	0.42	—	21.34	5.12	0.533	23.99
2	55.20	4.17	5.57	0.48	—	21.56	5.49	0.645	25.46
3	55.35	4.15	5.50	0.79	15.68	21.26	5.87	0.634	27.61
4	55.43	—	5.60	0.64	—	21.12	6.08	0.714	28.79
5	54.54	—	5.50	0.76	—	22.06	6.51	0.799	29.51

Table 19. Analytical date of preparation 4 (0.788%)

Ripening period (week)	Moisture (%)	Ash (%)	pH	Acidity (lactic acid %)	Crude fat (%)	Crude protein (%)	Water soluble protein (%)	Amino nitrogen (%)	SN/TN (%)
0	55.61	4.11	6.10	0.17	15.14	21.83	1.84	0.291	8.43
1	55.23	4.58	5.64	0.55	—	21.52	6.60	0.662	30.67
2	54.67	4.17	5.50	0.66	—	21.38	6.77	0.615	31.67
3	55.09	4.17	5.46	0.78	15.38	21.46	6.89	0.719	32.11
4	54.98	—	5.47	0.87	—	21.40	7.32	0.697	34.21
5	53.38	—	5.58	0.86	—	21.99	8.17	0.799	37.15

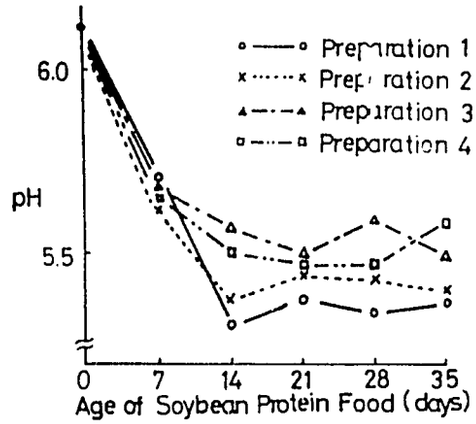


Fig. 15 Changes in pH of soybean protein food during ripening

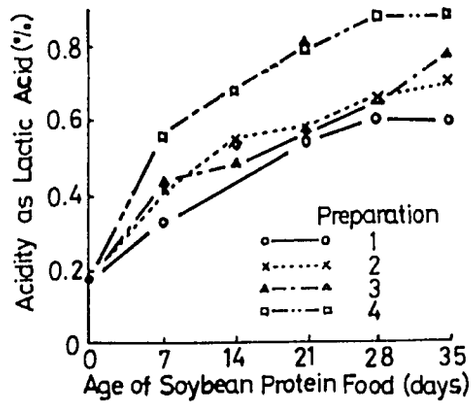


Fig. 16 Changes in acidity in soybean protein food during ripening

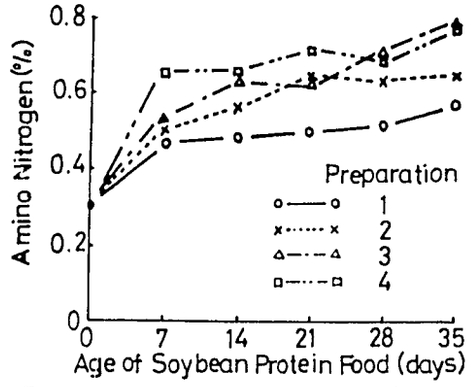


Fig. 17 Changes in amino nitrogen of soybean protein food during ripening

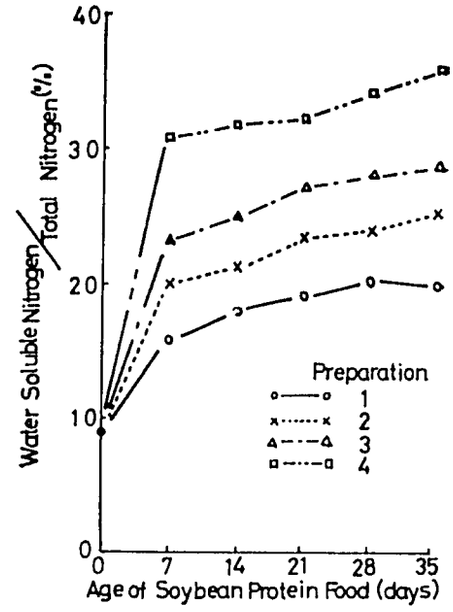


Fig. 18 Protein decomposion in soybean protein food during ripening

not proportional to the amount of enzyme used.

As described before, the SN/TN value of the best ripened cheese-like soybean protein food is around 30. Considering this point, sensory evaluations of the products of the four preparations were made every week. The results are summarized as follows:

Preparation 1 (0.197% enzyme): Ripening was slow and the SN/TN value was 20 after 5 weeks. Texture was coarse, gritty and less sticky. It showed no sour and bitter taste, but flat. The product was still green after 5 weeks.

Preparation 2 (0.295% enzyme): The SN/TN value reached 20 in 7 days and gradually increased to 25 in 5 weeks. Ripening was also slow in this preparation. Texture was coarse after a week of ripening. But a little smoothness was observed after 4 weeks. No sour and bitter were appeared after 5 weeks.

Preparation 3 (0.394% enzyme): The SN/TN value reached the desirable value in 3 weeks. Texture was fairly smooth. No sour and bitter taste were detected. After 4 weeks of ripening, the product showed good texture and taste.

Preparation 4 (0.788% enzyme): The SN/TN value was over 30 in 7 days. Texture was coarse and immature. After 3 weeks, the taste and texture became cheese-like. However, sour taste was already observed in 7 days and bitter in 2 weeks. With the progress in ripening period, undesirable after taste increased.

The preparation 1 and 2, 0.197% and 0.295% enzyme respectively, showed slow ripening. The preparation 4, 0.788% enzyme on the other hand, demonstrated rapid protein decomposition. But it showed coarse texture, uneven ripening, and sour and bitter taste. The preparation

3, 0.394% enzyme in respect of soybean proteins, resulted good products with desirable taste and texture. The amout of enzyme used in the preparation 3 was, therefore, concluded as optimum in the process of cheese-like soybean protein food.

VI. DETERMINATION OF THE OPTIMUM RIPENING TEMPERATURE

Ripening process in cheese making is generally carried out under the conditions of low temperature and long period. It is our purpose to produce cheese-like soybean protein food within a short period. The amount of enzyme and ripening temperature are pointed out as the main factors influencing the ripening period of this kind of food. Ripening temperature is a very important factor because it affects upon not only ripening period but also taste and texture of the product.

Cheese-like soybean protein food was prepared and ripened at 15°C, 17.5°C, 20°C and 25°C and then optimum temperature was tried to find out.

EXPERIMENTAL

1) Preparation of cheese-like soybean protein food

Cheese-like soybean protein food was prepared according to the procedure described in Chapter I. Four different ripening temperatures, 15°C (preparation 1), 17.5°C (preparation 2), 20°C (preparation 3) and 25°C (preparation 4) were compared. Percentage of the ingredients was shown in Table 20.

Table 20. Formula of ingredients of preparation

	Weight
Concentrated curd	900 g
Papain*	0.830 g
Starter	80 g
Sodium chloride	20 g

* Ensyme unit of papain: 8.42×10^3 PU/g

2) Analytical method

Moisture, ash, pH, acidity, crude fat, crude protein and water soluble protein were analyzed on each preparation extending over 4 weeks according to the methods described in Section 2 of Chapter IV. Amino nitrogen was analyzed by the method of Van Slyke.

RESULTS AND DISCUSSION

Analytical data for each sample are shown in Table 21, 22, 23 and 24.

Taste and texture of each sample ripened at four different temperatures extending over 4 weeks were tested once a week, resulting in the following:

Preparation 1 (15°C): Texture became good as the progress in ripening period, even though it was coarse. Ripening was not enough even after 4 weeks.

Preparation 2 (17.5°C): Better than preparation 1. Texture became smooth and cohesive

Table 21. Analytical data of preparation 1 (15°C)

Ripening period (week)	Moisture (%)	Ash (%)	pH	Acidity (lactic acid %)	Crude fat (%)	Crude protein (%)	Water soluble protein (%)	Amino nitrogen (%)	SN/TN (%)
0	56.82	3.11	6.37	0.17	14.98	21.28	3.93	0.109	18.48
1	56.47	3.17	5.70	0.38	—	21.79	5.48	0.135	25.15
2	56.34	3.15	5.29	0.54	—	20.55	5.99	0.234	29.15
3	56.22	3.12	5.50	0.44	15.24	19.80	5.48	0.243	27.68
4	55.84	3.17	5.57	0.54	—	20.78	6.67	0.252	32.10

Table 22. Analytical data of preparation 2 (17.5°C)

Ripening period (week)	Moisture (%)	Ash (%)	pH	Acidity (lactic acid %)	Crude fat (%)	Crude protein (%)	Water soluble protein (%)	Amino nitrogen (%)	SN/TN (%)
0	56.82	3.11	6.37	0.17	14.98	21.28	3.93	0.109	18.48
1	56.60	3.21	5.32	0.51	—	22.04	5.52	0.122	25.05
2	56.28	3.16	5.21	0.89	—	21.69	7.55	0.246	34.81
3	56.39	3.02	5.32	0.67	14.72	19.82	7.05	0.271	35.57
4	55.92	3.19	5.38	0.71	—	20.56	7.52	0.268	36.58

Table 23. Analytical data of preparation 3 (20°C)

Ripening period (week)	Moisture (%)	Ash (%)	pH	Acidity (lactic acid %)	Crude fat (%)	Crude protein (%)	Water soluble protein (%)	Amino nitrogen (%)	SN/TN (%)
0	56.82	3.11	6.37	0.17	14.98	21.28	3.93	0.109	18.48
1	56.55	3.25	5.32	0.54	—	21.73	5.69	0.146	26.13
2	55.74	3.13	5.19	0.88	—	21.94	8.13	0.247	37.06
3	55.47	3.21	5.30	0.99	15.72	20.53	7.93	0.273	38.63
4	55.11	3.11	5.42	0.92	—	21.77	8.65	0.285	39.73

Table 24. Analytical data of preparation 4 (25°C)

Ripening period (week)	Moisture (%)	Ash (%)	pH	Acidity (lactic acid %)	Crude fat (%)	Crude protein (%)	Water soluble protein (%)	Amino nitrogen (%)	SN/TN (%)
0	56.82	3.11	6.37	0.17	14.98	21.28	3.93	0.109	18.48
1	56.73	3.31	5.28	0.48	—	21.74	6.27	0.133	28.84
2	56.02	2.85	6.95	0.80	—	21.69	8.92	0.221	41.12
3	56.61	3.24	—	0.55	14.51	19.64	9.72	0.344	49.49
4	56.28	3.07	—	0.80	—	22.54	10.26	0.360	45.52

after 3 to 4 weeks. Odor of soybean was disappeared after 3 weeks. No bitter and sour taste were detected.

Preparation 3 (20°): Texture became smooth after 2 weeks of ripening. Taste and flavor also became good after 3 weeks, but slight bitterness was felt.

Preparation 4 (25°C): Sample became cohesive after 2 weeks ripening, but it was soft and sticky. Ripening speed was fast, but taste was poor. After 3 weeks, ester odor was occured and it was impossible to eat due to putrefaction.

Fig. 19, 20, 21 and 22 show the changes of pH, acidity, amino nitrogen and SN/TN value

during ripening.

As shown in Fig. 22, the higher the ripening temperature, the faster the decomposition of protein is. The same tendency is observed in amino nitrogen (Fig. 21).

The experiment of this time was carried out during summer. The temperature of mixing room was 35°C. Enzyme reaction, therefore, considerably went fast until the time when paraffin coating was finished after raw materials and enzyme were mixed and stirred. The high value of SN/TN was observed at initial stage.

Ripening takes long time at 15°C. At 25°C decomposition of protein is rapid and ripening period is shortened. But it is easy to have bitterness of the product and also easy to be

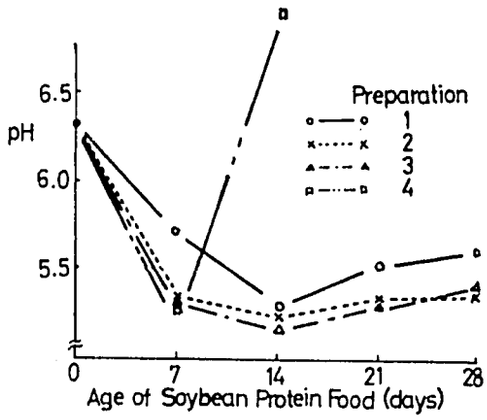


Fig. 19 Changes in pH of soybean protein food during ripening

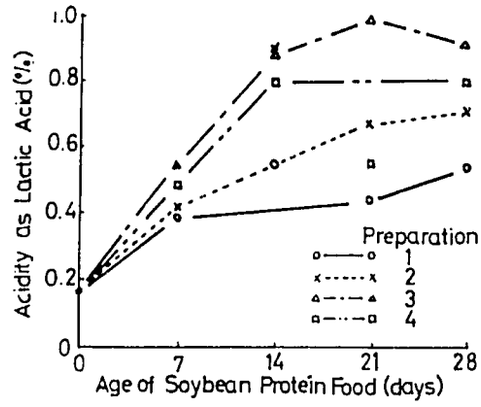


Fig. 20 Changes in acidity in soybean protein food during ripening

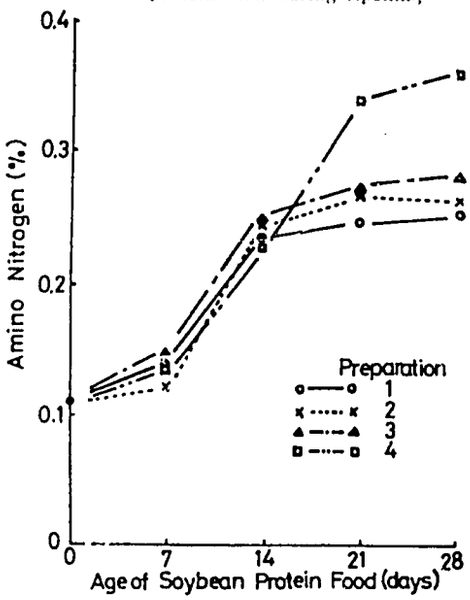


Fig. 21 Change in amino nitrogen of soybean protein food during ripening

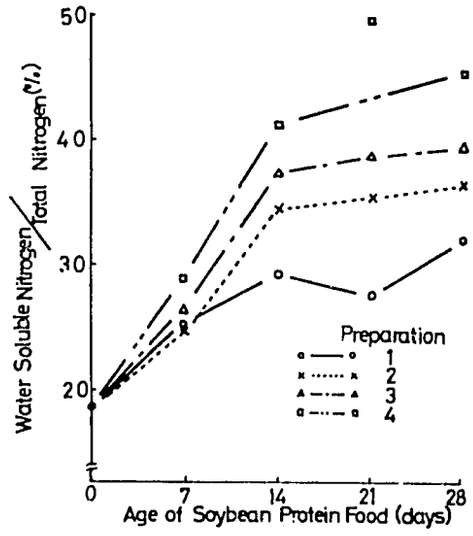


Fig. 22 Protein decomposion in soybean protein food during ripening

contaminated by various fungi. In case of 20°C, bitterness of the product is stronger than 17.5°C but ripening time is shorter than 17.5°C.

As a conclusion, around 17.5°C is thought to be the best ripening temperature.

VII. TRIAL PRODUCTION OF CHEESE-LIKE SOYBEAN PROTEIN FOOD UNDER THE BEST CONDITIONS

Manufacturing procedure of cheese-like soybean protein food was proposed in Chapter I and the best conditions at each process were found out by the experiments from Chapter II to Chapter VI. The following manufacturing experiments were made under the best conditions of each process in the procedure in order to get same data which might be useful for further improvement of the product.

1. Production of cheese-like soybean protein food using papain only

EXPERIMENTAL

1) Preparation of Cheese-like soybean protein food

The following best conditions found out in the previous experiments were used for preparation.

a. Condition of soymilk extraction: Soak soybean in water at 20°C for 15 hours and add 10 times of water, and then heat for 2 minutes after trituration.

b. Agglutinant: 3.2 g of calcium sulfate was added for 1 kg of soymilk.

c. The amount of enzyme: 8.42×10^3 PU/g of papain was used at the rate of 0.394% in respect of soybean protein.

d. Ripening temperature: 17.5°C.

e. Percentage of each ingredient is shown in Table 25. Fat was not added.

Table 25. Formula of Ingredients of Preparation

Concentrated curd	Papain	Starter	Sodium chloride
890 g	0.934 g	80 g	30 g

2) Analytical method of the product

Moisture, ash, pH, acidity, crude fat, crude protein and water soluble protein were analyzed by means of the methods described in IV-2. Amino nitrogen was analyzed by the Van Slyke method.

RESULTS AND DISCUSSION

Table 26 shows the analytical data of the product after 4 weeks when the best taste and the best texture were obtained during ripening. The product became very smooth and cohesive 3 weeks after preparation. Mouth feeling became more smooth after 4 weeks. It melted nicely in mouth. Cheese-like flavor was appeared after 3 to 4 weeks. The product showed very good taste without any bitterness after 4 weeks of ripening.

Table 26. Analytical data of preparation after 4 weeks

Moisture (%)	Ash (%)	pH	Acidity (lactic acid %)	Crude fat (%)	Crude protein (%)	Water soluble protein (%)	Amino nitrogen (%)	SN/TN (%)
55.43	4.15	5.60	0.64	15.68	21.12	6.08	0.13	28.8

The changes of pH, acidity and decomposition of protein are shown in Fig. 23, 24 and 25. PH was 6.1 at the time of preparation. It became more acidic with the progress in ripening, and stopped decreasing at about pH 5.5. It was the general tendency that the pH decreased gradually to 5.1 to 5.2 with the progress in ripening period and equilibrated at about this pH. Rapid changes were observed in pH and acidity during first week of ripening. SN/TN value was increased considerably during first week of ripening due to the active enzyme reaction. As this experiment was done in winter, the temperature of concentrated curd at the time of mixing

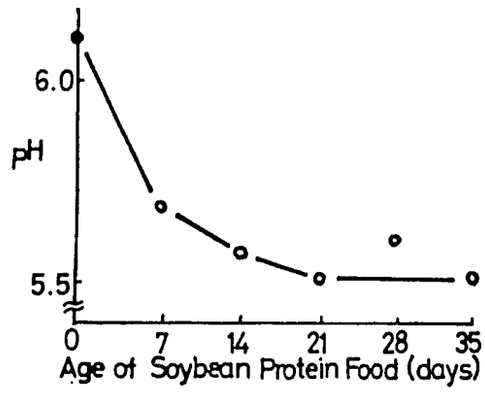


Fig. 23 Changes in pH of soybean protein food during ripening

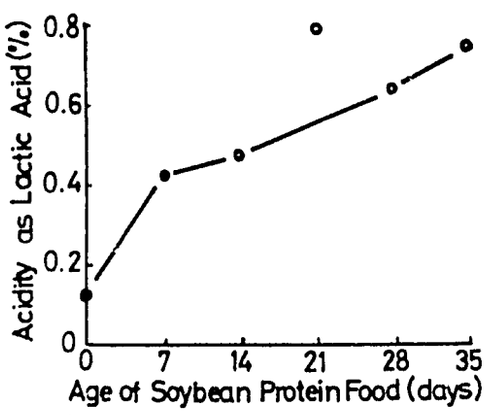


Fig. 24 Changes in acidity in soybean protein food during ripening

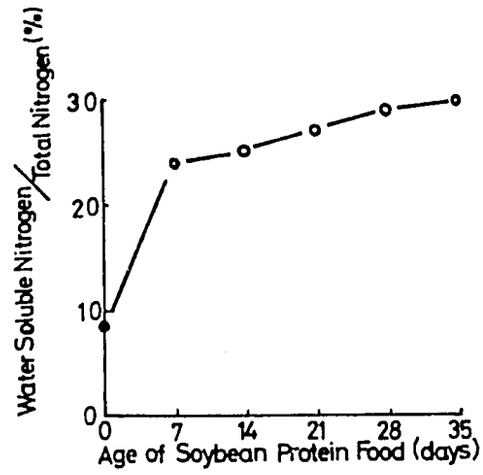


Fig. 25 Protein decomposion in soybean protein food during ripening

was low. So SN/TN value was much lower than those of the cases of Chapter IV to chapter VI. It would be summarized that SN/TN value was quite different at the beginning of ripening due to the temperature of preparation although the ripening condition was the same. In case of practical production of cheese-like soybean protein food, temperature of mixing has to be kept 10—15°C, and it is necessary to keep the starting condition of ripening constant.

2. Production of cheese-like soybean protein food using papain, Bioprase, Pronase together

In Chapter IV, papain was used as an excellent enzyme, but it was also described that Bioprase or Pronase could be used as a proteolytic enzyme for preparing cheese-like soybean protein food. Only a papain was used for all trials in the previous experiments. The following experiment was carried out to investigate whether it is effective or not to use other enzymes together with papain.

EXPERIMENTAL

1) Preparation of cheese-like soybean protein food

The products were compared one another with the following 4 preparations.

a. Preparation 1: Papain was used.

b. Preparation 2: Papain and Bioprase were used together.

c. Preparation 3: Papain and Pronase were used together.

d. Preparation 4: Papain, Bioprase and Pronase were used together.

Manufacturing procedure was the same as that described in the previous section.

2) Percentage of each ingredient and the amount of enzyme

a. Percentage of each ingredient: Table 27 shows the percentage of each ingredient excluding enzyme.

Table 27. Formula of ingredients of preparation

Concentrated curd	Starter	Sodium chloride
700 g	63 g	15.6 g

b. Combination of used enzymes: Activity unit of each enzyme is as follows:

Papain .....18.66×10^3 PU/g

Bioprase.....26.46×10^3 PU/g

Pronase .....464.6×10^3 PU/g

The amount of each enzyme in 700g of concentrated curd is shown in table 28. The amount of each enzyme was adjusted so that the total activity units for each preparation became the same as that of papain used in the previous experiments.

Table 28. The amount of enzyme combination

	Papain (mg)	Bioprase (mg)	Pronase (mg)
Preparation 1	293	0	0
Preparation 2	147	103	0
Preparation 3	147	0	6
Preparation 4	98	69	4

RESULTS AND DISCUSSION

Analytical data of each preparation during ripening are shown in Table 29, 30, 31 and 32. The changes of pH, acidity, amino nitrogen and SN/TN value are shown in Fig. 26, 27, 28 and 29.

Table 29. Analytical data of preparation 1 (papain)

Ripening period (week)	Moisture (%)	Ash (%)	pH	Acidity (lactic acid %)	Crude fat (%)	Crude protein (%)	Water soluble protein (%)	Amino nitrogen (%)	SN/TN (%)
0	57.15	3.37	6.19	0.07	12.84	22.95	0.61	0.037	2.66
1	57.07	3.39	5.30	0.62	—	22.41	5.22	0.083	23.29
2	57.08	3.40	5.23	0.67	—	22.00	5.33	0.108	24.23
3	56.78	3.36	5.30	0.65	13.17	22.23	6.66	0.157	29.96
4	57.01	3.42	5.19	0.64	—	22.31	6.53	0.097	29.27
5	57.13	3.36	5.14	0.90	—	22.26	6.64	0.132	29.83

Table 30. Analytical data of preparation 2 (papain-Bioprase)

Ripening period (week)	Moisture (%)	Ash (%)	pH	Acidity (lactid acid %)	Crude fat (%)	Crude protein (%)	Water soluble protein (%)	Amino nitrogen (%)	SN/TN (%)
0	57.15	3.37	6.19	0.07	12.84	22.95	0.61	0.037	2.66
1	57.13	3.35	5.22	0.75	—	22.70	5.70	0.085	25.11
2	57.21	3.33	5.23	0.85	—	22.68	5.84	0.120	25.75
3	56.69	3.40	5.29	0.87	13.29	22.51	6.44	0.181	28.61
4	57.08	3.37	5.12	0.99	—	22.03	9.19	0.180	41.72
5	56.86	3.30	5.10	1.22	—	22.32	8.49	0.270	38.04

Table 31. Analytical data of preparation 3 (papain-Pronase)

Ripening period (week)	Moisture (%)	Ash (%)	pH	Acidity (lactic acid %)	Crude fat (%)	Crude protein (%)	Water soluble protein (%)	Amino nitrogen (%)	SN/TN (%)
0	57.15	3.37	6.19	0.07	12.84	22.95	0.61	0.037	2.66
1	57.26	3.32	5.24	0.68	—	22.54	5.00	0.121	22.18
2	57.23	3.36	5.21	0.79	—	22.81	5.43	0.132	23.81
3	56.46	3.36	5.20	0.95	13.50	22.52	6.58	0.169	29.22
4	57.29	3.39	5.02	1.11	—	22.33	9.18	0.180	41.11
5	56.90	3.33	5.11	1.08	—	22.70	7.25	0.219	31.94

Table 32. Analytical data of preparation 4 (papain-Bioprase-Pronae)

Ripening period (week)	Moisture (%)	Ash (%)	pH	Acidity (lactic acid %)	Crude fat (%)	Crude protein (%)	Water soluble protein (%)	Amino nitrogen (%)	SN/TN (%)
0	57.15	3.37	6.19	0.07	12.84	22.95	0.61	0.037	2.66
1	56.57	3.33	5.26	0.80	—	23.11	5.93	0.132	25.66
2	56.78	3.33	5.20	1.09	—	23.04	6.96	0.142	30.21
3	56.79	3.35	5.30	0.95	13.51	22.23	6.77	0.188	30.45
4	56.92	3.33	5.16	1.14	—	22.71	8.82	0.239	38.84
5	56.93	3.28	5.03	1.46	—	22.26	9.64	0.292	42.52

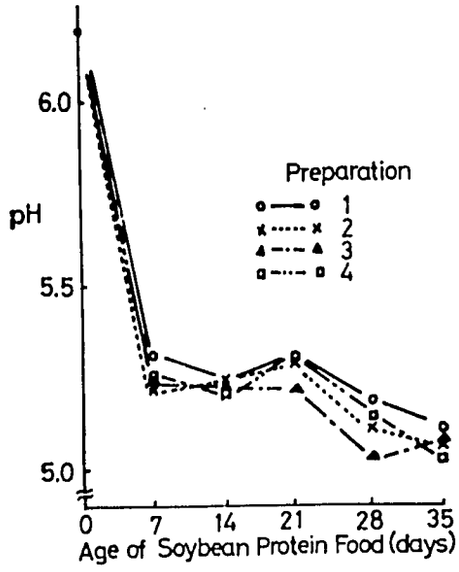


Fig. 26 Changes in pH of soybean protein food during ripening

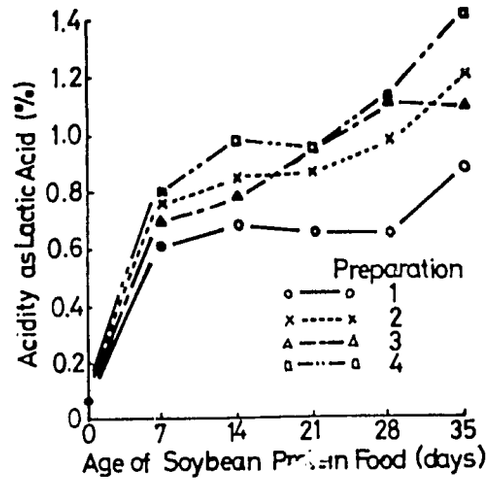


Fig. 27 Changes in acidity in soybean protein food during ripening

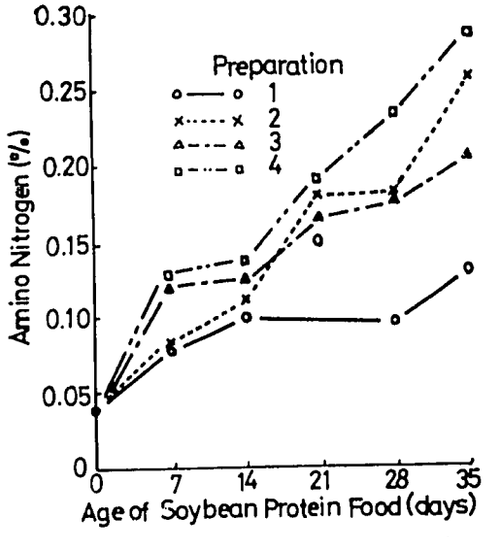


Fig. 28 Changes in amino nitrogen of soybean protein food during ripening

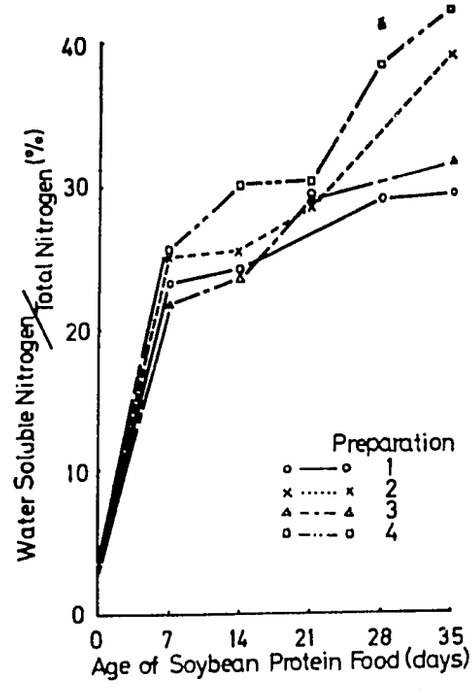


Fig. 29 Protein decomposion in soybean protein food during ripening

SN/TN value of preparation 2, 3 and 4 is high, that is, decomposition of protein is fast comparing with preparation 1 which corresponds to previous cheese-like soybean protein food prepared with papain only. Slight bitter taste was detected in the products of preparation 1 and 2, but none in preparation 3 and 4. Texture was the best in preparation 4 which was prepared with 3 enzymes.

It is concluded that the use of mixed enzymes, Bioprase and Pronase together with papain, is more effective to produce the product of good flavor and texture, and to shorten the ripening period compared with the single use of papain.

VIII. EVALUATION OF THE CHEESE-LIKE SOYBEAN PROTEIN FOOD BY FEEDING EXPERIMENTS

In order to investigate the nutritional value of the cheese-like soybean protein food, protein efficiency ratio (PER) and biological value (BV) were determined by feeding experiments with the albino rat.

EXPERIMENTAL

1) Test diet

The soybean protein food used in the experiment was prepared by the method described in VII-1, and ripened for 3 weeks. Table 33 shows the analytical data of the soybean food sample. The composition of casein diet used as a control and the soybean protein food diet are shown

Table 33. Analytical data of cheese-like soybean protein food

Moisture	53.87%	Acidity as lactic acid	0.733%
Crude protein	24.10%	pH	5.12%
True protein	20.35%	Ca	0.41%
Water soluble protein	5.33%	Na	0.85%
Amino nitrogen	0.173%	K	0.10%
Crude fat	14.86%	P	0.52%
Ash	3.32%		
Crude fiber	0.00%		
Nitrogen free extract	3.85%		

Table 34. Composition of test diets

Ingredient	Casein diet (%)	Soybean feed diet (%)
Milk casein	10.1	—
Soybean food	—	30.0
Sucrose	20.0	14.0
Wheat starch	58.4	52.0
Soybean oil	6.0	—
Mineral mixture	4.5	3.0
Fiber	1.0	1.0
Vitamins	enough	enough
Protein level in dry matter	9.45	9.52

in Table 34. Protein content in dry matter were 9.45% and 9.52% for the casein diet and the soybean protein diet respectively.

2) Determination of protein efficiency ratio

The rats which had average initial body weight 60 g were used. Each group, consisted of 6 rats, was fed by the soybean protein food and the casein diet for 21 days under the constant condition of 24°C and 65% humidity. The PER was calculated from the amount of protein intake and weight gain during this period.

3) Determination of biological value

Twelve rats, average initial body weight 140—150 g were used in this experiment. They were divided into 2 groups, 6 rats each. Both groups were fed by the same non-protein diet 1) for the first 7 days and then each group was fed by the respective test diet for another 7 days. Nitrogen balance was calculated from the data of last 3 days of each feeding period.

RESULTS AND DISCUSSION

The PER and the BV determined are shown in Table 35 and 36. Average PER and BV of the cheese-like soybean protein food were 2.7 and 63.0 respectively. While these values of casein were 3.1 and 83.1.

Slightly different figures have been reported for these values by different workers according to the difference in their experimental conditions. Hackler and Hand (2) reported the PER for casein as 2.86 and for soybean curd as 2.20. PER is, therefore, considered to be slightly increased by fermentation. Tamura and Arimoto (9) reported the BV of casein as 75.7, raw soybean as 27.0, boiled soybean as 52.3, boiled defatted soybean as 56.2 and natto as 52.3—54.7. These values are all lower than the results of the present experiment.

Table 35. Protein efficiency ratio of test diets (for 21 days)

		Initial body weight (g)	Weight gain (g)	Protein intake (g)	P.E.R.
Casein diet	1	65	71	21.7	3.3
	2	55	46	18.6	2.5
	3	59	54	19.6	2.8
	4	62	87	25.3	3.4
	5	56	68	21.7	3.1
	6	64	68	21.2	3.2
	Average	60.1	65.6	21.5	3.1
Soybean food diet	7	64	54	21.2	2.6
	8	57	53	20.7	2.6
	9	63	73	23.3	3.1
	10	62	57	19.8	2.9
	11	65	47	19.1	2.5
	12	55	47	19.6	2.4
	Average	61.0	55.1	20.6	2.7

1) Sucrose 20.0%, soybean oil 6.0%, fiber 1.0%, wheat starch 68.4%, minerals 4.5% and sufficient amount of vitamins.

Table 36. Determination of biological value on test diets

		Initial body weight (g)	Non protein period (3 days) N-in feces (mg)	Non protein period (3 days) N-in urin (mg)	Test diet period (3 days) N-in take (mg)	Test diet period (3 days) N-in feces (mg)	Test diet period (3 days) N-in urine (mg)	N-absorbed (mg)	N-retained (mg)	N-Biological (mg)
Casein diet[1]	1	162	31.1	98.8	700.4	81.5	186.7	650.0	562.1	86.5
	2	125	25.1	94.8	532.2	69.7	158.2	487.6	424.2	87.0
	3	137	32.7	97.8	532.2	66.6	186.7	498.3	409.4	82.2
	4	177	32.0	69.6	684.4	91.4	191.1	625.0	503.5	80.6
	5	151	30.4	86.7	623.5	88.5	216.6	565.5	435.5	77.0
	6	165	29.3	51.1	539.4	70.1	124.7	498.6	425.0	85.2
	Average	152.8	30.1	83.1	602.1	77.8	177.3	537.5	460.0	83.1
Soybean food diet[2]	7	149	29.1	70.8	504.0	68.6	253.7	464.5	281.6	60.6
	8	139	27.6	106.3	536.0	72.6	236.8	491.0	360.5	73.4
	9	165	20.6	50.1	721.6	57.5	301.5	684.7	433.3	63.3
	10	141	28.2	63.1	508.8	62.6	240.2	474.4	297.3	62.7
	11	135	23.6	68.0	681.6	59.8	312.5	645.4	400.9	62.1
	12	124	24.5	80.3	662.4	70.6	350.7	616.3	345.9	56.1
	Average	142.1	25.6	73.1	600.7	65.3	282.5	562.7	353.3	63.0

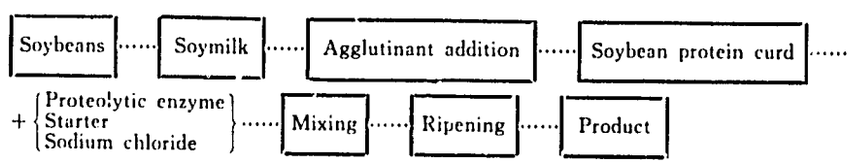
1: N content in dry matter: 1.38%
2: N content in dry matter: 1.21%

The figures above described indicate that the nutritional value of soybean protein is completely retained in the soybean protein food. That means the manufacturing process does not decrease the nutritional value of soybean protein, but slightly increases. Our cheese-like soybean protein food is, therefore, considered to be a good protein food. Sulfur-containing amino acids are the limiting amino acids of soybean protein. It is convinced that the nutritional value of the chesse-like soybean protein food can be further increased by the addition of cystine or methionine.

IX. SUMMARY

1) As a part of developing studies of new soybean protein food, soybean proteins were digested by a proteolytic enzyme and produced a cheese-like soybean protein food. The purpose of the present investigations is to establish the procedure to manufacture the cheese-like soybean protein food.

2) The manufacturing procedure of the cheese-like soybean protein food from soybeans was established. The outline of the procedure is as follows:



3) Investigations have been made to find the optimum conditions for each step of the manufacturing procedure.

a. The optimum conditions for extracting soymilk: Soaking time is 15 hours. The amount of water added is 10 times of the weight of soybeans. Extracting time is for 2 minutes at boiling temperature.

b Among 4 agglutinants (calcium chloride, calcium sulfate, hydrochloric acid and gluconic acid), calcium sulfate is the most suitable one for the purpose. The best yield was obtained with calcium sulfate concentration of 0.03—0.04 N in soymilk and coagulation temperature of 70°C.

c. Trypsin, Molsin, papain, Bioprase and Pronase were determined their digestion abilities on protein solution in vitro, and on soybean proteins in the process of cheese-like soybean protein food.

Papain showed the best result in both experiments. The optimum amount of papain (activity 8.42×10 PU/g on soybean proteins) in actual manufacture was found as 0.394%. Trypsin showed almost no activity because of the presence of trypsin inhibitor in soybeans. Molsin has the optimum pH at 2.3. This is far below than pH 6.3 at which the cheese-like soybean protein food is processed. Trypsin and Molsin are, therefore, not applicable to the practical manufacture. Pronase and Bioprase are also applicable in the manufacture besides papain.

d. The ripening temperature of around 17.5°C is the optimum to cure the curd in conside: ration of ripening period, the flavor of the products, and other conditions.

4) According to the optimum conditions decided in 3, pilot productions were made. The results indicated that the temperature of mixing ingredients had to be kept between 10 and 15°C. Thus produced products were acceptable. The effect of mixed enzyme was investigated in comparison with papain. Enzyme mixtures were papain and Bioprase, papain and Pronase, and papain, Bioprase and Pronase. The mixed enzyme showed higher ability of protein digestion. Especially the mixture of three enzymes demonstrated faster ripening, and improved texture and taste.

5) The products manufactured under optimum conditions with papain were tested by feeding experiments with rats. PER of soybean curd has been reported as 2.2, while BV of raw soybean, boiled soybean and natto have been reported as 27.0, 52.3 and 52.3—54.7 respectively. Our product showed better results, PER 2.7 and BV 63, compared with the values reported heretofore.

It is noteworthy that poor digestible soybean proteins could be changed to nutritive food by fermentation process using proteolytic enzymes.

As a conclusion, the cheese-like soybean protein food which had good flavor and high nutritive value was successfully developed through the present investigations.

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AN ARTICLE FOR THE SEMINAR ON PROTEIN FOOD PROMOTION

Generally speaking, the increase in population density and concentration of housing conditions have gradually made it more difficult to rely on natural food resources. Subsequently, progress in the storage of foods, food transportation and cooking methods come into the picture and the problem of food processing is focused.

Referring to food processing methods, it may be closed up that palability likes and dislikes, conveniency should be emphasized in order to meet the desire of the consumers. Further, the cost must be reasonable.

I should like to point out that the problem of food processing must always be considered from the consumers' standpoint so as to satisfy them. Efforts should be made to elevate the value of foods as a commodity.

It must not be overlooked, however that food processing is also very valuable in the improvement of the nutritive value of foods. We are aware of loss in nutrients that is apt to occur during the processing procedure.

To cover this defect food enrichment was undertaken to restore the nutritive value of original foodstuff which occurs during the procedure and further to improve the nutritive value.

Nowadays in Japan, enrichment of vitamins, minerals and further more essential amino acids to processed foods is admitted by law. For instance, enrich= ment of vitamin B_1 to rice and wheat flour is necessary from the nutritional viewpoint and we are now proceeding to enrich lysine and threonine. To margarine we enrich vitamin A and to soy bean paste (Miso) vitamin A, calcium and methionine is enriched. In this way the enrichment of processed foods has been found to be very valuable in nutritional improvement by covering the lack in necessary nutrients and thus improve food habits without meeting resistance from the mass.

Finally, I wish to add that though it is very promising to add the missing nutrients of the original foods, in food processing, antiseptics, color and odor reagents also have to be added. As these substances are sometimes added in excess caution must be taken to avoid their dangerous effects.

More and more research is needed in food processing techniques to promote the value of foods for the future.

I fully respect Mr. Amara Bhumiratana, director, Institute of Food Research and Product Development, for his efforts in sponsoring this Seminar on Protein Food Promotion at a time when we are in need of further research in this field.

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DEVELOPMENT OF SOY/COCONUT MILKS FOR THE PHILIPPINES*

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It was my pleasure and privilege to be assigned as a visiting Professor of Food Science and Microbiology at the University of the Philippines College of Agriculture (Los Banos) for the period July 1, 1967 to June 15, 1969 under Cornell University's International Agricultural Development program. One of my major assignments under that program was to develop, with the support of an U.S. AID project (no csd-1815), soy or soy/coconut milks for the use in the Philippines and other countries of Southeast Asia. Our findings on this project were published as an article entitled: DEVELOPMENT OF FLAVORED SOY MILKS AND SOY/COCONUT MILKS FOR THE PHILIPPINE MARKET by K. H. Steinkraus, L. T. David, L. J. Ramos, and J. Banzon. The Philippine Agriculturist. Vol. LII. No. 5: 268-276. 1968. Results of this study will be reviewed.

Briefly, processes were devised for the production of flavored soy and soy/coconut milks that proved to be acceptable by over 90% of the Filipino people tasting them. We used primarily 6th grade students in the elementary schools as taste panels as we believed that 6th graders were old enough to respond intelligently to our questions regarding flavor acceptability.

However, as our study progressed, we became aware that most students in the village and public schools did not have enough money to buy a bottle of the soy milk each day. Thus, in order to produce a soy milk in a form that the average student could buy, it was necessary to package 60 ml quantities frozen in narrow plastic bags and saleable for 5 centavos in order to get the product to the school children. In such form, called ice candies in the Philippines, the soy milks were very popular and were purchased avidly in the school canteens.

Since these initial studies another obstacle to the commercial production of soy milks in the Philippines has arisen. There is inherent antipathy toward soybean by the Philippine coconut industry which views soybean oil as a direct competitor to coconut oil.

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* Abstract of paper to be presented at Protein Food Promotion Seminar Kasetsart University (Bangkok). November 22 - December 1, 1970

Although soybean production is showing some increase, soybean production is still so limited in the Philippines that it does not look as though there will be sufficient soybeans to support a large scale commercial soy milk production for many years. Some of the large bottlers of soft drinks and other companies are interested in producing soy milks particularly as a protein-rich soft drink much as has been done in Hong Kong, Bangkok, Singapore and in Taiwan. However, the overall supply of soybeans is so limited and precarious that it is doubtful that a sufficient production of soy milk could be sustained commercially. And the Philippine Government has consistently prevented importation of soybeans by assessing prohibitive duty on the imports.

In India, U.S. AID, through its University of Illinois contract, has approached a similar problem differently and probably better. In India first emphasis has been placed upon production of soybeans. Now that production of soybeans has been achieved and large quantities of soybeans are becoming available, they are fostering development of a commercial soybean processing industry. However, this would have been much more difficult in the Philippines because of the inherent opposition by the large agricultural coconut sector to development of alternate sources of oil.

In India, development of soy milks faces a different problem than that encountered in the Philippines. The Filipinos generally are not milk drinkers. Although they do consume quantities of sweetened condensed milk, the use of fresh cow's or buffalo milk is very limited. They are not conditioned to cow's or buffalo milk flavor. Thus, the flavor of a milk substitute does not need to resemble cow's or buffalo milk to be acceptable. However, in India, most of the people, even the poor, have had some contact with animal milks. They like and appreciate animal milk flavor. It is believed that any milk substitute to succeed would have to resemble cow's or buffalo milk in flavor and other characteristics. It is practically impossible to duplicate cow's or buffalo milk flavor by even the best processes known for manufacturing regular soybean milks today. In order to make soy milks that taste like cow's milk, it is necessary to use more sophisticated processing. It is essential to remove the soybean fat including the phospholipids before aqueous extraction of the soybean proteins to make a milk if a cow s or buffalo milk flavored product is the objective. Cornell University has developed such a process and has applied for a patent on the process through Research Corporation in New York. Cornell University and Research Corporation have given the U.P. Agricultural University, site of the University of Illinois U.S. AID soybean project, free rights to develop and modify

this more sophisticated process for making cow's or buffalo milk flavored soy milks for use in India. It is possible that Cornell University and Research Corporation would extend similar free rights to the process to universities in other countries.

Briefly, the process involves a two-stage defatting, deflavoring step in which ethanol and chloroform are used to extract the lipids including the phospholipids and most of the remaining soybean flavor. Following recovery of the solvents from the defatted, deflavored base, an aqueous extract is made to which bland, refined oil is added along with milk flavor. The mixture is then homogenized and the product is sterilized in bottles or cans to yield a completely stable milk that can be preserved without refrigeration and which tastes remarkably similar to cow's milk. Final flavor formulations must be developed within the country using the prospective consumers as taste panels. Plans are underway to build a pilot plant for the purpose of developing the process at the U.P. Agricultural University at Pant Nagar, India.

So, in conclusion, our studies in the Philippines have demonstrated very well that protein food promotion requires first a sufficient supply of the indigenous ingredients and second products developed not only to satisfy the organoleptic requirements of the prospective consumers but thirdly products within their purchasing power. Unless all three aspects are solved, new protein food promotion is likely to fail.

DEVELOPMENT OF FLAVORED SOYMILKS AND SOY/ COCONUT MILKS FOR THE PHILIPPINE MARKET[1]

KEITH H. STEINKRAUS[2], L. T. DAVID, L. J. RAMOS[3] and JULIAN BANZON[4]

INTRODUCTION

In developing food products, it is desirable to work with the prospective consumers in producing the most acceptable flavors. This is particularly true for protein-rich food products intended for supplements in developing countries.

Soymilks distributed as soft drinks have become commercial successes in Hongkong (Lo. 1964), Bangkok (Green Spot Ltd., 1968), and Singapore (Yeo Hiap Seng Canning & Sauce Factory Ltd., 1969).

The flavors used in these soymilks include sugar, skim milk powder,full-fat spray-dried cow's milk, malt flavor etc. The exact flavorings are industrial secrets.

More recently, Coca-Cola Export Inc. has been market-testing a soymilk-based soft drink in Brazil (Malaspina, 1969). Flavorings used have included chocolate and caramel.

The Department of Food Science and Technology, Cornell University, Geneva, New York, has been studying soymilk production and flavors for about 10 years (Hand, et al., 1964; Wilkens, Mattick and Hand, 1967; Steinkraus, 1967; Lo, Steinkraus, Hand, 1968a, 1968b; Lo, et al., 1968c, 1968d). Much of these studies have been devoted to removal or prevention of development of typical soymilk flavor.

In July 1967, U.S. AID/Washington through its Office of War-on-Hunger financed a project (Cornell Contract csd-1815) on the development of soy-based foods for infants and children. The project involved development of soymilks or soy/coconut milks and other soy-based foods with flavors acceptable to children in the Philippines.

This paper reports results of flavor studies on soymilks or soy/coconut milks developed for the Filipinos, with taste panels composed of Filipinos in the

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laboratories and in the public and private schools. It also presents the best technology for making soymilks known at this time.

MATERIALS AND METHODS

Three varieties of yellow soybeans were used in the study: Davao, a variety of soybeans grown in Mindanao and sold on the commercial market; and the Taichung and Hsieh Hsieh varieties from Taiwan, grown at the International Rice Research Institute by Dr. Richard Bradfield.

Soymilks were produced according to procedures developed in the Department of Food Science and Technology, Cornell University, Geneva, New York. These procedures yield soymilks with very bland flavors, but these can be very easily modified with additives.

The basic process included the following steps:

1) Soybeans were carefully washed and sorted to remove dirt and damaged beans.

2) The soybeans were soaked for 4 to 6 hours in 3 times their weight of water or dilute alkali (0.1% sodium hydroxide solution).

3) The soybeans were drained and rinsed.

4) The soybeans were ground for 5 minutes in a Waring Blendor in the laboratory or through the 023 screen of a Rietz Disintegrator. They were ground with water with or without additives in the proportions of 10 kilos water per kilo of dry beans, allowing for the water absorbed by the soybeans during soaking. The water was pre-heated so that grinding occurred at about 170° F (76° C). In some control studies, the soybeans were ground with water at room temperature.

5) The soybean slurry was filtered through a standard milk filter pad.

6) Flavoring ingredients, if any, were added.

7) The soymilks were bottled in 6 to 8 ounce soft drink bottles, capped and sterilized at 250° F (121° C) for 12 minutes.

Coconut milks were produced by grinding grated coconut meat with water (1:1) (w/v) and filtering the slurry through cloth.

When desired, the coconut milks were combined with soymilks in proportions of 1:20, 1:10 or 1:5 (v/v). Soy/Coconut milks were homogenized at 6000 psi to prevent separation of a high fat cream layer in the bottled milks.

DETERMINATION OF FLAVOR ACCEPTABILITY

Initial flavor acceptability tests were run with sixth grade children

from both public and private elementary schools in the vicinity of Los Banos and San Pablo, Laguna. Approximately 335 children were used in the taste tests. The procedure used was very simple. The soy-milks with various flavors were presented individually to the children who rated them as "like" or "dislike." The children were asked to write a comment as to why they liked or disliked the sample. The comments and suggestions of the children were used to formulate more satisfactory flavors.

Additional taste panels were organized among laboratory personnel in the Dept. of Agricultural Chemistry, University of the Philippines, College, Laguna.

These panels were used to determine fine differences among samples and also the response of adults to various flavors of soymilks. Triangle matching tests, flavor preference and flavor, color, and aroma-rating score sheets were used.

Soy or soy/coconut milks were rated on the bases of over-all acceptability and preference, considering color, flavor and viscosity. A common preference scale used was the following:

PREFERENCE SCALE	SAMPLE CODE		
	X	Y	Z
9 Like extremely			
8 Like very much			
7 Like moderately			
6 Like slightly			
5 Neither like nor dislike			
4 Dislike slightly			
3 Dislike very much			
1 Dislike extremely			

RESULTS AND DISCUSSION

It was found that unflavored soymilks made by the best processes developed to date were unacceptable in flavor to the majority of Filipino taste panels.

Approximately 33% of the Filipinos tasting unflavored soymilk produced by the method yielding the blandest flavor (Hot water (170° F) grind) indicated that it was acceptable.

Soymilks produced with a hot (170° F) grind and flavored with 5% sucrose were rated as "liked" by 107 out of 221 sixth grade children, an acceptance rate of about 48% (table 1).

TABLE 1. Over-all summary of response of Grade 6 elementary school children to soy or soy/coconut milks with various flavors

Formulation Soymilk +	No. of Children Tasting	Percent Like
Sucrose Series		
5% sucrose	221	48%
9% sucrose	243	82
Coconut milk Series		
9% sucrose + 10% coconut milk	335	83
5% sucrose + 5% coconut milk	192	78
5% sucrose + 10% coconut milk	176	85
5% sucrose + 20% coconut milk	164	86
9% sucrose + 5% coconut milk	121	96
Vanilla Series		
9% sucrose + 10% coconut milk + 1% vanilla	64	86
9% sucrose + 0.1% vanilla	184	91
7% sucrose + 0.1% vanilla	249	95
9% sucrose + 0.1% vanilla + 5% chocolate	302	96
9% sucrose + 0.1% vanilla + 5% chocolate + 10% coconut milk	273	97

The children themselves suggested raising the sugar content. When this was done, 82% of the children indicated a liking for soymilks containing 9% sugar. Another suggestion of the students, the addition of 0.1% vanilla, resulted in a rating of "like" by more than 90% of the children. With 0.1% vanilla added, it was found that the sugar content could be lowered to 7% without decreasing acceptability. Addition of chocolate (Hershey's Chocolate Syrup) at a 5% level (v/v) to the soymilk along with a sugar content of 9% resulted in a rating of "like" by 96% to 97% of the children. Addition of coconut milk also generally increased acceptability of the soymilks.

A notable exception was found at Sta. Ana Elementary School which is in the heart of the coconut plantations in Laguna. Here, addition of coconut milk to the formulations resulted in a very low acceptability- 29% (table 2). This is probably related to the fact that coconut is widely used and it has a low prestige value.

Mothers at Sta. Ana School were even more critical of soymilks containing

coconut milk. Only 20% (table 3) of the mothers rated simple soymilk containing 9% sucrose and 10% v/v coconut milk as "liked .

TABLE 2. Responses of Grade 6 children in Sta. Ana Elementary School[1] (San Pablo, Laguna) to soy or soy/coconut milks with various flavors

Formulation Soymilk +	No. of Children Tasting	Percent Like
9% sucrose + 10% coconut milk	17	29%
9% sucrose + 0.1% vanilla + 5% chocolate	22	86
9% sucrose + 0.1% vanilla + 5% chocolate + 10% coconut milk	17	74

[1] A small barrio school.

TABLE 3. Responses of mothers[1] at Sta. Ana Elementary School to soy or soy/coconut milks with several flavors

Formulation Soymilk +	No. of Mothers Tasting	Percent Like
9% sucrose + 10% coconut milk	34	20%
9% sucrose + 5% chocolate + 0.1% vanilla	32	81
9% sucrose + 0.1% vanilla + 5% chocolate + 10% coconut milk	32	78

[1] Sta. Ana Homemaker's Club, San Pablo, Laguna.

Since the children indicated a high degree of acceptability for soy or soy/coconut milks with certain flavors when the milks were given to them, the question was raised as to whether they would buy them if these were made available in the school canteens. To test them in competition with regular soft drinks, two highly acceptable soymilk formulations were used. The first contained 9% sucrose + 0.1% vanilla, a low cost flavoring combination suggested by the children themselves.

The second formulation contained 9% sucrose + 0.1% vanilla + 5% chocolate (Hershey's Chocolate Syrup). The second formulation had an ingredient costing twice as much as the first formulation. The plain soymilk was sold at 15 centavos and the chocolate at 20 centavos/7 ounce bottle.

It was found that children, particularly in the private school (Maquiling), bought the sterilized, bottled soymilk in reasonable quantities. In the public schools, however, most of the bottled soymilk was sold to teachers, as the majority of the children did not bring enough money to school each day to purchase a whole bottle of milk costing 15 to 20 centavos.

Ice candies costing 5 centavos are a very popular snack in all schools. They are flavored sugar water frozen in plastic bags. They contain no protein. Our soymilks were introduced into similar narrow (diameter about 1 ¼") plastic bags (60 ml/bag), frozen and offered for sale in the canteen. It was found that we could not produce enough to satisfy the demand. Even in direct competition, they outsold the traditional ice candies.

It became clear that if a product was to be developed to satisfy the needs of the majority of the students, economic data, regarding the purchasing power of students in the schools, were needed.

It was found (table 4) that from 12 to 24% of the children brought no money on a given day. From 39 to 65% brought 5 centavos or less to school on a given day. From 53 to 85% of the children brought 10 centavos or less to school per day. Thus, the majority of the children in the schools surveyed did not have enough money to buy a soft drink costing 15 centavos every day. On the other hand, ice soymilks were within the purchasing power of the majority of the children in the schools. This was reflected in the rate at which children purchased them. Even in the quantity consumed per ice candy, the ice soymilks contributed protein and other nutrients absent in traditional ice candies, to the benefit of the diet of the children.

TABLE 4. Summary of survey of amount of money brought by students[1] in four elementary Filipino schools[2]

Amount of money brought per day	Percent of children in category[3]
No money	12-24%
5 centavos (1.25 cents U.S.)	27- 4
10 centavos (2.5 cents U.S.)	14-20
15 centavos (3.75 cents U.S.)	7- 8
20 centavos (5.0 cents U.S.)	2- 7
25 centavos (6.25 cents U.S.)	4-10
more than 25 centavos	4-12

Additional taste studies were undertaken primarily with selected panels within the Dept. of Agricultural Chemistry, for the purpose of substantiating flavor differences, if any, among soybean varieties and among various processes of making soymilks.

No significant difference was found among the flavors of soymilks produce from Davao, Hsieh-Hsieh and Taichung soybeans using a hot (170° F) water grind.

Comparing soymilks produced by grinding the soybeans with hot water (170° F) and with cold water (90° F), it was found that 50% of the panel preferred soymilks prepared by the hot grind while 33% preferred milk made by grinding the beans with water at room temperature.

Two-thirds or more of the panel members preferred the flavor of soymilks made from Davao, Taichung, or Hsieh-Hsieh soybeans ground without hot water (170° F) through the Rietz in preference to those ground in the Waring Blendor. This may be related to the incorporation of more oxygen into the slurry during beating in a Waring Blendor. Greater oxygenation may produce more undesirable flavors.

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[1] *Survey included from 693 to 1534 students over a period of 1 week.*

[2] *Maquiling Elementary School, College, Laguna.*
Lopez Elementary School, Los Baños, Laguna.
Sta. Ana Elementary School, San Pablo, Laguna.
Sto. Angel Elementary School, San Pablo, Laguna.

[3] *Percents include widest range on any given day during week.*

The taste panel was unanimous in preferring soymilks prepared from Taichung soybeans soaked in dilute alkali (0.1% NaOH) to those soaked in water. On the contrary, only 50% of the panel preferred soymilks prepared from Hsieh-Hsieh soybeans soaked in dilute alkali to those prepared from the soybeans soaked in water.

The taste panel was unanimous in preferring soymilk containing 0.15% $NaHCO_3$ to those containing no sodium bicarbonate. The panel found 0.2% sodium bicarbonate too strong. Some 83% of the panel preferred 0.15% sodium bicarbonate to 0.1% sodium bicarbonate.

Sodium bicarbonate can be added to the grinding water or to the final milk. It was found that 50% of the taste panel preferred soymilks in which the sodium bicarbonate was added during the grinding. Thirty-three percent of the panel could not tell any difference among the milks.

Comparing regular hot grind soymilk containing 9% sucrose and 0.1% vanilla with the soymilk made by the regular formula but containing 10% coconut milk (v/v) and regular soymilk containing 5% Hershey Chocolate syrup, the taste panel gave an average score of 6.3 (like slightly) for the regular soymilk, 7.8 (like very much) for the soymilk containing 10% coconut milk, and 7.5 (like very much) for the chocolate soymilk. These ratings are based upon a scale of 9 (like extremely) to 1 (dislike extremely). The findings reflect the fact that coconut milk or chocolate covers up any residual soybean flavor. Inasmuch as coconut milk costs about the same as soybean milk, while the cost of the chocolate alone equals the cost of the other ingredients, it is obvious that coconut milk is the choice for covering or masking residual soybean flavor for soymilks processed in the Philippines.

The protein fraction of coconut milk coagulates when heated. This makes it impossible to produce a sterilized coconut milk, as the product is no longer fluid. However, when the coconut milk was combined with soybean milk, the coconut protein no longer showed any visible coagulation and the milk remained a free-flowing liquid. This was true of combinations containing as much as 20% (v/v) coconut milk. It was necessary, however, to homogenize the mixture of coconut and soybean milks to avoid separation of a high fat cream layer.

All soymilk or soy-coconut mixtures have proved to be very stable on storage. Since they are sterilized, there is no problem with bacterial spoilage. However, there would be a possibility of instability of fats resulting in rancidity. Soy and soy/coconut milks stored for over a year have shown no flavor reversion or rancidity based on taste tests.

Based upon the overall results of the flavor studies, the following process produced the most acceptable low-cost soy/coconut milk:

1) Clean soybeans carefully.
2) Soak soybeans 4 to 6 hours in 3 times their weight of 0.1% sodium hydroxide.
3) Drain and rinse.
4) Grind soybeans through the 023 screen of a Rietz Disintegrator with hot (170° F) water containing 0.15% sodium bicarbonate.
5) Filter slurry through a milk filter pad.
6) Add 10% by volume of coconut milk prepared by grinding grated coconut with water 1:1 (w/v) and filtering.
7) Add 9% sucrose and 0.1% vanilla extract.
8) Homogenize at 6000 psi.
9) Bottle in 6 to 8 ounce soft drink bottles.
10) Sterilize for 12 minutes at 250° F (15 lbs. steam pressure). Or alternatively replacing step 8, boil the milk for 30 minutes, maintaining constant volume, cool, and fill 60 ml portions into plastic ice candy bags and freeze.

The process is ready for commercialization.

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SOYBEAN RESEARCH IN THE NORTHEAST

by

Vichitr Benjasil

Among agronomic legume crops, soybean is by far the most important economic crop of the world. Soybean (GLYCINE MAX (L) Merrill) is nature of Asia but grew to prominence in the United States where it is a major source of vegetable oil and protein for humans and livestock. Major soybean production areas of the world are the United States, China, Indonesia, Japan, Korea and U.S.S.R. At present the crop is becoming increasingly important in India and many other countries where protein food is in acutely short supply.

Oil content of soybean seed ranges from 14 to 24% while protein ranges from 30 to 50%. Its oil is now used primarily as vegetable oil for shortening, margarine, salad oil and paints. The lecithin from the oil is used in baked goods, candies, chocolate, cocoa and margarine. Soybean protein contains all the essential amino acids for animal feed and human food. Whole beans are used in the production of soybean milk, curd, soy sauces, fermented products, beansprout and numerous other high protein foods in oriental countries.

Soybean has been grown in Thailand for many years mainly for human consumption. Annual production before 1950 was less than 10,000 tons but increased up to 25,000 tons in 1960 and drastically increased to 52,800 tons in 1967, at a market value of 126 million Bahts. This increase in production resulted in more extensive use of vegetable oil for human consumption and the establishment of many vegetable oil mills.

Up to the present, average yield of soybean is relatively low comparing to that of other countries (900 kgs per hectare to U.S. 1600 kgs per hectare). Attempts have been made by the Department of Agriculture and other government agencies to increase average yield of soybean per area by varietal introduction, selection and hybridization as well as to increase the annual area in production.

Most of soybean planting areas of Thailand are in the Central Plain and in the North. Less than one percent of total acreage is planted in the Northeast where soil is less fertile for most crops. Increased soybean production in this region is generally judged to be desirable. It could become an important source of cash income and provide a source of protein food supplement for humans and livestock.

Numerous soybean experiments have been carried out in many experiment

stations throughout the country. Yields fluctuate wildly ranging from 900 - 1500 kgs per hectare at Mae-Jo, 600 - 2500 kgs per hectare at Chai-Nat and about 1200 kgs per hectare at Tak-Fa. This is also the case in the Northeast in 1969- 1600 kgs per hectare were obtained from Khon Kaen Experiment Station while only 500 kgs per hectare were recorded at Kalasin.

The first soybean work at Northeast Agriculture Center was carried out in 1969. Select varieties including S.J.2 as a check were tested in field trials and 16 varieties were also planted for study and observation on adaptability to environment.

In a trial including eight varieties, two gave yields above 1200 kgs per hectare. Prospects of finding adapted varieties are promising.

No. 4	1,450	kg/hectare
Black Manchurian	1,150	"
No. 4 Shiny seed	1,700	"
S.B. 60	900	"
S.J. 2	280	"
No. 517	480	"
No. 10	130	"
No. 46 TE No. 5	85	"

Dry season plantings under irrigation for study and observation were made on Feb. 2, 1970 of 58 varieties obtained from F.A.O. and 8 promising varieties from early trials. Of this number, 30 varieties gave yields above 600 kg per hectare. A few varieties that show a promising future in the Northeast are listed with their approximate yielding capacity as follows:

	Days to harvest	Seed color	Yield Kg/hectare
Clark	100	Yellow	1875
Hark	8A	Yellow	1325
Amsoy	100	Yellow	1040
Mandarin	122	Yellow	1000
Santa Maria	105	Black	1010
S.J. 2	105	Yellow	980
Fort Lamy	122	Black	970
Hanton	100	Yellow	940
No. 4	105	Black	940

Soybean research projects underway at the Northeast Agricultural Center in 1970 are as follows:

1. Observation and Studies on Soybean Varieties:

   This work is a continuation of late season work last year. The purpose is to study and to observe these varieties, general growth characteristics, adaptability to environment including disease and insect resistance and yielding ability in order to selected those promising varieties for further test and improvement.

2. Soybean Varietal Trial:

   This test is part of soybean improvement program in cooperation with the Department of Agriculture. Fourteen varieties listed below are tested in field yield trial in Randomized Complete Block Design with 4 replications.

   1. K.S. 167 (tall type)
   2. Taichung No. 2
   3. K.S. 167 (small seed)
   4. K.S. 252
   5. 63-8 (large seed)
   6. 63-8
   7. Bominori
   8. Tailong No. 3
   9. 64 - 64
   10. N.T.U. K.S. No. 5
   11. Acadian
   12. Santa Maria
   13. 64 - 62
   14. S.J. 2 (check)

3. Molybdenum Effects on Soybean:

   The beneficial effects of molybdenum on growth of legumes has been established since 1937 (Bortels, H.) and it is generally accepted that molybdenum is required in process of nitrogen fixation and also is an essential element in enzyme reductase which reduce nitrate to nitrite in the process of protein synthesis. Increase in yield of soybean due to molybdenum application have been reported by several workers (Boswell and Anderson, Gupta and Mackay, Titatarn et. al.).

Up to 75% increase in yield was observed in some locations, however, average increase is about 21%.

A set of experiments are being carried out at Northeast Agricultural Center to study various aspects of soybean treatment with molybdenum.

3.1 Molybdenum effect on soybean grown under Northeast soil condition.

3.2 Increasing molybdenum content of seed by foliar application as a mean of supplying soybean molybdenum requirement.

3.3 Influence of seed-borne molybdenum on progeny response to molybdenum application.

4. Nutrient Deficiency Study of Soybean grown in

   a) sand culture.

   b) different series of soil of the Northeast.

5. Viability of soybean seed stored in different temperature.

6. Survey of insect pests of soybean in the Northeast. Several types of insects have been detected in soybean planting.

   These are as follows:

COMMON NAME	SCIENTIFIC NAME	GROWTH STAGE
Jassid	-	young seedling
French bean fly	Agromyza phaseoli	" "
Leaf roller caterpillar	Cacaecia micaciana	to flowering
	Lamprosema diamenalis	"
	L. indica	"
Leaf mining caterpillar	Stromopterex subsecirella	"
Leaf sucking bug	Anoploenemis phasiana	"
Leaf eating caterpillar	Heliothis armigera	"
	Prodenia litura	"
Pod boring caterpillar	unknown	after flowering
Seed boring caterpillar	unknown	" "

7. Survey and Indentification of Soybean Diseases in the Northeast:

   There is no serious diseases on soybean plantings at the present except seed rot after planting which causes poor stand. Seed treatment can overcome seed rot, however, fungicide seed treatment prevent nodulation and consequently reduces yield.

Future research program on soybean at Northeast Agricultural Center will be concentrated more exclusively on:

1. Variety selection for better adaptability and higher yield.
2. Breeding and selection for higher yield and other special purpose.
3. Cultural practice including planting date, spacing, planting method, weed control, water management and etc.
4. Fertilizer requirement.
5. Nodulation and innoculation.
6. Diseases and insects control.
7. Seed storage method.
8. Utilization.

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A SURVEY OF THE STATE OF THE ART IN THE PROCESSING OF FRESH COCONUTS FOR FOOD USE

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The objective of this survey was to determine the state of the art in the processing of fresh coconuts for food use. To obtain first hand information, the authors visited research centers in England, India, Ceylon, Thailand and the Philippines. This document presents a summary of our observations along with our conclusions and recommendations.

Before embarking on the journey, we read a number of documents received from a variety of sources which discussed new and improved processes for making a variety of coconut protein food products. In several instances, it was reported that plants had been built and were operating based on some of these processes. We could find no evidence that any such plants are in operation at this time. As far as we could find, all of the processes that have been reported in the literature with one exception have been abandoned even by their initial proponents. The exception is that of the Franklin Baker Company in the Philippines who do have the capability of drying coconut meats and expelling part of the oil to recover a press cake that can be converted into a coconut flour. However, we found no evidence that they have developed a market for this type of coconut flour.

There is still considerable research activity on coconuts, both product research and process research. The major and important area of product research is that of making a more economical and convenient coconut milk. Coconut milk is used extensively in several countries for making curries and in other food applications. Presently, most of the coconut milk is made in the home by a tedious process that is extremely wasteful both of oil and protein. Efforts to commercialize the production of coconut milk either as whole milk, concentrate or cream should be encouraged. It is estimated that by commercializing the operation, the recovery of nutrients per nut could be approximately doubled. This could be extremely important in countries where proteins and calories are both deficient.

There appears to be adequate know-how presently available to make these products. Under the direction of Mr. Amara Bhumiratana at the Institute of Food Research and Product Development of Kasetsart University, a canned concentrated coconut milk has already been developed. The Applied Scientific Research Corporation of Thailand, under the guidance of UNIDO Advisor Dr. C. Lewis Wrenshall, have developed a process for making a sterilized whole coconut milk. What is now needed is a marketing effort. It is recommended that national and international agencies concerned with food and nutrition find means for encouraging the manufacture and sale of coconut milk products in those countries where it is presently popular. For reasons that will be explained later, we do not recommend an effort be made to encourage the use of coconut milk in those countries where it is not now popular.

Another product under development at the Applied Scientific Research Corporation of Thailand that may have good potential is coconut honey which is made from coconut milk and invert sugar. It is a very tasty product that can be used as we use honey in the United States. While it might not be considered to be an important nutritive supplement in a tropical country, it conceivably could become an important item of foreign exchange. It is very possible that a good marketing company could develop this into a substantial export business. Here again, the research has been done and what is now needed is market development.

Weaning foods are under consideration by several groups. One of these is experimenting with an expeller coconut flour and if successful could have an available source of raw material supply. The others depend upon coconut milk or coconut protein isolate as a protein supplement and therefore could not become marketable until these ingredients are available. The same is true of a chocolate coconut protein drink which is based upon a coconut protein isolate. Both a weaning food and an attractive beverage could be important dietary supplements in any of the coconut producing countries. However, means for the economic recovery of the coconut proteins must first be devised.

This, of course, is the objective of the process research that is presently underway in a number of research centers. In our judgement, the process most likely to be commercially successful of those presently under investigation is that of the Tropical Products Institute in London. This is a wet process of fresh coconuts which depends upon centrifugal separation into three product streams: oil, protein and water solubles. The economic feasibility of the process has yet to be established. It is contingent upon an adequate recovery of the available oil.

This point of oil recovery bears close scrutiny. It is the real key to

any viable process for producing coconut proteins. It is one of the key factors causing the other processes that have been investigated to fail. One must look at the current uses of coconuts in order to see any proposed process in a proper perspective.

In the producing countries, coconuts are used for two purposes: food and copra. Perhaps some of the investigators in the past have been mislead by concentrating their attention solely on the food uses and ignoring the economics of the copra process. The food uses have been and still are very primitive. In the main, the coconut kernel is scraped out of the shell by hand and squeezed to recover coconut oil. The residue is discarded. The coconut milk probably, on average, represents less than half the available nutrients in the coconut. It is relatively easy to devise a commercial process that is superior to this; and in those countries where coconut milk is used in large quantities, it is our opinion as expressed earlier that a commercially produced coconut milk could become a successful product.

However, the economics of even this are not as simple and straightforward as they might seem to be at first glance. The immediate assumption is that the processor would probably pay about the same price for the coconuts as does the home user. This may or may not be true. It would have to be determined where and how the people buy their coconuts and how much they pay for them. It may be that many or most of them have their own coconut tree and never really enter the cash market. It would require some special kind of marketing arrangement to acquire these people as customers. Nonetheless, the basic idea is sound so it should be possible ultimately to overcome whatever marketing problems arise.

In some countries, such a new manufacturing facility would find that the copra industry would be their primary competitor for coconuts, The copra industry is really rather deceptive. Superficially it looks quite primitive; actually, it is quite efficient for what it is trying to do. The objective of the copra industry is to produce coconut oil and copra meal at the least possible cost. It would be difficult to devise a system that is more economical than that now in use. The coconuts are dried at or near the point of production. The cost of drying is absolutely minimal. They are dried either by the sun or in simple inexpensive kilns heated by burning coconut shells. Consequently, there is no excess weight shipped from the producing areas to the manufacturing or export centers. The relatively inexpensive expellers which are in common use can recover 94 to 95% of the available oil and there are only two product streams, both of which have enjoyed established markets. it is generally recognized that the production of copra is unsanitary and that copra is often infested with insects and mold. However, this does not appear to have

seriously affected either the market or the price for coconut oil and coconut meal. One hidden factor that is generally not considered in an evaluation of the economics of the copra processing industry is the unknown quantity of oil that is lost between the time the coconut is split open and the copra is ready to go to the expellers. This hidden loss could be an important consideration in evaluating the economics of any new process against the existing copra industry.

The other important consideration about copra is that for many of the countries it represents a very important component of their foreign exchange. Exportable items very properly have high priorities in the governments of developing countries. Any process that would reduce significantly the value of exports could not expect to be very popular. Therefore, if a process for the recovery of coconut protein only recovers 85% of the available coconut oil, this would reduce the amount of exportable coconut oil by 10%.

To look at this from another perspective, at an 85% oil recovery, each pound of protein produced would have to bear a burden of about 10¢ for the loss of oil value alone over and above the cost of the meal and any additional costs of processing. It is because of these considerations that we do not recommend an attempted introduction of traditional coconut milk into those countries where it is not now extensively used. Even commercially produced coconut milk, although having a competitive advantage over home produced milk, would probably be a substantially less efficient operation than copra processing. It sould be noted that most of the now abandoned processes started with coconut milk and ended in a maze of product streams and too-high product costs.

It is our recommendation, therefore, that any further process research for the recovery of proteins from coconuts be guided by the following criteria in the order named:

1. Economic feasibility -Probably the most important factor is an adequate recovery of the oil. One cannot overemphasize this point. For every pound of protein recovered, there will have been seven pounds of coconut oil in the process. Economically, the oil totally dominates. Any process that ignores this could be predoomed to failure. Other factors to be considered under this criterion are proper sizing and location of plants.

2. Profitable disposability of all of the products streams -This has been a major pitfall of most of the processes that have been abandoned and that are presently under investigation. While they have concentrated their attention upon one product stream, they have created four or five other streams for which markets would

have to have been developed. Ideally, a process for coconuts should yield no more than four product streams: oil, protein, fiber and water solubles. The market exists for the oil and it is presumed that markets can be developed for the protein. The fiber and the water solubles are unavoidable by-products for which markets would have to be developed.

3. Technological feasibility- Based on the accumulated judgement of the many people with whom we talked, there appear to be three processes that should be considered as a means for producing food proteins from coconuts. The first of these is to screw-press or to prepress solvent extract desiccated coconut. The major advantage of this approcah is that plants already exist in which such operations could be carried out. The major disadvantage may be the limited potential food applications of the protein products. The second process would be to prepare coconut meal by traditional solvent extraction procedures and then seek food applications for coconut flour, coconut protein concentrates, and coconut protein isolates made from that solvent extracted meal. The third process would be a modification of the centrifugal system used by the Tropical Products Institute. If successful, this process would have a number of advantages that make its greater technical challenge worth undertaking

All of the three above processes have the capacity to meet the first two criteria. In our judgement, all three are also potentially feasible from a technological point of view.

4. Market potential of the product streams -Although this should be inherent in the second criterion, it is sufficiently important to establish as an independent criterion. Each of the protein products developed by any process under investigation should be thoroughly evaluated for its highest and best potential use. It is not sufficient simply to try to do with coconut protein the same things that have been done with soybean protein. Rather, it would be important to determine those uses for which coconut protein products are uniquely useful. This should maximize both their consumption and their economic return to the producers and the processors.

5. Nutritional value -It has been traditional among protein research groups to assign top priority to nutritional value. This has led to the expenditure of large sums of research effort on nutritious formulas which have not been able to meet the challenge of the market-place. We believe that it is reasonable to start with the premise that coconut protein has been demonstrated to be nutritious and that processing technologists have become sufficiently sophisticated that

they know fairly well what to do to avoid damaging a protein's inherent nutritional value. We believe that in the processes outlined above, most of the inherent nutritional quality would be retained except perhaps for some disproportionation of amino acids that might occur during isolation procedures (similar to that which occurs during the isolation of soy protein). We do, however, believe that nutritional value should be a final criterion when food product prototypes have been developed.

In conclusion, there are a number of competent people doing research on coconut food products. To a large degree, their research suffers from too little contact with the food industry and with limited means to follow through on a product idea. It is to be hoped that this Seminar will serve as a step toward significant marketing efforts of some of these already developed products.

PROCESSING VEGETABLE PROTEIN FOODS

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I. INTRODUCTION.

As the population of the world grows there is a sense of urgency springing from the stark reality that the demand for food exceeds the supply. An estimated two-thirds of the worlds population is now living on nutritionally inadequate diets.

The consumer s affinity for meat and other animal proteins is sometimes offset by the high price and lack of supply. The high cost of meat results from the inefficiency with which animals convert vegetable protein into muscle. Efforts are being made by both plant and animal breeders to search for methods which can reduce the cost of feed per unit weight of meat, but there is no immediate prospect of altering the basic economic cleavage between animal and vegetable proteins. In order to meet the protein needs of the world's expanding population it is necessary to expand the use of protein foods from plant sources. Processing of vegetable protein foods is an important problem from the point of view of economics and nutrition. In this paper, methods for processing vegetable protein foods are briefly reviewed.

II. SOYBEAN PROTEIN

The use of soybeans to help combat malnutrition in the world well deserves attention. Specialists in production, processing, food formulation and nutrition, realize the full potential of the various forms of soybean protein.

Whatever the quality of the foods that are used to boost the nutritive content of indigenous foods, certain basic nutritional considerations must prevail. The problem we are trying to solve today is "calorie-protein malnutrition." Energy alone, or protein per se, will not correct the situation completely because the malnutrition that exists in the world today is multi-nutrient.

The priority demand of a living organism is for energy--expressed in the measuring unit of calories. However, empty calories, those combustion units unaccompanied by nutrients, have severe limitations; they do not go far in maintaining life. Protein is an energy source comparable in calorie yield to carbohydrate. In the absence of sufficient energy from other sources, protein will be used.

The value of protein lies in its specific patterns of amino acids. The amino acids are classified into "essential" and "nonessential" depending upon whether they must be supplied in the diet already formed or whether they can be synthesized by the body. Only plants can make certain of the amino acids that we need for life. Because no animal body can make them, these amino acids are called "essential". We are dependent directly or indirectly through use of other animal tissue on some plants for these dietary essential amino acids.

The terminology "essential" and "nonessential" is useful when referring to foods but it is misleading when referring to physiological requirement. The importance of the nonessential ones is equal to that of the essential ones in building and maintaining protein tissue. If the nonessential amino acids are not present when needed, the essential ones must be broken down and the molecules rearranged to form the nonessential ones.

Determining the optimal proportions in which to supply the body with dietary essential amino acids and with dietary sources of those that can be synthesized is an area that needs further research. For instance, there is evidence that top quality egg protein does not support growth as well when it is fed as the sole source of protein as when it is diluted to some degree with other sources of nitrogen. Similar results have been obtained for milk and casein. In egg protein, the ratio of essential to nonessential amino acids is approximately 1. The implication is that a ratio of 1 is too concentrated for optimal utilization. The ratio in soy protein is about 0.8.

The limiting amino acid in soy protein is methionine plus cystine. Too often the term "limiting" is used synonymously with "deficient" without referrence to whether the standard is another protein or whether it is the physiological requirement for that amino acid. In comparison with egg, soy protein is "deficient" in methionine-cystine. However, as little as 1 ounce of soy protein will supply the entire methionine-cystine requirement of an adult. If all the amino acids needed to build a complete protein are not present at the same time and in sufficient amounts, the protein will not be built at all. The time factor becomes more critical as the intake of protein and calories is reduced from optimal to minimal levels.

Protein Efficiency Ratio (PER) does not give adequate or accurate evaluation of foods intended for human consumption. It seems to have been a good tool for specialists interested in rations that would produce rapid gains in animals for a competitive market--for such purposes, the faster the growth, the better the diet. PER is not a complete enough measure of the value of foods for people. As now

measured, a standard PER involves a 2 to 4 week restricted paired feeding test with a protein level of about 10 percent in a standard dietary pattern of highly available carbohydrate and an ideal fat and assortment of minerals and vitamins. Studies made over longer than the standard 2-or-4-week feeding test indicate that PER values may change significantly during subsequent weeks of feeding. For human nutrition, evaluation of a protein must include more than PER values. Just as the PER is not enough for evaluating protein for human diets, so does our knowledge of amino acid requirements leave much to be desired. The quantitative values available to us have been obtained under rigidly controlled conditions, on semi-synthetic diets, and with individual amino acids supplied in chemically purified form. The results obtained under such conditions are helpful, but we must recognize their limitations as guidelines for building diets from foods.

The protein content of some foods of plant origin can be overestimated by frequent practice of using the factor 6.25 to convert total nitrogen to protein content. The use of the factor 6.25 began because some of the first proteins analyzed contained 16 percent nitrogen (100/16 = 6.25). This falsely assumed that all nitrogen present in food--that is, total nitrogen--was potentially protein nitrogen. It did not take into account the presence of other nitrogenous compounds such as choline nitrates, nitrites and purine bases. The nitrogen content of the principal protein in food may vary from a low of 13.4 percent for an alcohol-alkali soluble protein in avocado to high of 19.3 percent for amadin in almonds.

It is more reliable to use conversion factors for foods and feeds based upon the nitrogen content of protein isolates, but also taking into consideration the various nitrogenous compounds and the nitrogen content of the chief proteins present in the food. The factors should be substantiated by amino acid analyses. Use of these factors give the protein content of a food more accurately than does the indiscriminate use of the factor 6.25. The protein content of soybeans is more accurately represented by use of 5.71 as a factor than 6.25. Adding soy protein to mixed or indigenous foods can, indeed, significantly improve the quantity and quality of the protein available from the food items.

Cognizance must be taken of the advisability of adding the least amount of soy protein that can increase the protein supplies to the level of meeting the needs of an underfed population. Adding as little as 2 percent of soy protein to an indigenous food that is used regularly can mean a significant improvement in potential nutrient supply. Adding unnecessary amounts of soy protein not only limits the number of people who can be served from a given supply but can cause undesirable

changes in the flavor and preparation characteristics of the cereal or flour or other product to which it is added. A lifetime of malnutrition cannot be corrected by suddenly loading food with added nutrients. A malnourished body does not have the ability to utilize large amounts of protein and other nutrients thrust upon it until it has progressed well along the road to recovery.

III. SOY PROTEIN CONCENTRATES AND ISOLATES.

Much attention has been focused recently on commercial production and utilization of food-grade soy protein products (Meyer, 1967) Soy protein concentrate is the product prepared from high quality, sound, clean, dehulled soybeans by removing most of the oil and water-soluble nonprotein constituents and shall contain not less than 70 percent protein (Nx 6.25) on a moisture-free basis. Soy protein concentrates are manufactured from hexane-defatted flakes or flour by three processes, which differ primarily in the means utilized to immobilize the major protein components during separation of the low molecular weight carbohydrates, mineral matter, and other minor constituents. One process takes advantage of the fact that the protein components are insoluble in aqueous alcohol of about 60 to 80 percent concentration (Mustakas et al., 1962). Various solvent compositions and extraction temperatures can be employed and are chosen to give the minimal loss of protein compatible with an economical extraction rate of sugars and soluble matter. For economic reasons the organic solvent must be recovered in an efficient manner. Another process is based upon the long-known fact that the major soy globulins have limited solubility in aqueous acid at their average isoelectric point of about pH 4.5 (Moshy, 1964). In this process, there is a greater loss of protein nitrogen because of the solubility of the "whey" proteins at this pH. In a third process, the proteins of the soybean source material are denatured by moist-heat treatment to insolubilize the proteins. The sugars and other constituents are then extracted with water (McAnelly, 1964). All three processes are amenable to batch or continuous extraction operations. After drainage of solvent, the residual material is desolventized and dried. The product prepared by aqueous acid leaching may be neutralized with foodgrade alkali prior to drying. Drying may be accomplished in a spray drier. The yield of dried concentrate from each process is about 60-70 percent, based on the weight of defatted soybean flakes or flour.

Since the recovery of solvent is mandatory in alcohol-solvent processing, the solubles are concentrated sufficiently to permit their economical recovery in the form of a molasses like syrup or in a dry state. This product contains, primarily, the sugars, nitrogenous constituents, and mineral matter, and can be used as

an additive in feedstuffs. With aqueous processing the soluble solids can also be recovered by evaporative means.

The soy protein concentrates derived from the three basic processes contained approximately 71-72 percent protein, 3-4 percent fiber, 4-5 percent ash, 5-6 percent moisture, 0.3 percent fat and others. The residual polysaccharides in the concentrate consist mainly of arabinogalactan and acidic pectin-type polysaccharides together with some galactomannan, xylan hemicellulose, and cellulose arising from the soybean hull. The crude fiber content is indicative of the efficiency of the dehulling operation in preparing the defatted source material. The concentrates prepared by the aqueous alcohol and the water extraction process have low nitrogen solubility indices because of protein denaturation by the solvent in the former instance, and through moist heat in the latter. In contrast, the product of aqueous acid extraction, when neutralized before drying shows a higher nitrogen solubility index. Soy protein concentrates have a low flavor level and range in color from cream-yellow to light tan. High nitrogen solubility is retained in the concentrate prepared by aqueous acid leaching followed by neutralization. All soy protein concentrates possess water absorption and fat-binding characteristics, functional properties of value in various food systems. The low flavor level, together with improved absorption characteristics as compared to commercial soy flours, have been major factors in the acceptance of soy protein concentrates for food use.

SOY PROTEIN ISOLATE (97% protein on the moisture free basis) can be prepared from defatted soybean flakes or flour, which has had minimal exposure to heat in order to retain maximum protein dispersibility. The protein is extracted with an aqueous medium which may vary in pH from near neutrality to an alkaline pH. The important variables such as liquid-solids ratio, pH, time, and temperature are selected to obtain optimally economic, and not necessarily maximum yields. The aqueoud extract is separated from the fibrous residue by screening, filtering, and centrifuging devices. The pH of the clarified extract is then adjusted to about pH 4.5 with food-grade acid to precipitate the major globulin proteins. The protein curd is concentrated and washed with water by filtering, centrifuging, and combinations of the two. In most instances the protein is concentrated to a slurry or cake containing 15 to 30 percent solids.

The concentrated protein can be either dried as such, or neutralized with food-grade alkali and dried. The edible protein is sold in the neutral or sodium proteinate form since this product is water-dispersible, and hence lends itself to ready incorporation in food-products systems for maximal functional value. Potassium

and calcium proteinates have been offered for sale. Spray driers are most often used for the drying operation. The yield of soy protein isolate varies from 33 to 43 percent, based on flake or flour weight, depending upon the variety of soybeans used.

The proximate analyses of some typical soy protein isolates are as follows:

	Sample A	Sample B	Sample C
Protein (N x 6.25)%	92.8	92.2	94.7
Protein (dry basis)%	97.4	98.7	98.4
Moisture %	4.7	6.4	3.7
Crude fiber %	0.2	0.1	0.2
Ash %	3.8	3.5	2.7
Nitrogen sol. index, %	85	95	----
pH (1:10 aq. disp.)	7.1	6.8	5.5

Samples A and B are sodium proteinates and, hence are water-dispersible; whereas samples C represent the "isoelectric" form which has a lower pH, lower ash, and is nondispersible in water. When properly processed, the soy protein isolates are light in color and possess a low flavor and odor level.

IV. SPUN VEGETABLE PROTEIN FIBER.

A method for preparing textured foods from spun vegetable protein has been developed in the United States. The protein is extracted from soy meal or other vegetable sources with water and alkali and refined to yield an isolate of 97% purity. It is necessary to achieve this degree of refinement in order that disagreeable flavor components present in the raw material will be removed. The protein, in the form of a concentrated solution (10 - 30% solids) or spinning dope, is then extruded through dies or spinnerettes into a coagulating bath where fiber formation occurs. The diameter of these filaments can be varied from 0.001 to 0.030 inch after dehydration. By altering the composition of and treatment given the spinning dope, the configuration of the orifices in the spinnerettes, the composition of and conditions in the bath and the degree to which the fibers are stretched, their character can be varied from delicate, tender fibers to coarse, tenacious strands. The bath for coagulation of proteins may contain 0.5 - 2.0% salt, 0.5 - 1.0% lactic acid and 300 ppm sulfur dioxide.

The fibrils play a critical role in textured foods. They are intimately mixed with fats, flavoring, coloring, supplemental nutrients and stabilizers and

bound together with a heat coagulable protein or other binding system. The fibrils may be either aligned or randomly oriented. Each component introduces a degree of freedom in the formulation. Hence, it is feasible to prepare a wide array of highly dissimilar foods. After fabrication, individual products can be sliced, ground, or diced.

The composition of a typical vegetable protein food is as follows:

Vegetable protein fibrils (dry basis), %	50
Protein binding materials (dry basis), %	10
Fats (dry basis), %	20
Carbohydrates (dry basis), %	17
Flavors, colors, and supplemental nutrients, %	3

In the ready-to-eat state, the produce comprise 60 - 70 percent water. The fibrils may account for 30 - 60 percent of the total dry weight. Soy bean protein makes a good product because of its nutritional quality and economy. Other proteins from corn (zein), milk (casein), cottonseed, peanut, sunflower and safflower can also be spun into fibrils.

Egg albumin is used for binding the fibrils. It makes a significant nutritional contribution. It might be possible to use vegetable protein gels to supplement egg albumin with such materials.

The fat content may be varied from 9 - 50 percent of the dry weight. Higher melting fats of either animal or vegetable origin can be used. Other vegetable proteins or protein-rich materials, lactalbumin, amino acids, minerals and vitamins can be incorporated in the fiber matrix to achieve nutritional balance.

The flavor and color of the product may be improved by incorporating meat broth, meat fat, vegetable protein hydrolyzates, and flavor enhancers. Similarly, fruit pulp, spices, and other materials may be employed in the formulation.

The PER of foods fabricated from these fibrils approaches that of casein without specific amino acid supplementation. The broad range of amino acids and other ingredients used in the formulations affords the necessary complementation. Higher protein efficiency levels can be achieved by incorporating small quantities of selected amino acids or proteins.

The technology of the spun process is complex. A substantial investment is required to produce spun vegetable protein foods in commercial quantities. The economic advantages inherent in continuous processing and the improvement in efficiency offer much economic promise. On the basis of existing technology, ready-to-eat protein foods can be produced in commercial quantities for less than one-half

the cost of the corresponding cooked animal protein. Further technological sophistication and increasing output are expected to reduce further the production cost.

Spun vegetable protein can be applied to a number of new food products. Foods made from spun-protein include bacon and meat products. They will assume a role complementary to meat. In some cases, meat is incorporated in the spun-protein foods. Spun-protein foods will also be used in the following manner: (a) in formulated specialities, either alone or in combination with meat, (b) in foods with unique nutritional characteristics, and (c) in places where meat consumption is restricted for religious or cultural reasons. In formulated foods, the uniform quality and economy afforded by spun-protein meat analogs are welcomed by food processors. Because their composition can be varied and precisely controlled, spun protein foods are useful in well-defined diets and for dietary supplementation of vitamins, minerals and other nutrients. Spun-protein meat analogs are finding application among groups with religion oriented dietary restrictions. Dehydrated meat analogs prepared from spun-protein can be used as condiments for use in the home, in quick bread and casserole mixes, dips and pourable salad dressings. They are also useful to bakers and vegetable processors who would like introduce into their products additional organoleptic nutritional quantities. They are well suited to snacks, spreads, and salads.

V. OTHER VEGETABLE PROTEIN SOURCES

The production of protein foods and concentrates from plant sources has been a subject of interest to the food processors (Luh, 1969). Orr and Adair (1967) reported the use of oil seeds as a source of protein foods and concentrates.

Peanut is a good source of vegetable protein. Commercial production of peanut protein isolate has appeared in India (Milner, 1969). It is used to replace skim milk solids in "toning" of milk. Buffalo milk, the principal market milk of India, contains up to 8% butterfat. By adding peanut protein concentrate or skim milk solids to an equivalent level of the buffalo milk solids and doubling the volume with water, the final solids content remains the same but the fat is reduced to half. Starch hydrolysate can also be used as the carbohydrate source in "toning" of buffalo milk.

Peanut butter contains a rich source of vegetable protein and peanut oil. It is consumed in large quantities in the United States for peanut butter sandwiches, snack foods, and many formulated foods. In Taiwan, peanut butter was used as one of the ingredients for making ice cream. One important thing to watch is the possible occurrence of mycotoxins in moldy peanuts. The growers as well as the processors

must be aware of the fact that when certain species of molds grow in peanut, aflatoxin and other mycotoxins may occur in the product. By careful drying, packaging, storage, and inspection, the mycotoxin problem can be solved.

Cotton seed protein concentrate has a variety of specialized additive uses. It is used in relatively small concentrations for cookies, biscuits, crackers, doughnuts, and specialty bread.

Cottonseed flour utilization was started with the appearance of Incaparina in Guatemala. In this case, larger proportion of cottonseed protein was used in the food formulation, in contrast to its minor use as an additive ingredient previously. The Incaparina commercial experience, which has grown slowly but successfully in Colombia and Guatemala, has demonstrated that traditional processes for recovering oil as a primary product from cottonseed can be modified to provide nutritious and sanitary protein concentrates. The problem in adapting commercial screw presses or pre-press solvent extraction deoiling methods for production of edible cottonseed protein concentrates lies in the careful control of heat which is required to bind or otherwise render biologically inactive the toxic polyphenolic pigment of this species, gossypol. Unfortunately, this can be accomplished only with a significant loss in protein nutritive value. This loss occurs because lysine is made nutritionally unavailable by chemical binding, principally to gossypol. Cottonseed protein, even with its lysine content intact or completely available, obviously has only modest nutritional supplementation value for cereal cottonseed protein mixtures. In such cases, marked nutritional improvement can readily be achieved by adding synthetic lysine, or a lysine-rich concentrate such as soybean flour.

Use of these gossypol-inactivated cottonseed products in food mixtures at levels high enough to produce a meaningful nutritive impact is also limited by the strong yellow-green color which they confer on such mixtures. Color deteriorates even more markedly when such mixtures, usually with cereals, are heat-processed by cooking or steaming (Milner, 1969). The Southern Utilization Research and Development Laboratory in New Orleans, Louisiana has been working on the liquid cyclone technique using hexane as the suspending medium to achieve physical removal of the intact gossypol pigment glands from cotton seed protein. Laboratory samples with protein contents of up to 70% have been demonstrated. The product is very light in color and shows good promise as a source of vegetable protein for cereal products and beverages.

A new protein source may come from glandless varieties of cotton seed which evolved from genetic studies. With pigment glands and thus gossypol virtually

absent, there appear to be few problems in production of bland, light-colored products of high nutritive value. The group at the Southern Laboratory has been experimenting with the production of protein isolates from glandless cottonseed by alkali extraction, as well as by air classification methods. In contrast to soy protein isolates, these cottonseed products appear to be soluble at low pH, suggesting possibilities for applications in acid-type beverages.

Mungbean has been utilized in the oriental countries as a food, and as a raw material for food products. Bhumiratana and Nondasuta (1969) reported on protein food development work on mungbean and soybeans. They were successful in making protein-rich biscuits and cookies from wheat flour, mungbean protein, sugar and margarine. Kaset biscuits were fortified with methionine (.075%), lysine (.05%) and threonine (.025%). The basic components were wheat flour (25%), mungbean residue (dried, 25%), sugar (25%), margarine (18.8%) and fresh egg (6.2%).

They were successful in canning concentrated soy milk fortified with methionine (0.01%). Various meals supplemented with texturized mungbean protein were fed to 111 children with an average body weight of 13 kg. The target daily protein intake was set at 1.5 gm/kg body weight (19.5 gm/head) of which 0.9 gm/kg was derived from normal diet, and 0.6 gm was supplemented by texturized mungbean protein. In a 54 day feeding period, the mean weight gain for the control was 0.16 gm per month, while that with texturized mungbean protein was 0.21 gm per month.

Single cell proteins derived from yeast and bacteria has become an important research subject. Many new methods using various substrates to produce protein by yeast and bacteria have been developed. Conventional single cell proteins are derived from Torula yeast. The term "single-cell protein" has come to relate primarily to microbial fermentation of substrates such as petroleum and similar hydrocarbons (including methane) as presumably cheap sources of carbon. A very extensive literature has developed on the engineering, production, and biochemical aspects of this subject. Numerous microorganism are capable of utilizing normal alkanes. Bacteria generally have higher protein contents (50-80% dry basis), but yeasts (50-55% protein) grow at lower pH where pure culture conditions are easier to maintain. They are also easier to harvest. Yeasts are generally higher in lysine and are, therefore, useful for supplementing cereals.

There are unresolved questions concerning the composition and nutritive quality of these materials: (a) Part of the single cell protein may be present as purines, nucleic acids, and amino sugars which may be indigestible or otherwise deleterious; (b) The cheapness of petroleum or natural gas as fermentation substrates

is offset by higher oxygen requirements than needed with other substrates, and this introduces major engineering problems; (c) Purified alkanes or methane may need to be used to avoid the problems of toxic residual factors transferred from crude oil substrates, requiring the extra costs of solvent extraction; (d) efficient recovery of cells is another difficult step. This problem, incidentally, appears to be such a cost factor in production of algae in Japan that the use of these products in foods is restricted to flavoring.

Much has yet to be learned about the functionality and food uses of most single-cell proteins. Production of bland, highly functional, isolated protein products which could be made by rupturing the cells and removing cell wall debris, is considered too costly at this time.

SUMMARY

To meet the protein needs of the world's expanding population it is necessary to expand the use of protein foods from plant sources. The use of soybeans and other vegetable proteins to help combat malnutrition in the world deserves attention. The limiting amino acid in soy protein is methionine and cystine. However, as little as 1 ounce of soy protein will supply the entire methionine-cystine requirement of an adult. Cognizance must be taken of the advisability of adding the least amount of soy protein that can increase the protein supplies to the level of meeting the needs of an underfed population. Adding as little as 2 percent of soy protein to an indigenous food that is used regularly can mean a significant improvement in potential protein supply.

Attention has been focused on commercial production and utilization of food-grade soy protein products. Soy protein concentrate is the product prepared from high quality, dehulled soy beans by removing most of the oil and water-soluble nonprotein constituents and shall contain not less than 70% protein on the moisture-free basis. Soy protein concentrates are manufactured from hexane-defatted flakes or flour by one of the three processes, which differ primarily in the means utilized to immobilize the major protein components during separation of the low molecular weight carbohydrates, mineral matter and other constituents. The three processes are based on the following principles: (a) the protein components are insoluble in aqueous alcohol of about 60-80% concentration; (b) the major soy globulins have limited solubility in aqueous acid at pH 4.5; (c) the proteins of the soy bean are denatured by moist-heat treatment to insolubilize the proteins, and the sugars and other constituents are then extracted with water. All three processes are amenable to batch or continuous extraction operations. After drainage of solvent the residual

material is desolventized and then spray dried. The yield of dried concentrate from the process is about 60-70%, based on the weight of defatted soy bean flakes or flours. The soy protein concentrates possess water absorption and fat-binding characteristics, functional properties of value in various food systems. The low flavor level, together with improved absorption characteristics as compared to commercial soy flours, have been major factors in the acceptance of soy protein concentrates for food use.

Soy protein isolates containing 97% protein on the moisture free basis can be prepared from defatted soy bean flakes or flour, which has had minimal exposure to heat in order to retain maximum protein dispersibility. The protein is extracted with an aqueous medium which may vary in pH from near neutrality to an alkaline pH. The aqueous extract is separated from the fibrous residue by screening, filtering and centrifuging devices. The clarified extract is then adjusted to pH 4.5 with food-grade acid to precipitate the major globulin proteins. The protein curd is concentrated and washed by filtering and centrifuging. The protein preparation is concentrated to a slurry of 15-30% solids, and then spray dried. It can also be neutralized with food-grade alkali prior to spray-drying. The edible portion is sold in the neutral or sodium proteinate form since this product is water-dispersible, and hence lends itself to ready incorporation in food-products systems for maximal functional value.

A method for preparing textured foods from spun vegetable protein and utilization of vegetable proteins from other sources are described.

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การเพิ่มปริมาณโปรตีนในข้าว

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ข้าวเป็นอาหารหลักของคนไทยทั้งชาติ ปริมาณโปรตีนส่วนใหญ่จึงได้รับมาจากข้าว โดยเฉพาะในท้องถิ่นชนบทที่ห่างไกล คนเหล่านั้นได้โปรตีนจากอาหารสัตว์น้อยมาก แทบจะเรียกได้ว่าโปรตีนเกือบทั้งหมดที่ได้รับมาจากข้าวอย่างเดียว บางท้องที่จึงมีปัญหาการขาดโปรตีนเกิดขึ้นแก่เด็ก ๆ โดยเฉพาะในระยะอายุก่อนเข้าโรงเรียน การเพิ่มโปรตีนในอาหารเป็นสิ่งที่ควรคำนึงถึงเพื่อสุขภาพอันดีของประชากรไทยโดยทั่วไป การเพิ่มโปรตีนในข้าวเป็นสิ่งหนึ่งที่น่ากระทำ นอกเหนือจากการทำอาหารโปรตีนราคาถูกให้เข้าถึงครอบครัวที่มีรายได้ต่ำ เพราะการเพิ่มโปรตีนในข้าวบังเกิดผลโดยกว้างขวางทั่วไปหมดทุกครอบครัว ผู้บริโภคไม่รู้สึกว่าได้รับประทานข้าวที่มีคุณภาพดีขึ้นไม่เหมือนกับการฝืนรับประทานอาหารที่แปลกใหม่ต่ออาหารประจำวันที่เขาคุ้นเคย ถ้าคนไทยทั่วไปได้รับประทาน-ข้าวที่มีโปรตีนเพิ่มขึ้นอีกสัก 10–20% ของปริมาณเดิมก็เป็นที่น่าพอใจแล้ว

ความสำคัญของอาหารโปรตีนไม่ได้อยู่ที่ปริมาณโปรตีนเสมอไป แต่อยู่ที่คุณภาพโปรตีนของอาหารนั้น ๆ กล่าวคือโปรตีนของอาหารนั้นมีปริมาณกรดอมิโนแต่ละชนิดได้สัดส่วนตามความต้องการของร่างกายหรือไม่ การขาดกรดอมิโนอย่างหนึ่งอย่างใดที่จำเป็นต่อร่างกาย หรือมีอย่างหนึ่งอย่างใดมากเกินไปก็ทำให้เสียสัดส่วนและโปรตีนชนิดนั้นด้อยคุณภาพ โปรตีนสัตว์มีคุณภาพดีกว่าโปรตีนพืช ในบรรดาธัญญพืชทั้งหลายโปรตีนข้าวนับว่ามีคุณภาพดีกว่าชนิดอื่น ๆ กรดอมิโนไลซีนซึ่งธัญญพืชชนิดอื่นมักจะขาดนั้นมีอยู่ประมาณ 3.7% ของโปรตีนข้าว ปริมาณกรดอมิโนบางชนิดในข้าวไม่เป็นปัญหาใหญ่เท่ากับในเรื่องข้าวโพดหรือข้าวสาลี ในเมื่อคุณภาพของโปรตีนข้าวไม่เป็นสิ่งที่ต้องวิตกมากนักแล้วดังนี้ จึงเพียงแต่หาทางให้ได้ข้าวที่มีโปรตีนสูง ก็จะช่วยให้เกิดประโยชน์ได้มาก

โดยปกติปริมาณโปรตีนในข้าวอยู่ในราว 6–9% ปริมาณโปรตีนในข้าวเกี่ยวข้องกับพันธุ์และสภาพแวดล้อมประกอบกัน ในการสำรวจปริมาณโปรตีนในข้าวรวม 1,787 สายพันธุ์ พบว่ามีปริมาณโปรตีนตั้งแต่ 5.4 ถึง 12.3% แสดงว่าข้าวต่างพันธุ์อาจมีปริมาณโปรตีนต่างกันได้ถึง 7% ซึ่งนับว่ามีความหมายในด้านคุณค่าทางอาหาร ข้าวพันธุ์ใดมีปริมาณโปรตีนถึง 10% ขึ้นไปนับได้ว่าอยู่ในเกณฑ์ที่สูงเป็นที่พอใจ การศึกษาปริมาณโปรตีนในข้าว

พันธุ์ต่าง ๆ แล้วพยายามคัดเลือกสายพันธุ์ที่มีโปรตีนสูง และเลือกผสมพันธุ์ไว้จะทำให้ได้พันธุ์ข้าวโปรตีนสูงในที่สุด การกระทำเช่นนี้เป็นโครงการระยะยาว เนื่องจากต้องใช้เวลานานในการคัดเลือกพันธุ์และผสมพันธุ์ แต่ทว่าถ้าได้-ผลออกมาแล้วจะเป็นผลที่ถาวรและแน่นอนกว่าวิธีการอื่น

ในการปรับปรุงพันธุ์ข้าวเพื่อให้ได้ข้าวพันธุ์ใหม่ที่มีปริมาณโปรตีนสูงดังกล่าว เราไม่อาจคำนึงถึงผลทางด้านปริมาณโปรตีนอย่างเดียว ต้องนึกถึงด้านผู้ผลิตและผู้บริโภคด้วย ในด้านผู้ผลิตนั้นชาวนาย่อมคิดถึงผลผลิตต่อไร่กับความต้านทานโรคยิ่งกว่าสิ่งอื่น ตามผลของการวิจัยผู้เขียนพบว่าปริมานโปรตีนจะกลับกันกับผลผลิต ถ้าโปรตีนสูงผลผลิตมักต่ำ ข้าวที่มีผลผลิตสูงมักมีโปรตีนต่ำ ข้าวพันธุ์ IR 8 หรือที่เรียกกันว่าข้าวมหัศจรรย์ซึ่งมีผลผลิตสูงมากมีโปรตีนราว 6–7% เท่านั้น บางครั้งมีผู้คิดเป็นปริมานโปรตีนต่อไร่ ดังนี้ในเนื้อที่ 1 ไร่เท่ากันข้าวโปรตีนสูงผลผลิตต่ำ กับข้าวโปรตีนต่ำผลผลิตสูง จะให้ปริมาณโปรตีนคิดตัวเลขออกมาแล้วใกล้เคียงกัน แต่ในด้านอาหารแล้วเราจะคิดทำนองนั้นไม่ได้ คนเราบริโภคข้าวได้ในปริมาณจำกัด สมมุติว่าวันหนึ่งบริโภคได้เพียง 500 กรัม ก็ควรที่จะบริโภคข้าวที่มีโปรตีนสูงไว้ก่อน อนึ่งปริมาณของปุ๋ยที่ใช้ก็เป็นของสำคัญ ถ้าหากให้โปรตีนสูงมากโดยต้องใช้ปุ๋ยไนโตรเจนมาก จะไม่มีผลในทางเศรษฐกิจนัก เพราะชาวนาย่อมคิดถึงรายจ่ายมากกว่าปริมาณโปรตีนซึ่งแลไม่เห็น การศึกษาพันธุ์ข้าวรวมกันไปกับอัตราปุ๋ยไนโตรเจนที่ใช้,ผลผลิต,และปริมาณโปรตีนกำลังกระทำอยู่ นอกจากนั้นความต้านทานโรคเป็นสิ่งที่ต้องพิจารณาอย่างยิ่ง ข้าวพันธุ์ กข 1 และข้าวพันธุ์ กข 3 ซึ่งเป็นพันธุ์ใหม่ที่กรมการข้าวได้แนะนำแก่ชาวนาเป็นพันธุ์ที่ต้านทานโรคใบสีส้ม อันเป็นโรคที่ระบาดอยู่ขณะนี้ ปริมาณโปรตีนของข้าวทั้งสองพันธุ์นี้อยู่ในเกณฑ์ปานกลางประมาณ 7—8% สำหรับในด้านผู้บริโภคก็มักคำนึงถึงคุณภาพภายหลังการหุงต้ม คนไทยเราเป็นนักกินข้าว พวกเราโดยมากพิถีพิถันในคุณภาพของเมล็ดข้าวที่หุงแล้วว่าถูกปากถูกใจเราแค่ไหน ข้าวไทยเราแต่ดั้งเดิมมีอยู่หลายพันธุ์ที่กิน "อร่อย" ถึงแม้ได้ข้าวโปรตีนสูงมาทั้งยังมีคุณภาพอื่น ๆ เป็นอย่างดีประกอบ ถ้าหากไม่ถูกใจผู้บริโภคก็จะไม่ได้ผลสมบูรณ์

ความต้องการที่แท้จริงคือต้องการข้าวที่มีโปรตีนสูง ผลผลิตดีต้านทานโรคได้ คุณภาพในด้านการหุงต้มดีซึ่งนับว่าเป็นความปรารถนาค่อนข้างหลายประการ ผลที่สุดคงจะได้สมบัติไม่ครบถ้วนตามนี้ แต่ขอให้เราตั้งความหวังเอาไว้ก่อน ประการสุดท้ายที่ควรกล่าวรวมไว้ด้วยคือแหล่งปลูก ประเทศไทยเรามีภาคเหนือ ภาคตะวันออกเฉียงเหนือ ภาคกลาง และภาคใต้ซึ่งมีสภาพดินฟ้าอากาศผิดกัน ข้าวที่จะให้สมบัติครบถ้วนดังที่กล่าวแล้วนั้นควรปลูกในที่ใดก็ได้ กล่าวคือไม่ว่านำไปปลูกในภาคไหนควรให้สมบัติใกล้เคียงกัน ขณะนี้การทดลองได้กระทำพร้อมกันทั้งสี่ภาค

ธัญญพืชอีกอย่างหนึ่งที่กำลังอยู่ในระหว่างการปรับปรุงคุณภาพและปริมาณโปรตีนคือข้าวโพด ในประเทศไทยข้าวโพดไม่ใช่อาหารสำคัญของคนไทย ปัจจุบันเรานำมาประกอบอาหารบางชนิด ใช้เป็นส่วนประกอบของขนมหลายอย่าง แต่มิใช่เป็นอาหารประจำวัน เรามักใช้ข้าวโพดเป็นอาหารของสัตว์ซึ่งก็ต้องการโปรตีนเช่นเดียวกัน ข้าวโพดมีปริมาณโปรตีนประมาณ 8—12% แต่คุณภาพโปรตีนของข้าวโพดต่ำกว่าของข้าว เพราะขาดกรดอมิโนไลซีน ในสหรัฐอเมริกาได้มีผู้ปรับปรุงพันธุ์จนได้ข้าวโพดพันธุ์ใหม่มีไลซีนสูง เช่น Opaque—2 อย่างไรก็ตามลักษณะของเมล็ดไม่เป็นที่นิยมนัก เป็นเมล็ดที่ขุ่นไม่ใส ค่อนข้างนิ่ม และเก็บไม่ทน ถูกแมลงและเชื้อราทำลายง่าย ขณะนี้มหาวิทยาลัยเกษตรศาสตร์ กำลังมีการสำรวจปริมาณโปรตีนและปริมาณไลซีนของข้าวโพดพันธุ์พื้นเมือง และพยายามที่จะคัดเลือกพันธุ์และผสมพันธุ์ เพื่อชักนำ genes ที่มีไลซีนสูงเข้าไปในข้าวโพดบางพันธุ์ที่มีลักษณะอย่างอื่นดีทำนองเดียวกันกับเรื่องข้าว ความปรารถนามีหลายประการ คือต้องการข้าวโพดพันธุ์ที่มีโปรตีนสูง ไลซีนสูง ผลผลิตดีลักษณะเมล็ดตามความนิยม ความต้านทานแมลงดี เก็บรักษาไม่ลำบาก

3 classes as follows:

Class	Range in Protein	No. Lines	% of population
Low Protein	5.00 to 6.50	157	8.8
Medium Protein	6.50 to 8.50	1466	82.0
High Protein	8.50 to 12.50	164	9.2

Selected lines from each of the above classes are presently growing at the BKN, SPT, SRN and KGT Rice Experiment Stations under uniform soil conditions to more accurately assess whether fluctuations in protein content were due to genetic or environmental conditions. (See Item 2).

A total of 1407 non-glutinous and 380 glutinous lines from the genetic stock were analyzed. Separation of the population by endosperm characteristics (See Figure 2) did not indicate a close relationship between high protein and glutinous endosperm.

Reference is made to item number 4 of the original sheet which pertains to further study of the 16 high protein lines from Thailand which were identified by IRRI scientists.

The lines were planted during December 1968 while daylength was short at the BKN Rice Experiment Station along with 4 check varieties. Since they were sensitive to photoperiod, flowering occurred quickly and yield data were not meaningful. Protein percentages have been determined on 7 of these lines and the results are as follows:

Variety Name or Accession No.	% Protein (Wet Basis) Grown at BKN
Acc. 7471	11.97
Acc. 8282	11.74
Acc. 8208	11.91
Acc. 8210	11.83
Acc. 8211	10.92
Acc. 8115	10.98
Acc. 8292	11.66
Gam Pai Hybrid 4-1-2-1 (CK)	9.53
IR 8 (CK)	7.96
C 4-63 (CK)	10.14
Leuang Tawng (CK)	11.83

STUDIES ON THE PROTEIN CONTENT OF RICE[1]

Dr. Ben R. Jackson, Mr. Sermsak Awakul
and Dr. Krisna Chutima[2]

Reasons for Undertaking the Work

Rice constitutes a major part of the diet of the Thai people and especially for those living outside of Bangkok. An appreciable quantity of the protein is lost in the milling process since the bran and polish are higher in protein than the endosperm. Unlike most other cereal grains, there is a reasonably good balance of the essential amino acids, thus the primary problem is not so much to supplement with certain amino acids as to simply find ways to increase the protein content. The problem of protein deficiency in the diet of the Thai people becomes most acute in the Northeastern region where there is a lack of animal protein and seafood.

In wheat and corn the protein and amino acid content has been found to be under genetic control. Breeding work has shown that the genes controlling these characters can be transferred to improved varieties. There is some evidence to suggest that in rice high protein content is also heritable and recent reports from the Cereal Chemists at IRRI have confirmed the earlier observations.

High protein content is important not only to Thailand but to some of her neighbors who depend on Thai rice exports to feed their people. Since many different indigenous varieties are grown the throughout the kingdom, a preliminary screening of existing material for protein content would appear worthwhile.

Past and Present Work

A total of 1787 lines from the Genetic Stock belonging to the Breeding Division were analyzed for protein content using duplicate samples to serve as a check against the original analysis.

Figure 1 shows the frequency distribution of the entire Genetic Stock collection which ranges from 5.00 to 12.25 percent content with a mean protein content of 7.48 ± 1.65. For purposes of classification, these were divided into

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[1] *A cooperative project between Kasetsart University and the Rice Department, Ministry of Agriculture, Bangkok, Thailand.*

[2] *Rice Breeders, the Rice Department and Chemist, Kasetsart University.*

Protein Content Study of Variety-Fertilizer Tests at BKN and KLG

Major emphasis has been placed on the breeding of varieties which produce high grain yields when supplied with the proper inputs including fertilizer, insecticides and good water control. Frequently, claims have been made that the so called "Miracle Rice" varieties have produced 200 to 400 percent more than the indigenous strains. At least a part of the new technology has been transferred from the laboratory and field experiments to the farmers themselves as evidenced by the rapid rise in rice production in certain countries of Southeast Asia.

Since rice is the basic food of the Thai people and the average annual consumption is estimated at approximately 190 kilograms of paddy, investigation of the effect of fertilizer on the protein content of the rice grain of selected varieties seemed appropriate. Accordingly, grain samples were obtained from Variety-Fertilizer experiments that had been conducted at different stations throughout the country. Protein analysis of the grain was conducted by Dr. Krisna Chutima, Biochemist at Kasetsart University. Statistical analysis of the data was performed by personnel of the Statistics section of the Rice Breeding Division.

Data in Table 1 were obtained from protein analysis of samples originating from the Variety-Fertilizer tests grown at BKN and KLG experiment stations which were presented earlier in Table 2. Statistical correlations were made between the following characteristics (1) percent protein and yield and (2) percent protein and fertilizer. The results indicated that none of the correlations or regression coefficient were statistically significant. However, there is a strong tendency for the unfertilized plots to be highest or near the highest in protein content.

The data in the following table represents the average yield and protein content of the 4 varieties presented in Table 2. Yields and protein were converted to percent of the check or "Zero" nitrogen treatment in an attempt to more easily show the effects.

Table 1

Fertilizer N in Kg/ha	BKN		KLG	
	Protein % of check	Yield % of check	Protein % of check	Yield % of check
0	100	100	100	100
24	83	189	88	180
48	86	215	93	196
72	89	245	92	233
96	95	258	101	241

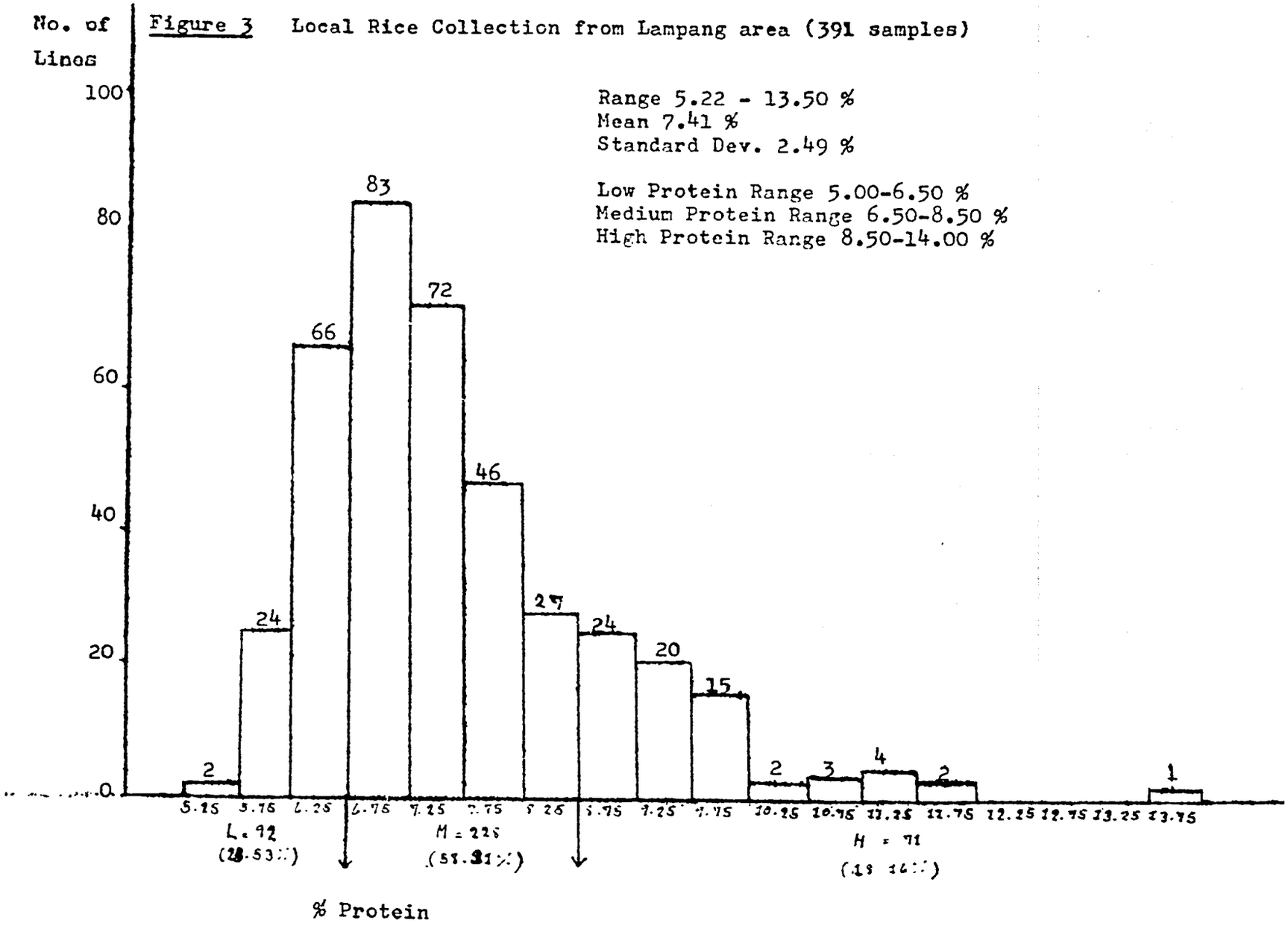


Figure 3 Local Rice Collection from Lampang area (391 samples)

The above material is presently growing under field conditions at several different experiment stations. It is anticipated that growth will be normal and thus permit valid comparisons of yield and protein content.

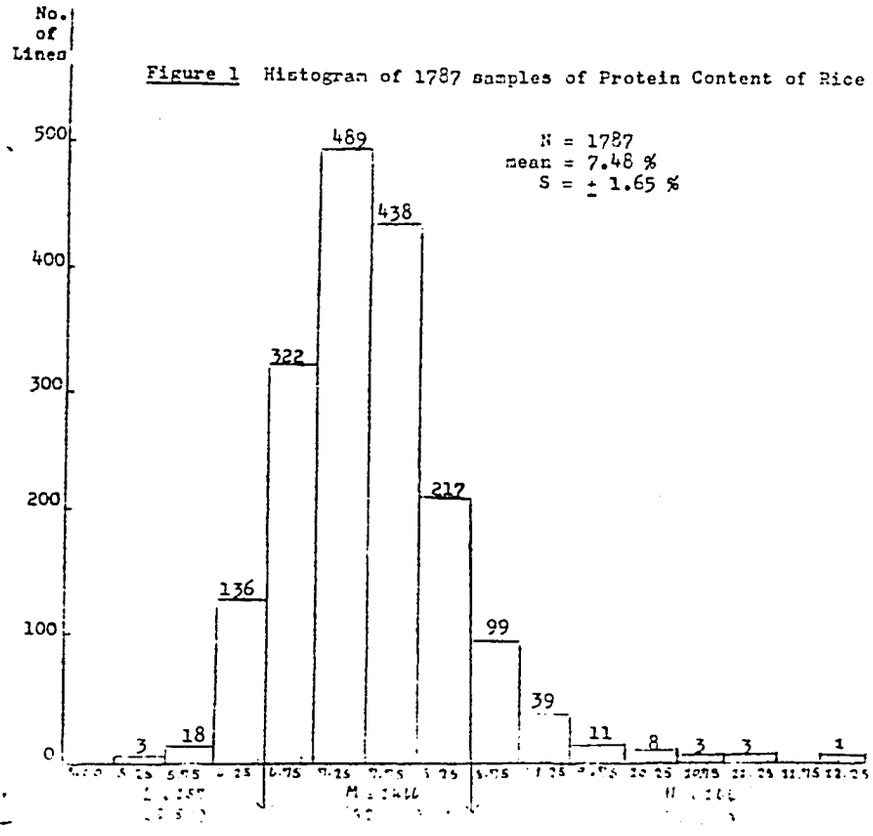
Point number 5 of the original report outlined plans to make additional collections of local varieties from the Lampang area where the first high protein lines were found. Shortly after harvest, personnel of the San Patong and Pan Stations in the North were requested to travel through the province (Changwad) of Lampang and collect samples. A total of 390 samples were received and protein analysis has been completed.

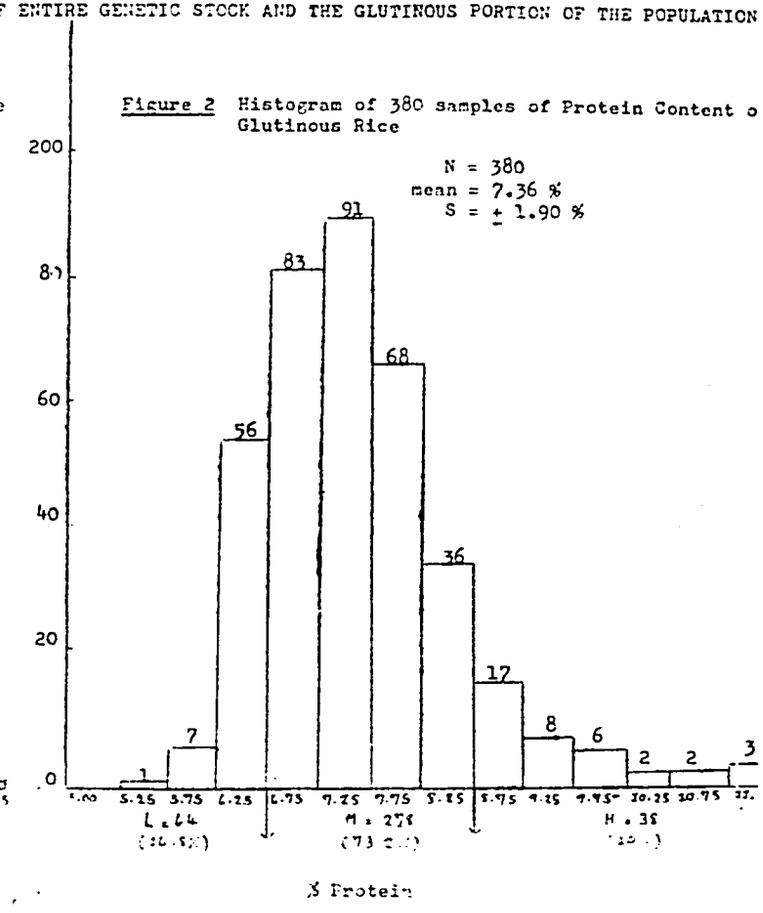
Figure 3 presents the frequency distribution for these samples which ranged between 5.25 and 13.75 percent protein with a mean of 7.41 and standard deviation of ± 2.49. Eight different Amphoes contributed to the collection but differed markedly in the number of high protein lines contributed as may be seen in the following table:

Amphoe	No. Samples Collected	High Protein Samples No.	High Protein Samples %
Chae Hom	86	26	33.1
Term	61	19	31.1
Ko Kah	24	11	45.8
Sob Prahb	35	10	28.6
Ngao	91	5	5.5
Muang	19	-	-
Maeta	27	-	-
Hahng Chot	47	-	-
Total	390	71	18.2

Almost all of the samples that contained more than 9 percent protein were designated as upland type; that is, they were grown on sloping land. Under such conditions, yields are generally less than lowland - rice which is usually not subjected to drought stress. Thus, at least a part of the high protein content may be the result of association with low productivity. All high and few low protein samples have been planted under uniform lowland conditions at the BKN Station to determine whether large genetic differences do exist.

FIGURES 1 AND 2. SHOWING DISTRIBUTION OF PROTEIN CONTENT OF ENTIRE GENETIC STOCK AND THE GLUTINOUS PORTION OF THE POPULATION





Protein content of IR5 Variety-Fertilizer Experiments in Central and Northeast Regions

Grain samples from the IR5 Variety-Fertilizer trials grown in the Central Plain and Northeastern regions were analyzed for protein content by variety, location and fertilizer level. The data were of particular interest since comparison could be made of the new hybrids and present recommended varieties.

The following table presents the results by location and is a condensation of Tables 3 and 4 found in this report.

Central Plain (3 Stations)

Variety	Low Rate (N6)		High Rate (N12)	
	Yield	% Protein	Yield	% Protein
NMS-4	463	7.51	477	8.39
LPT 123	502	7.09	455	7.59
C4-63	642	7.10	733	7.64
IR5	697	6.89	773	7.39
Average	576	7.15	609	7.75

Northeast (4 Stations)

Variety	Low Rate (N12)		High Rate (N24)	
	Yield	% Protein	Yield	% Protein
Gam Pai	595	7.01	619	7.95
NSPT	623	7.21	657	7.58
IR5	645	7.01	717	7.61
G.P.Hyb. 4-1-2-1	703	7.92	774	8.27
Average	641	7.29	692	7.85

In the Central Plain, protein content appeared to be associated with variety yields at both fertility levels. At the high fertilizer level (N12), a significant correlation coefficient (-.576) was obtained between protein content and yield. The higher fertilizer level also produced a consistent increase in protein content.

At both experiment stations the addition of the first increment of nitrogen (N 24) produced the largest percent increase in yield (Between 80 and 90 percent) but also resulted in the lowest protein content of any treatment. Yields and protein content continued to increase as additional increments of nitrogen were applied until the protein content of the grain attained about the same percent as the 0 nitrogen check. The implications are as follows:

1. If the farmer applies only a minimal amount of fertilizer to his rice he will obtain a large economic gain in the form of additional yield.

2. Consumers will obtain less protein from the rice than when the farmer did not apply fertilizer.

3. A systematic search for genetically high protein varieties should be initiated in order to offset the disadvantage of eating low protein rice grain.

Table 2 Protein content of 4 varieties grown under 5 fertility levels at BKN and KLG, 1968 Wet Season

Fertilizer Levels	IR5		C4-63		56-1-2 LT x IR8		CNT 3176 LY/2 x T(N)1	
	BKN	KLG	BKN	KLG	BKN	KLG	BKN	KLG
0	8.22	7.02	9.25	7.65	9.56	7.63	10.44	7.34
24	7.26	6.40	7.54	6.57	7.82	6.54	8.30	6.66
48	7.56	6.85	8.00	7.18	7.73	6.51	8.95	7.10
72	7.60	6.49	8.38	7.23	8.23	6.79	9.12	6.90
96	8.43	7.51	8.87	7.59	8.45	7.12	9.71	7.84
Average	7.81	6.85	8.41	7.24	8.36	6.92	9.30	7.17
Protein x Fert. (None of the following estimates were significant at 5% level)								
r	.245	.381	.018	.198	.390	.259	.125	.433
b	.003	.004	.0003	.002	.007	.003	.003	.005
Protein x Yield (None of the following estimates were significant at 5% level)								
r	-.220	-.034	-.233	-.015	-.695	-.563	-.404	-.0617
b	-.006	-.00009	-.0009	-.00005	-.003	-.002	-.0027	-.0002

r Correlation coefficient

b Regression coefficient

The Northeast experiments received twice as much nitrogen fertilizer as the Central Plain but this had very little effect on average protein content. Correlations between yield and protein were even less than the Central Plain. This might be due to yields of the 4 varieties being more closely the same since the recommended varieties were not attacked by Yellow-Orange Leaf Virus. The performance of Gam Pai Hybrid 4-1-2-1 is of interest since it not only produced the highest yields under both fertilizer levels but was considerably higher in protein content than any other variety. In addition to having a glutinous endosperm, this line has excellent plant type, long grain, stiff straw and is non-sensitive to photoperiod.

Table 3. Yield and protein content of 4 varieties of rice grown in Variety-Fertilizer tests at 3 locations in the Central Plain, 1968 Wet Season

Variety Name	CENTRAL PLAIN											
	Low N Level (N6)						High N Level (N12)					
	CNT		SPR		BKN		CNT		SPR		BKN	
	Yield Kg/Rai	Protein Content %	Yield Kg/Rai	Protein Content %	Yield Kg/Rai	Protein Content %	Yield Kg/Rai	Protein Content %	Yield Kg/Rai	Protein Content %	Yield Kg/Rai	Protein Content %
LPT 123	599	6.82	575	6.28	333	8.17	520	7.40	553	6.64	293	8.66
NMS-4	616	7.10	465	6.58	307	8.84	626	7.80	512	7.62	293	9.76
IR5	844	6.54	633	6.10	615	8.03	889	6.84	760	6.58	669	8.76
C4-63	774	6.78	509		644	8.32	877	7.79	660	6.81	663	8.31
Average	708	6.81	546	6.29	475	8.34	728	7.46	621	6.91	480	8.87
			r = -.473 ns						r = -.576 *			
			b = -.003 ns						b = -.003 ns			

ns = Non Significant

* = Significant at 5 % level.

Table .: Yield and protein content of 4 varieties of rice grown in Variety-Fertilizer tests at 4 locations in the Northeast, 1968 Wet Seasc

Variety Name	NORTHEASTERN REGIONS															
	Low N Level (N12)								High N Level (N24)							
	PMI		SKN		SRN		KKN		PMI		SKN		SRN		KKN	
	Yield Kg/Rai	Protein Content %	Yield Kg/Rai	Protein Content %	Yield Kg/Rai	Protein Content %	Yield Kg/Rai	Protein Content %	Yield Kg/Rai	Protein Content %	Yield Kg/Rai	Protein Content %	Yield Kg/Rai	Protein Content %	Yield Kg/Rai	Prc Con %
NSPT	680	6.10	668	7.77	564	6.69	581	8.17	733	6.93	627	7.37	588	7.48	680	8.
Gam Pai	646	6.32	691	7.64	516	6.76	468	7.32	730	7.32	626	9.10	602	7.75	518	7.
IR5	643	6.00	703	7.03	709	7.09	524	7.90	776	5.43	815	8.20	721	6.85	558	9.
G.P.Hybrid	686	5.70	778	7.78	612	6.12	736	10.23	827	6.84	833	8.70	594	8.27	844	9.
Average	664	6.03	710	7.56	615	6.69	577	8.41	767	6.63	725	8.34	626	7.59	650	9.
			r = .082^{ns}										r = -.192^{ns}			
			b = .001^{ns}										b = -.002^{ns}			

ns = Non Significant

FEEDING OF INFANTS WITH RICE-MILK MIXTURES

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Pre-cooked rice powder is quite popular among Chinese families of low socio-economic class for weaning babies in recent years. Paste prepared with the rice powder might be better than rice gruel in a sence that it is more concentrated in calories. However, rice powder is not suitable for feeding infants as the sole or main protein source, since its protein level is low and its protein is short in lysine content. Protein level of the commercial pre-cooked rice powder preparations, which are flavored with sugar, ranges between 7.1 and 7.5%. Net protein utilization (NPU) of rice is known to be rather low, 57, in rats.[1] Considering its acceptability to the poor mothers, the pre-cooked rice powder was mixed with skim-milk powder by various ratios and the nutritive value of the mixtures was studied with rats and normal infants. Nutritive value of two mixtures of rice powder and wholemilk were also studied. The results of this study show that some of these mixtures can be used successfully in infant feeding.

MATERIALS AND METHODS

Rice-skim milk mixtures: Two kinds of pre-cooked rice powder was used in the present study. One is a non-commercial preparation. Rice was cooked into gruel, treated with amylase, drum dried and pulverized. This rice preparation does not have particular odor and used in all four mixtures. Another is a commercial one (Santa Claus Brand) which contains 7.1% protein. Rice was cooked, heated to dryness and then pulverized. It is white in appearance and has pleasant odor. RM-2 and RM-3 (Table 1) contained this preparation.

Rice powder and skim milk powder were mixed by the ratio of 2:1 (RM-1), 4:1 (RM-2), 9:1 (RM-3) and 5:1 (RM-4), and adequate amounts of vegetable oil, sugar, mineral and vitamin mixtures were added (Table 1). Protein, fat and energy value of the food mixtures are shown in table 2. 250 g of the powder mixture was blended with 1000 ml of water, distributed in bottles and steamed.

Dry skim milk powder used was made in U.S.A. and the dry whole milk powder used was of OAK brand of Australia.

Rice-whole milk mixtures were formulated as shown in table 1.

SELECTION OF INFANTS:

Infants studied were selected from volunteer families. Their parents were usually both working and paid visits to the clinical research centre quite often. Infants' ages ranged from $2\frac{1}{2}$ to 7 months on admission but mostly 4 to 6 months of age. Infants applying for admission were first examined by a pediatrician and those who had acquired chronic diseases, congenital abnormalities or were very poorly nourished were omitted. Their body weights between plus and minus 15 per cent. of the mean weights of normal Chinese infants of the same age and sex group. Only one marasmic baby was admitted for therapeutic purpose.

FEEDING AND CARE OF INFANTS:

On admission, an infant was usually given a milk formula (M-2), and then a test diet was given gradually in increasing amounts, replaced completely 5 to 7 days later. All babies were fed five times a day and the amount taken was recorded each time within an error of ± 5 gm. Some fruits such as banana, papaya and orange juice were given once a day. Some biscuits were given to infants of more than 7 months of age.

Body weight and height of the infants were measured three times a week and once every 2 weeks respectively. Body temperature was measured twice a day and the frequency of defecation and nature of stools were checked and recorded. Physical examination was conducted by a pediatrician routinely, and if necessary treatment was given. All infants were taken care of by full-time nurses and aides for the whole time.

ANIMALS:

Weanling male albino rats were used for the determination of protein efficiency ratio and net protein utilization.

RESULTS

PROTEIN EFFICIENCY RATIO: PER of RM-1 and RM-2 was determined with weanling albino rats, 5 in each group. Protein level of the test diets was 10%, and a 10% casein diet served as the control. PER calculated were 2.73, 2.45 and 2.65 for RM-1, RM-2 and casein diet respectively. It is apparent that the mixed proteins of rice and skim milk is good in quality and comparable with casein protein.

NET PROTEIN UTILIZATION: Net protein utilization was also studied with weanling albino rats.[2] Protein level of the test diets was 10%. NPU of RM-1 and casein calculated from the data obtained were 72 and 65 respectively. These data indicate the superiority of RM-1 over casein as the protein source.

FEEDING OF INFANTS WITH RICE-SKIM MILK MIXTURE NO. 1 (RM-1): Ten boys of 3- to 7-month old were subjected to a growth test with RM-1, mostly for 3 months.

Because RM-1 contains 27% of skim milk, appearance of the liquid preparation is milky but has higher viscosity than cow's milk. Protein level of the liquid formula is 2.7%, and its caloric content is 83 calory per 100 g. Calculating from the data obtained during 8th to 17th or 8th to 27th day of the feeding, the range of daily calory and protein intakes were 98-135 calories and 3.1 to 4.4 g per kg body weight. The average intakes were 113 calories and 3.7 g respectively.

Seven out of 10 boys gained their weight satisfactorily or excellently as can be seen from table 3. Average weight gain of 8 boys, exluding cases No. 5 and 6, was 532 g per months. An average normal Chinese boy would gain about 470 g monthly between 4 and 7 months of age.[3]

Although there were several infants who did not grow well on RM-1, the mixture was considered to be a good one in general. A $8\frac{1}{2}$-month old marasmic girl who weighed only 4.9 kg was admitted and given RM-1 formula. The growth response was excellent. She gained 1.8 kg in 45 days and 2.1 kg at the end of 60 days without having any gastro-intestinal disturbance. She was able to get 154 kcal. and 5.0 g of protein per kg body weight per day during the first 2 weeks of feeding, and 132 kcal and 4.3 g of protein per kg per day during the 5th and 6th week.

FEEDING WITH RICE-SKIM MILK MIXTURE NO. 2 (RM-2): The growth of infants fed with RN-1 was considered satisfactory, and the amount of protein supplied by RM-1 was much enough for the infant need. Therefore, another feeding trial with RM-2, in which the ratio of rice powder to skim milk was increased to 4:1, was carried out with 8 male infants. Since the infants of this group were younger, $2\frac{1}{2}$ to 5 months old, the liquid formula was prepared with 220 g of the mixture and 1000 ml of water. It provided 76 calories and 1.9 g of protein per 100 g. As the result, both calory and protein intakes were lower than those of RM-1 babies. The ranges were 83 to 104 calories and 2.3 to 2.8 g protein per kg per day. The average daily intakes were 93 calories and 2.5 g protein per kg body weight respectively.

Feeding period ranged from 1 to 4 months in this experiments, but only 2 cases were 2 months or shorter. Data of weight gain are shown in table 4.

As can be seen from the table, growth of the boys was generally satisfactory except cases 2 and 3. Although gained less weight, case 3 had been active physically and was able to stand at the age of 7-month.

The over-all average monthly weight gain for the eight boys was 453 g which is less than the average Chinese figure of 525 g for 3 to 7-month old boys. Lower calorie intake for their age, average of 93 kcal./kg/day, and the fact that two of our boys started from 4-month old and one started from 5-month old, might be responsible for this. Their average protein intake was about 2.5 g/kg/day which seemed to be not inadequate. It might be mentioned here that the average body weight gain of Chinese infants of younger than 6-month old who are mostly breast fed or fed with cow's milk can be considered quite normal comparing them with an American standard.[5] If cases 1, a 5-month old boy, and 3 were omitted, the average weight gain is 498 g per month which perhaps can be considered normal.

FEEDING EXPERIMENT WITH THE RICE-SKIM MILK MIXTURE NO. 3 (RM-3):

The ratio of rice to skim milk was increased to 9:1 (Table 1). The amount of milk protein is therefore about half that contained in RM-2. The ratio of rice protein to milk protein is approximately 2:1. This mixture contained the least amount of skim milk and consequently the protein level was the lowest, 8.1 per cent. Dietary protein intake ranged from 1.9 to 2.2 g/kg/day, averaging 2.0 g/kg/day.

In all, 7 male infants of 4 to 7-month old were subjected to a growth study with this mixture for 1 to 3 months. However, their growth was not adequate except in two older boys of 7-month old. Four younger boys grew well for the first one to two months and then the growth rate slowed down. The impression was that RM-3 formula was not suitable for younger infants.

GROWTH OF INFANTS FED WITH RICE-SKIM MILK MIXTURE NO. 4 (RM-4):

The ratio of rice to skim milk is 5 to 1 and the ratio of rice protein to milk protein is approximately 1 to 1. Protein level of this mixture is also rather low, 8.6%, but slightly higher than RM-3. The protein level and caloric value of the liquid RM-4 formula is 1.7 g and 87 kcal per 100 g respectively.

Nine infants of 5- to 7-month of age were fed with RM-4 formula for 1 to 3 months and 20 days. The data are shown in table 5. Weight gains of cases No. 1,2,7 and 9 which are 670 to 536 g per month are considered excellent for this age group. Cases 3,5 and 8 gained their weight normally, 430 to 340 g monthly. However, case 6 grew poorly. Protein and calorie intakes in this feeding

experiment were 1.8 to 2.2 g/kg/day and 91 to 108 cal/kg/day respectively. It was estimated from the results that if an infant could take 100 cal/kg/day (protein: 1.95 g/kg/day) or more with this diet normal growth could be obtained. Average weight gain of the 8 infants, excluding the poorest one, was 473 g per month. An average Chinese boy gains only 320 g per month between 5- and 8-month of age.[3]

GROWTH OF INFANTS FED WITH RICE-WHOLE MILK MIXTURE, RWM-1:

In the place of skim milk in RM mixtures whole milk powder was used. This formula, with raised fat level, proved to be very satisfactory in supporting weight gain of 7 to 9-month old infants for 2 to 3 months (Table 6). Average weight gain of 4 male and 3 female infants was 536 g per month, excellent growth rate for this age group. Their protein intake averaged about 2.2 g/kg/day. Apparently, this amount of the mixed protein (milk protein: rice protein = 2.5 : 1) is enough for the needs of 7 to 12-month old infants.

GROWTH OF INFANTS FED WITH A RICE-WHOLE MILK MIXTURE, M-2:

Formula M-2 was prepared primarily as an control diet for tests with vegetable protein food mixtures. It contains more protein but less fat than RWM-1 described above. This formula was studied with 11 boys and 3 girls of 4 to 7-month old for 1 to 5 months duration. Weight gain data obtained were analyzed at monthly interval and presented in table 7. As can be seen from the table, average monthly weight gain of our infants of 6-month or older on M-2 formula surpassed that of average normal Chinese boys[3] of the same age group considerably.

Growth data obtained with RM-1 for 4 to 7-month period were comparable with those obtained with M-2.

BODY HEIGHT GAIN OF THE INFANTS:

Body height was measured twice a month in the present study. The rate of growth in height was generally within the normal range for their age.

NITROGEN BALANCE STUDIES:

Nitrogen balance studies were performed with boys, at or near the end of the feeding experiment, and the diets were used as they were, without changing their protein levels. A balance period was six days.

Among four rice-skim milk mixtures only RM-4 was evaluated by nitrogen balance techniques. With this diet, nitrogen intake was only 228 to 269 mg/kg/day

during the balance period (3 cases). Nitrogen retention was 54 to 82 mg/kg/day (Av:68 mg) and thus was 28 per cent. of the nitrogen intake on average. It is considered from these data that the efficiency of protein utilization for RM-4 is quite good.

BLOOD CHEMISTRY DATA:

All subjects' blood was analysed for haemoglobin, haematocrit, total serum or plasma protein. These data were usually all within normal range, indicating no protein deficiency was induced. However, these are probably of less value in evaluating the protein quality in these clinical studies. No significant difference between groups was found for serum or plasma albumin level.

DISCUSSION

Of the rice-skim milk mixtures and rice-whole milk mixtures tested, only RM-3 (Rice: skim milk = 9:1) which contained least amount of milk and total proteins failed to support normal growth of infants of 4 to 6-month of age. RM-4 (Rice:skim milk = 5:1), the protein level of which is still rather low, supported the growth of 5 to 7-month old infants for 1 to 3 months quite well in most cases. The average monthly weight gain of infants studied, surpass that of an average Chinese infant of the same age and sex group, although did not reach the growth rate of American infants.[5] The results indicate, if the appetite was good, an infant could grow excellently on RM-4. Protein level of RM-4, 1.95g/100 kcal, seems not insufficient for infants of older than 5-month of age. The FAO/WHO expert group estimated that 1.5 g/kg body weight of breast or cow's milk protein can adequately cover the protein requirement of 6 to 9-month old infants[1].

Acceptability of RM-1 and RWM-1 was better than RM-2 or RM-4. Infants grew well on these formulas. Furthermore, rice-milk food mixtures might be used as supplementary foods in ordinary families if marketed. Therefore, RM-1 which contains higher level of protein and RWM-1 which is richer in calories might be the choices for the practical purpose. ND_pCal % of RM-1 was calculated to be 9.4, although that of RWM-1 was only 5.5 . The concept that ND_pCal % should be above 8 for infant feeding[1] may need further investigation.

Rice protein is known to be deficient in lysine content and the milk protein is rich in lysine but rather short in the sulfur containing amino acids. Essential amino acid composition of RM-1 and RM-4 was calculated and lysine is

no more insufficient, and the first limiting amino acids are methionine plus cystine. Protein scores of RM-1 and RM-4 based on the FAO reference pattern are 76 and 74 respectively. The chemical scores based on human milk protein was both 79, and while the first limiting amino acids are still methionine plus cystine for RM-1, tryptophan is limiting in RM-4. These scores are higher than those of rice protein itself, 70 and 75 for the protein score and the chemical score respectively[1].

SUMMARY

Pre-cooked rice powder was mixed with dried skim or whole milk powder by various ratios and formulated into weaning foods with vegetable oil, sugar, minerals and vitamins. These food mixtures were tested for their nutritive value by infant growth tests.

Only one formula (RM-3) which contains the least amount of skim milk, rice to skim milk ratio equals to 9, failed to support normal growth of infants of 4 to 6-month of age.

Formula RM-1, in which the ratio of rice to skim milk was 2 to 1, and a rice-whole milk formula, RWM-1, were well accepted and were able to support normal growth of infants of under 1 year of age.

ACKNOWLEDGEMENT:

We are most grateful to the financial support of the World Health Organization throughout this study.

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Table 1. Composition of rice-milk mixtures

Ingredients	RM-1	RM-2	RM-3	RM-4	RWM-1	M-2
	%	%	%	%	%	%
Rice, amylase treated	54	54	64	60	-	-
Rice, Pre-cooked	-	10	8	-	33	38
Skim milk powder	27	16	8	12	-	-
Whole milk powder	-	-	-	-	25	32
Vegetable oil	9	10	9	15	15	6
Sugar	8	8	8	10	24	22
Salt mixture	2	2	2.9	2.9	2.9	1.9
Vitamin mixture	0.1	0.1	0.1	0.1	0.1	0.1

Table 2. Protein, fat and energy value of the rice-milk mixtures

Food mixtures	Protein	Fat	Calorie	Protein /100 kcal.	% of cal. from fat
	%	%	kcal.	g	%
1. Rice-skim milk, RM-1	13.5	9.5	415	3.3	21
2. Rice-skim milk, RM-2	10.4	10.4	422	2.5	22
3. Rice-skim milk, RM-3	8.1	9.4	415	2.0	20
4. Rice-skim milk, RM-4	8.6	15.4	446	1.9	31
5. Rice-whole milk, RWM-1	9.1	21.7	473	1.9	41
6. Rice-whole milk, M-2	11.2	14.7	436	2.6	30

Table 3. Weight gain of infants* fed with RM-1

Case No.	Age at beginn.		Feed. period		Body Weight Beginn.	End	Gain	Gain/M
	M	D	M	D	g	g	g	g
1	4	10	4	0	7170	9750	2580	645
2	3	0	3	15	6380	7700	1320	377
3	4	10	3	10	6300	8200	1900	570
4	4	10	3	0	6900	8850	1950	650
5	7	4	1	16	7550	7750	200	133
6	6	20	2	0	7450	7650	200	100
7	5	0	3	0	6900	7950	1050	350
8	4	4	3	0	7100	9030	1930	643
9	4	8	3	0	7980	9650	1670	557
10	4	2	3	0	7250	8650	1400	467

* Male. Average monthly weight gain is 532 g excluding case No. 5 and 6.

Table 4. Body weight gain of boys fed with RM-2

Case No.	Age at beginn.		Feed. Period		Body weight Beginn.	End	Gain	Gain/M
	M	D	M	D	g	g	g	g
1	5	12	2	0	8270	8870	550	325
2	3	12	2	20	6055	7280	1225	459
3	3	9	4	0	6600	7850	1250	313
4	2	20	3	0	5500	7150	1650	550
5	4	10	3	0	7150	8650	1500	500
6	4	20	2	20	6150	7700	1550	581
7	3	13	1	0	6280	6800	520	520
8	3	20	3	0	7600	8730	1130	377
								Av.: 453 g

Table 5. Weight gain of male infants fed with RM-4

Case No.	Age at beginn.		Feed Period		Body weight		
					Beginn.	End	Gain/Month
	M	D	M	D	g	g	g
1	5	0	3	20	7,530	10,000	670
2	5	25	2	15	7,870	9,350	590
3	5	0	2	20	6,750	7,900	430
4	6	12	2	10	7,600	8,250	280
5	7	1	1	10	8,650	9,100	340
6	7	4	1	0	7,700	7,800	100
7	5	19	1	16	6,650	7,470	536
8	6	0	3	0	7,450	8,550	367
9	7	2	2	0	6,000	7,150	575

Av.: 432

Table 6. Growth data of infants fed with a rice-whole milk formula

Case No.	Sex	Age at beginn.		Period of feeding		Body weight		
						Beginn.	End	Gain/M *
		M	D	M	D	g	g	g
1	M	9	9	2	27	9050	10100	362
2	M	8	10	2	20	9250	10450	451
3	M	9	23	2	27	9420	11350	665
4	M	8	6	2	14	8470	10150	681
5	F	9	8	2	12	7650	9300	687
6	F	7	10	2	10	6900	7600	300
7	F	7	10	2	20	6300	7900	602

* Boy's average monthly weight gain: 540 g

Girls' average monthly weight gain: 530 g

Table 7. Growth of infants fed with a rice-whole milk formula, M-2

Case No.	Sex	Monthly Weight gain				
		5th M*	6th M	7th M	8th M	9th M
		g	g	g	g	g
1	M	-	300	350	150	-
2	M	-	-	500	500	-
3	M	600	650	350	-	-
4	M	-	-	-	450	250
5	M	580	700	500	450	400
6	M	-	450	230	170	-
7	M	-	-	-	450	450
8	M	-	330	-	-	-
9	M	-	-	280	320	-
10	M	-	-	530	270	-
11	M	-	580	120	-	-
12	F	-	520	400	-	-
13	F	-	650	500	-	-
14	F	-	330	350	-	-
Average		590	501	374	345	367
Average of Chinese boys		540**	490	280	180	60

* 5th month denotes the period between 4 and 5-month of age.

** In this series, 5th month denotes the period between $4\frac{1}{2}$ and $5\frac{1}{2}$ -month of age. These are data of Chen et al.[3]

Breeding for High Lysine Corn[1] in Thailand

by

Dr. Sutat Sriwatanapongse[2]

INTRODUCTION

Corn is an economically important crop. In some countries corn is used directly as a staple food and in other countries it is utilized more and more in livestock feeding. It is already well-known that the people in many of the areas have inadequate balanced protein in their diet. The source of protein comes from grains since the consumption of animal protein is low and the quality of meat is also poor. The improvement of flour protein, especially in corn, will help to reduce malnutrition in these areas of the world.

To improve the quality of corn, the level of protein as well as the quality of protein has to be considered. The discovery of the high lysine content of opaque-2 (O_2) and floury-2 (fl_2) endosperms (1, 2) has a great impact in improving the quality of protein since lysine is the most limiting essential amino acid in corn.

The nutritional value of opaque-2 corn is already well known. Feeding tests with rats (4) showed that no single, essential amino acid was limiting for growth in the proteins of whole, ground opaque-2 maize. The average weekly gain of rats fed on opaque-2 maize was much more than those fed on normal corn. Similar results were obtained in feeding trials on swine (5), chicken (6) and humans (7). Human nutrition studies were carried out recently using high lysine corn in Columbia (3). The treatment of four children who were in an advanced state of malnutrition resulted in a normal nutritional balance in their systems when the normal maize in their diets was replaced with opaque-2 maize.

OBJECTIVES

Opaque-2 kernel has soft endosperm with a dull, opaque oppearance. It has little or no corneous starch. Kernels rich in lysine generally are softer than normal grain. This softness makes them more susceptible to insect attack and less

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[1] *The project is supported in part by the National Institute of Health, U.S.A.*

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acceptable as human food. Moreover, the yield of opaque-2 maize is lower than the normal ones. The objectives of this project are to overcome these problems. Grain yield, percentage of protein and lysine as well as hard endosperm character will be considered together as a selection unit.

MATERIALS

For the past few years the Thai National Maize Improvement Program has been incorporating the opaque-2 and floury-2 genes into various sources of germ plasm adapted to Asia. Out of 14 opaque-2 converted lines (Table 1), 4 were selected on the basis of agronomic characters in 1969 test. Two composites were made, namely Opaque-2 Composite # 1 and Opaque-2 Composite # 2. Opaque-2 Composite # 1 was made up from 4 selected lines while the Opaque-2 Composite # 2 contains 14 opaque-2 converted lines. The floury-2 gene is likewise being transferred to similar genetic background.

Thus far the selection for high lysine has been carried out on the basis of the phenotypic characteristic of the seed (opaque), with the assumption that the two are perfectly correlated. The validity of the assumption may be good enough for preliminary work thus far completed but must be subjected to chemical analysis for further improvement. Results of protein and tryptophane analyses (Table 2) done at CIMMYT, Mexico, show some improvement. Tryptophane in opaque-2 converted varieties was about double that of the normal varieties.

BREEDING PROCEDURE

1. The improvement of existing opaque-2 materials.

   The following materials:

   1. Caribbean Mixed Comp. x o_2o_2
   2. Flint Comp. Amar. x o_2o_2
   3. Veracruz 181 Antigua Gr. 2 x o_2o_2
   4. Cuba Gr. 1 x o_2o_2
   5. Opaque Composite # 1
   6. Opaque Composite # 2

   will be further improved using S_1 selection. Many vigorous and acceptable plants within each variety will be selfed. Selfed ears will be shelled separately and analyzed for protein and lysine. Only seeds from ears having high protein and high lysine will be bulked to reconstitute a new population. This procedure will be repeated and yield test should be done every year.

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Table 1 - Grain yield and other agronomic characters of opaque-2 converted lines and their normal counterparts grown at Farm Suwan, 1969

No.	Entry	Yield (kg/ha)		1000 grain weight, gm		Protein (per cent)	
		Normal	Opaque	Normal	Opaque	Normal	Opaque
1*	Caribbean Mixed Composite	3941	3721	228	196	10.1	10.0
2*	Flint Compuesto Amarillo	4448	3797	225	217	10.0	9.4
3*	Veracruz 181 x Antigua Gr. 2	4662	4378	227	175	10.6	9.6
4	Cuba 40	3272	2914	183	161	10.3	10.0
5*	Cuba Gr. 1	4104	3737	193	185	10.8	10.5
6	Cuba 11J	3704	2686	231	178	9.6	10.0
7	Narino 330 x Peru 330	3690	3249	172	173	9.4	10.0
8	CM 103	2738	2733	182	188	10.8	9.1
9	CM 104	2947	2491	181	168	10.6	10.9
10	CM 105	3518	2930	168	180	10.0	10.1
11	CM 106	3323	3332	188	164	10.2	10.0
12	CM 109	1273	2761	111	155	11.7	9.6
13	CM 201	1548	1325	117	125	10.8	9.6
14	Antigua 2D	3611	2849	187	167	11.5	10.3
	L. S. D. (.05)	510		25.64			
	C. V. (%)	9.07					

* selected lines

Table 2 - Protein and tryptophane analyses of some materials grown in 1969.

No	Material	% Protein	% Tryptophane in	
			Protein	Sample
1	Cupurico x Flint Comp. (F) C II	10.50	.036	.34
2	Cuba Gr. I x Cuba 40 (F) C II	10.63	.032	.30
3	Thai Composite # 1	10.88	.034	.31
4	Puerto Rico Gr. I (E) C I	9.69	.035	.36
5	Puerto Rico Gr. I (EL) C III	9.75	.038	.39
6	Opaque-2 Comp. # 2	7.19	.052	.72
7	Flint Comp. Amar. x o_2o_2	7.75	.058	.75
8	Caribbean Mixed Comp. x o_2o_2	8.13	.060	.74
9	Floury-2 Comp.	11.19	.064	.57
10	Antigua 2D x o_2o_2	7.50	.054	.72
11	Ver. 181 - Antigua Gr. 2 x o_2o_2	8.50	.054	.64

Note: 1. No. 1 - 5 are normal and 6 - 11 are opaque-2 converted varieties.

2. Correlation between tryptophane and lysine is .81 (CIMMYT Report, 1967 - 68).

COMBATTING MALNUTRITION

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Medical Faculty, University of Indonesia
Seminar on Protein Food Promotion
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In this article I wish to discuss malnutrition, especially as found in the poor areas of the island of Java, Indonesia, and particularly aimed at the malnutrition of the young children in the age group 6 months - 2½ years.

When discussing malnutrition it is necessary to consider the factors leading to the malnutrition. Some of the factors will be put forward here:

1. Menu pattern and attitudes towards food intake.
2. Weaning pattern.
3. Attitude towards health and sickness.
4. Poverty.

MENU PATTERN

The menupattern on the island of Java is basically good. It consists of a meal of four dishes. The basic food rice, the others, we will call side dishes, consist of a dish prepared from vegetables, a dish of protein foods, mostly pulses (tempe = moulded and fermented products of soybean, ontjom = the same process but using groundnuts, bongkrek = using groundnut and grated coconut meat) but also a small amount of meat, fish and other animal food. The fourth dish consists of fruit, which however might be taken between the main meals as a snack. The meal is low in fat, usually about 5 - 10%

If taken in the right amount, this meal will supply the necessary requirement. The consumer, although a little thin, will have a good health and is free from atherosclerosis.

There are however weak points in the philosophy of this menu-composition. The first weak point is that the role of rice is over-valuated in the daily meal. A meal contains a sufficient amount of rice, the other parts of the menu are just there as appetizers to encourage and to make easy the intake of rice. So, if for some reason the proteinfoods are not present, a spicy dressing or even salt will be used as appetizer. This habit, also implied in the food management of the growing child is of course very dangerous. Salted fish, because of its stimulating taste, is very popular in the meal; its role as protein supplier is in fact not much, as

it is eaten only in small amounts because of its saltiness.

A second weak point is the presence of taboos. Women after pregnancy are not allowed for a certain time to eat some kind of vegetables and fruit; serious is the belief that to the young child should not be given meat and fish because it cause worms.

A third point: there is a general belief that one should not overeat and not aim at luxurious food. Showing to be hungry and demonstrating satisfaction after a meal is considered not decent/indecent. You should be able to perform your work even with a minimum of food. Fasting at certain times of the year is considered a virtue.

WEANING PATTERN

It is considered unusual if an infant is not breast fed. The breast secretion is usually good up to six months, and mostly the Indonesian child of up to six months is healthy even when compared with infants in well developed countries. The breast feeding is continued as long as possible, and stopped only after the mother becomes pregnant again, but sometimes only after a younger child is born. After six months, alerted by the crying of the child, the mother starts with additional food, which should be considered as the first step in the weaning process.

The weaning pattern is very weak indeed. It is not a pattern, which purposedlyprepares the young child to adapt to the existing menu of the adults. As earlier mentioned meat and fish are forbidden, eggs although not in the list of the taboos are usually not given. Milk is considered a necessity to replace breastmilk if the breasts have failed; but although not forbidden it is usually not given to older infants and has not the place as a "required" food, as it is in the Western world. This attitude towards milk however is gradually changing.

The result as often seen especially in poor families is that the 6 months - 2½ years old child is fed only with rice and salt as an addition to the decreasing amount of breastmilk . Fruit is given according to season, snacks abundantly; these snacks however are prepared mostly from a carbohydrate source with fat from coconut milk and very little protein.

Up to about 2½ year the child depends for its food on what the mother knows and considers good for him; he is in the stage of the passive consumer. At about 2½ year he becomes active and is allowed and is taking his part of the adult food. He adapts very soon to the spicy and hot foods. His food becomes much better and accordingly morbidity and mortality due to protein calorie malnutrition and vit. A deficiencies improve very much.

The improper food management of the young child is clearly caused by ignorance of the mother; it is not so easy to overcome this ignorance.

ATTITUDE TO ILL-HEALTH AND SICKNESS

Illness is usually brought too late to the doctor's attention; usually the man has worked himself up to the point that he is really sick and even has to lay down. This is because, it is considered childish to complain of sickness. This attitude is dangerous for the sick child. In the case of malnutrition, they are brought in an advanced stage of kwashiorkor and xerophthalmia. The mother does not recognise the earlier stage of the diseases, especially if living in a poor area. This was a very typical finding among the thirty cases of hemeralopia found in families living in a poor alley. When asked, why the children were not brought to the clinic earlier, the mothers gave the surprising answer: "But all the children here are the same".

There is certainly not a consciousness of good health among these people. The high morbidity and mortality among the age group 6 months - 2½ year is accepted as normal. They will not consider it strange if from 5 to 6 live births half of the children have died as a toddler.

The facts mentioned about improper food management and the attitude to illness and death are caused by ignorance. But in combatting these shortcomings we would not succeed very much if people do not possess a certain level of general knowledge/education. They should also know much more that is how life should be- as it is found better environments of living, which they should regard as the standard of normal life.

POVERTY

Poverty, next to ignorance, is the greatest barrier for achieving improvement. This is particularly true, when we want to improve the food of the population.

In the village, rice, vegetables, fruit and in the proper areas also fresh fish, for the daily food is acquired from the surrounding fields. The housewife goes to the market to buy salted fish, salt, sugar, tea, and coffee and spices.

Here also is bought the tempe and the ontjom (earlier mentioned) which are much liked and which are produced locally even in the remotest villages. Canned and other technological food products, which have been produced centrally in a city/town, become expensive because transportation facilities are low.

According to this marketing condition, the policy in Indonesia to

medical electronics, nursing requisites and nutrition.

The nutrition division has been researching food since the mid-50's. It built a pilot plant to produce eviscerated-fish protein in 1961, and converted it to full-scale production five years later. Another land-based factory in Sweden began producing large quantities of the fish protein early this year. At the same time, a 25,000-ton ship was converted into a floating protein factory.

EFP Top-Quality Protein

EFP meets new quality concepts. It will not offend anyone's food sensibilities. The product has 92-94% protein, with a solvent residue less than 100 ppm and as low as 50 ppm. It is produced on the factory ship virtually from live fish, with processing equipment that meets dairy sanitation standards.

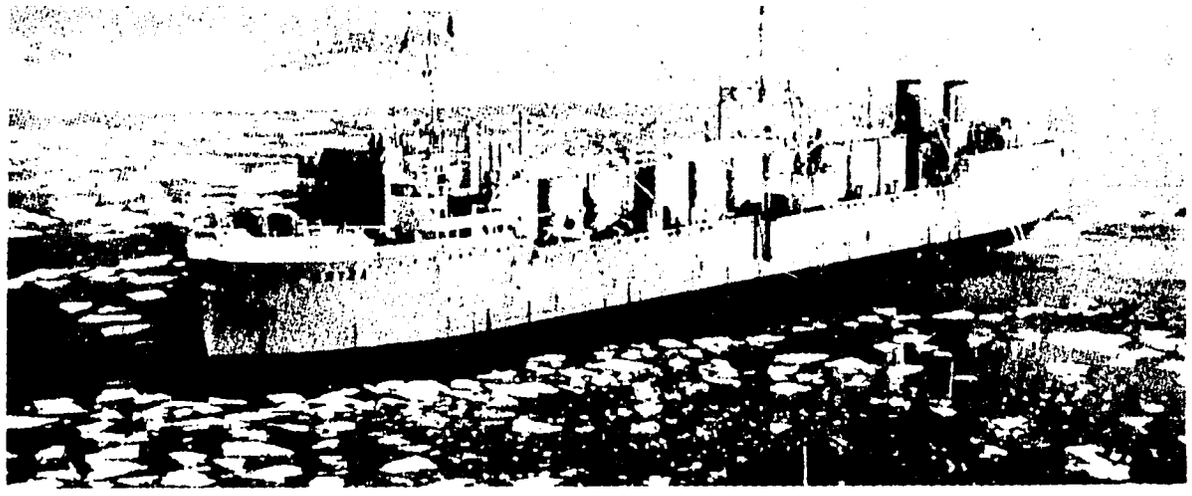
With its superior quality, EFP is expected to command a price at least 20% higher than the price of protein from whole fish. Higher price is indicated by the fact that it takes 8½ lb. of fish to produce 1 lb. of EFP. Only 6½ lb. of fish is required for 1 lb. of FPC from whole fish. The latter is only 81-82% protein compared to more than 90% for EFP 90 (Astra's trade name).

"EFP undoubtedly will be the best protein buy in the market on the basis of protein yield." That is the opinion of a Nabisco-Astra executive. It is better, for example, to pay say 50c/lb. for a 94% protein than 30c/lb. for a 40% protein.

EFP can stand on its own in nutrition values, as can be seen from the table comparing essential amino acid content of EFP with casein, egg and beef. If used alone as a protein enriching ingredient, EFP comes close to meeting all amino acid requirements. It even exceeds some of those requirements. The combination of EFP and soya flour gives even better than recommended amino acid levels.

Added to EFP's nutritional values are the very important attributes of being tasteless and odorless. It also is quite stable when stored in a cool dry place. And shelf-life of products containing it are determined by other ingredients rather than by the protein.

Nor is that all. Important functional values likely will be engineered into the protein. Such are being pursued in the research laboratories of both Nabisco and Astra. This research can make a major contribution to the performance of the ingredient by achieving properties such as wettability, solubility and whippability, as well as crumb structure, or texture. EFP is free of grittiness as produced, and it can be used as an ingredient even in soft candies.



FACTORY SHIP M/S Astra that produces EFP from "live" fish is converted 25,000-ton, 600-ft whaler. Its 20 silos hold 12,000 tons total of finished product, which is transferred by pneumatic conveyors to bulk carrier every 35 days. Ship has crew of 160. Eleven satellite trawlers, with landing capacity of 200,000 tons annually, bring fish to the floating factory. Ship takes process to source of raw material.

HOW EFP COMPARES NUTRITIONALLY

(Essential Amino Acid Content Expressed in Grams per 16g Nitrogen)

		Animal Ingredients				Vegetable Ingredients			
Amino Acid	FAO Std.	Astra EFP90	Casein	Egg	Beef	Wheat	Soya	Corn	Cottonseed
Lysine	4.2	9.8	8.1	7.2	8.4	2.3	6.3	2.8	4.4
Leucine	4.8	8.5	10.1	8.8	8.4	7.2	7.7	13.0	5.9
Isoleucine	4.2	5.1	6.6	5.7	5.1	3.2	5.3	4.6	3.8
Methionine	2.2	3.6	3.1	3.8	2.3	1.4	1.3	1.8	1.4
Phenylalanine	2.8	4.6	5.4	5.7	4.0	4.8	4.8	4.4	5.2
Threonine	2.8	5.1	4.3	5.3	4.0	2.9	3.8	4.0	3.6
Tryptophane	1.4	1.6	1.3	1.3	1.1	1.1	1.3	0.6	1.2
Valine	4.2	6.2	7.4	8.8	5.7	3.9	5.2	5.2	4.9

Challenging Opportunities

EFP has excellent potential in developed nations as an ingredient in foods for which protein enrichment is desired. Among such foods may be snacks, meat

Process Is Sophisticated

Innovations in the EFP process were developed by Astra researchers. Then efficient, sanitary equipment to carry out the various steps of the process was built-mostly by Alfa Laval in Sweden, with other firms making important contributions. Alfa Laval is world-famous for its advanced dairy processing equipment.

Equipment is made of stainless steel to resist corrosion and prevent metal contamination of product. It is designed to avoid places where bacteria can build up. And it is arranged for efficient in-place cleaning.

The major process innovation, evisceration, is performed mechanically by equipment for which patent application has been made. Bone also is mechanically separated from the fish.

To avoid an explosion hazard, apparatus containing solvent, or its vapors, is ventilated over inert-gas condensers. And means of rinsing with nitrogen or blanketing with carbon dioxide are provided where sparks could ignite an explosive atmosphere.

Operations Step by Step

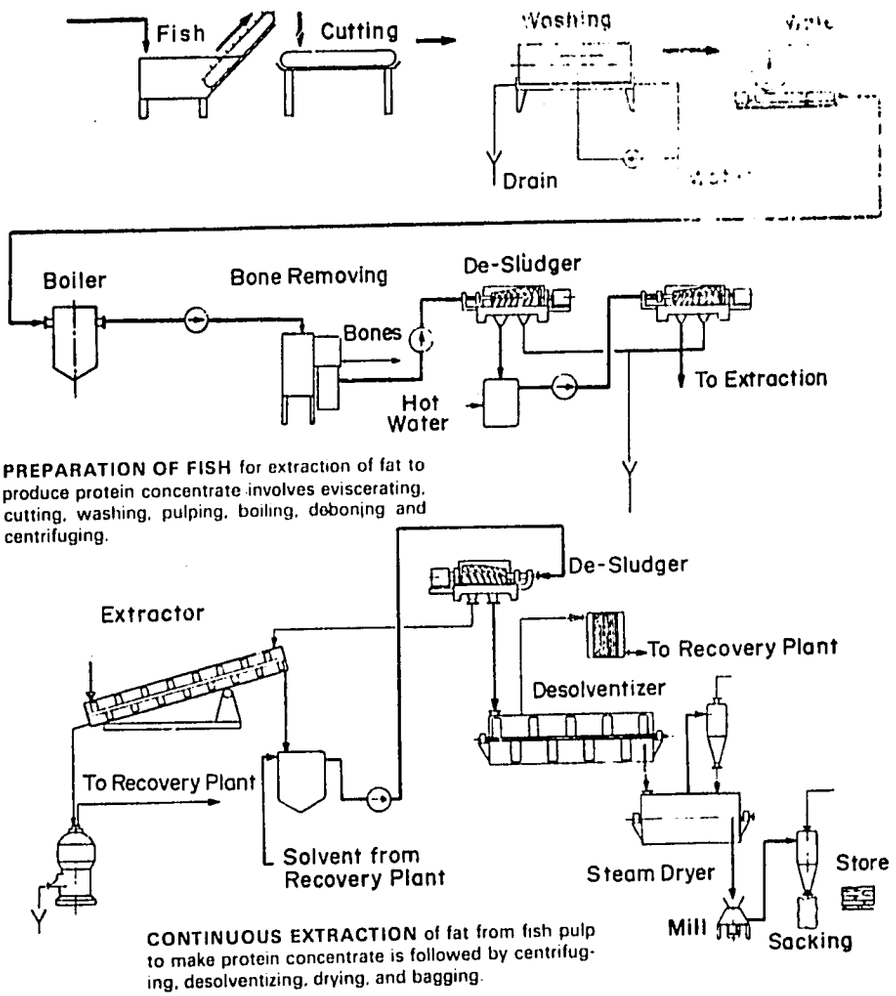
Steps in the preparation of the fish and the extraction of fat are illustrated in the flow diagrams. Eviscerated fish are cut into segments, washed to remove viscera and blood, pulped in water, and boiled. Then the material goes through a deboner, a desludging centrifuge, a hot-water treatment and a second centrifuge.

Now it enters a continuous extractor where neutral fat and phospholipids are dissolved out. The fat solvent flows counter-current to the fish pulp through the extractor, and it is centrifuged on discharge to clarify it for return to the recovery plant. Protein material from the extractor goes into a tank where solvent is added, then it is centrifuged to separate the solvent for reuse in the extraction process. Now the fish pulp passes through a steam-heated agitating desolventizer where any remaining solvent and odorous substances are removed. Drying in a steam-heated unit, milling, and bagging of finished protein complete the operation.

Fat solvent used in the process is isopropyl alcohol. The extracting agent is removed from the fats by boiling off in an evaporator, then is deodorized and concentrated.

Patents covering process arrangement, method, and apparatus have been applied for in most industrialized countries and fishing nations.

Astra considers some of the earlier fish protein concentrating techniques to be superficial and incomplete. Successful production of FPC involves many



PREPARATION OF FISH for extraction of fat to produce protein concentrate involves eviscerating, cutting, washing, pulping, boiling, deboning and centrifuging.

CONTINUOUS EXTRACTION of fat from fish pulp to make protein concentrate is followed by centrifuging, desolventizing, drying, and bagging.

intermingled biotechnical and biochemical problems. These had to be solved by well coordinated research and development, technical studies, knowledge of advanced techniques in chemical processing equipment and construction, and experience in sea fishing on a large scale.

Successful processing requires continuous operations carried out at the lowest possible temperatures for best quality. Continuous checks must be made on the purity and concentration of new and distilled solvent. And continuing analysis

for bacteria, on both material being processed and finished product, is required.

Still other factors in successful processing are minimizing loss of solvent, automatic process control, centralized supervision, and high standards of sanitation.

In its land-based operations in Sweden, Astra has produced the high-qualit protein from herring, which are in good supply in Scandinavian waters. And having used fat fish, the extraction process has demonstrated good capability and versatilit

FDA has recognized only hake as raw material for producing fish protein for human consumption. Canada, however, approves herring and similar fat fish such as pilchards, sardines and anchovies.

Develops Products, Markets

National Biscuit Co. had for some time been seeking a way to help relieve the world protein shortage. It found the answer in Astra and its high quality protein from eviscerated fish. So Nabisco-Astra Nutrition Development Corp. was set up on a 50-50 ownership basis. Astra is producing the protein, and Nabisco is developing products enriched with it and market testing those products.

The big challenge to Nabisco is to develop protein-enriched foods that are compatible with the eating habits, tastes and pocketbooks of potential markets in developing nations. Furthermore, these products are preferably made primarily from raw materials indigenous to the area involved.

To date, Nabisco's R&D lab has come up with 34 potential protein-enriched foods for developing countries. These incorporate EFP at an average level of 20%. Now the company is appraising the food habits in potential markets so as to refine the products to suit ethnic tastes. Quite a variety of foods have been developed, ranging from pasta to meat analogs, and including sandwich spread, cookies and crackers.

In marketing such foods, Nabisco will approach a market as a whole. It wi zero on any one group of people. The last thing it wants to do is create the image of a "poor man's food" for any product. That would very seriously impair acceptance among those who need it most.

None of the EFP-enriched items is on the market yet. But Nabisco hopes to have a few representative products going by the end of this year. Some research projects are nearing a conclusion.

There is real urgency behind this project. Protein is seriously short now. And the equivalent of another world in terms of population will develop in the 35 years between 1965 and 2000, with population doubling from 3½ billion to 7 billion.

Developing Markets

Highly experienced in international operation, Nabisco is approaching potential markets cautiously. It is exploring possibilities through classical market research techniques. Actual product samples are handed out to determine consumer reactions and preferences as precisely as possible. The researchers will find out which type of product will be bought by the greatest number of people with the greatest frequency. Local market research organizations and local people are utilized when feasible.

In its moves to introduce popular, low cost, protein-rich foods in the nations that need them most, Nabisco will work with any organization that can help. It is utilizing the cooperation of UNICEF, FAO, the U.S. State Department (including AID), and businessmen in developing countries.

Astra Researches Uses

Research by Astra has shown cereals and bread to be suitable for EFP enrichment. Addition of 5% fish protein to flour brought bread protein content from 11 to 15%. A strong enrichment effect is attained even in the presence of reducing sugar. Enrichment of hard bread has given a nutritional value equivalent with casein.

A critical test is the use of the protein in faffa, an Ethiopian baby food. Faffa with powdered milk or fish protein as the sole source of animal protein is being tested in a study of child growth. Tests also are under way with gruel containing fish protein, and with enriched foods integrated into a complete diet.

Top executive of Nabisco-Astra Development Corp. is Per E. Hoel, who also is head of Astra Nutrition U.S.A., Inc. (marketing firm for EFP 90) and who serves as vice-president of Astra Pharmaceutical Products, Inc., Boston. Executive Vice-President of Nabisco-Astra is Harry J. Watson, National Biscuit Co., New York City.

WHERE IT IS MOST NEEDED

Some reflections on the world food situation

From Naarden News, U.S. Edition, November 1968, volume 19.

The world food supply problem has formed the subject of many, many publications.

Our motive for adding to the flood of words which have been poured out on the subject lies in a report from Mr. Du Mee of Naarden-India concerning the group's share in a project aimed at making the residue of groundnuts after pressing--a substance rich in proteins--suitable for human consumption. We are indebted to Ir. B. J. Grootenhuis, Head of Development of Naarden, for the use of documentary material which provided a background to the report, and for his views on its interpretation.

We are often reminded that the world population is increasing by something like 180,000 every day, a development which, through the years, has caused many to exclaim anxiously, "where will it end?"

The answer to that question lies in a twofold realization: the growth of the world population is at present exponential, and we cannot go on indefinitely with an exponential growth curve. Among the theories which match this standpoint is: Exponential growth is characteristic of a transitional phase between two situations, in which birth rate and death rate are in equilibrium. Improved standards of living and advanced medical care have resulted in a fall in the death rate; the birth rate, however, has remained constant and the result is a disturbance in the population balance. Such temporary disturbances--although they may span several generations--have occurred previosly in Man's history, but never on the present scale. According

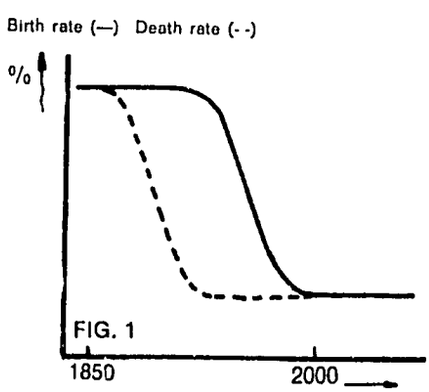


FIG. 1

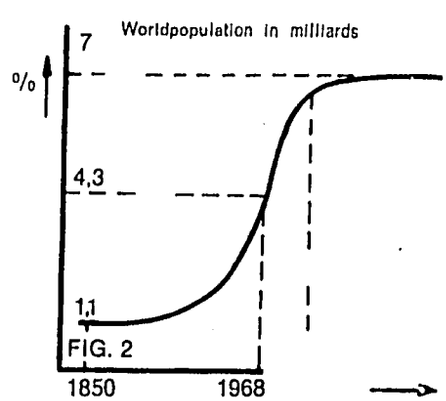


FIG. 2

to current predictions, the optimal family size--and, thus, the optimal birth rate--will adapt itself to the new situation one or two generations hence and will then diminish (see Fig. 1). In the meantime, however, the phase of exponential growth has become a fact (see Fig. 2), and, since this cannot be erased, the level of population at the outset of the new situation of equilibrium will be substantially higher than the present level. Futurologists differ fairly widely in their estimate of the absolute value, however analysis of these estimates for the year 2000 gives a minimum of 6,000 million and a maximum of 8,400 million.

Feeding the hungry mouths

Always there is the problem of feeding all these hungry mouths. The experts are divided on the question of how this can best be achieved, one group being convinced that new, unconventional sources of nourishment ("artificial meat") must be tapped if the world's population is to be fed, while another group--equally expert--is of the opinion that intensification and expansion of present methods of providing food will more than meet the anticipated rise in demand.

For so urgent a problem as this, discussion would appear to be the least desirable course. Here, more than anywhere, there is a case for adopting one of the alternatives while not discarding the other.

The most pressing problem at the moment is one of economic barriers and distribution facilities rather than food production. Under present conditions there is a lack of food production in areas where it is most urgently needed, namely the developing countries. The result is a vicous circle with fatal consequences. The countries concerned are too poor to import sufficient food; their peoples are undernourished, so their physical output is limited; production consequently lags, the national income is inadequate ... and the circle is completed.*

In recent years more and more voices have been heard clamouring for fresh efforts to break this circle, since it has been shown that food shipments, even as gifts, are not in themselves a solution. Calculations show that, in order to bring living standards throughout Asia to the present level enjoyed in Japan (which it itself only about one-quarter of the level in western Europe), it would

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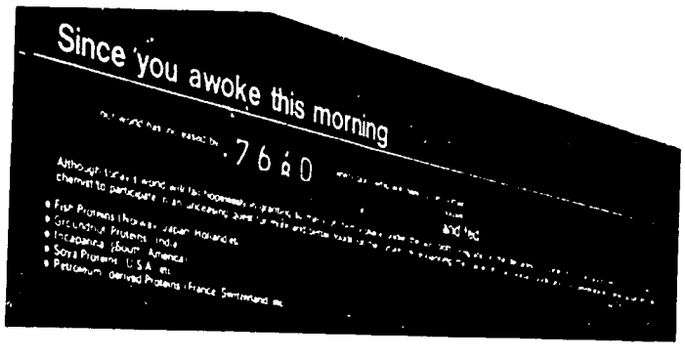
**) Research has produced more and more evidence to show that "indolence" and lack of intelligence in many under-developed areas is in all probability attributable to protein deficiency during infancy, as a result of which brain development is retarded.*



The world food problem as it has been visualized at Naarden's expositions

be necessary to provide:

22,000,000,000 tons of potable water
82,000,000 tons of rice (more than half the world crop)
10,000,000 tons of wheat
180,000,000 tons of vegetables
60,000,000 tons of fish
13,000,000 tons of meat.

Quite apart from the fact that supplies on such a scale are clearly not feasible, this solution possesses the considerable disadvantage that it would dislocate the economies of the countries concerned and undermine local food production. The real solution lies in producing adequate amounts of food in all countries with the means available there.

The possibilities

Earlier studies of the problem have shown that, leaving aside incidental cases of acute hunger resulting from serious calorie deficiency, lack of protein is in most instances the primary cause of under-nourishment. Thus foods rich in protein are the most important when dealing with the problems of hungry nations. Ironically enough, major sources of protein are available in many under-developed areas. These are principally vegetable proteins (in soya, groundnut and cottonseed meal) and fish proteins (in fishmeal). In addition, experiments now being conducted are aimed at extracting protein substances from leaves, and the cultivation of microbial proteins using crude oil as a basis. Soya beans, groundnuts and cottonseed are grown on a large scale in many developing countries, the vegetable oils extracted from them being exported to richer lands.

The residual materials left after pressing operations are toxic and unfit for consumption (often as a result of incorrect processing), and are usually employed as soil fertilizers, or are even thrown away. Just how undesirable such practices

are may be gauged from the fact that, for example, groundnuts grown in India contain sufficient protein to provide half the population of 560 million with a diet containing adequate amounts of this ingredient. Fishmeal presents an equally encouraging picture. World fishmeal production is now running at about 1½ million tons annually, sufficient to provide 650 million people with nourishment at the set minimum standard. As it is, countries like Chile and Peru, where hunger exists, export huge quantities of fishmeal of a quality well suited to human consumption to the rich nations of the West at dumping prices. Much of the calorific value of the meal is lost, for the importing countries use it to feed pigs, the meat from which does not go to still the hunger of the people whose dietary needs are the greatest. In this, the Western nations are guilty of indulging in a luxury at the double expense of underfed peoples, and unless this situation is rectified it may well lead to a catastrophe.

On the other hand, care must be exercised in considering the "inexhaustible supplies of food" which, many maintain, exist in the world's oceans. A single edible fish forms the last link in an extremely costly "food chain". For example, one kilogram of cod represents the fifth and final stage of a process which began with something like 50,000 kilograms of phytoplankton. It has been estimated that the present yield of fish from the sea cannot be more than doubled, or at the most trebled, without disturbing the biological balance in the oceans. The only alternative would be to deliberately empty the oceans of fish and embark on the cultivation of phytoplankton!

The problems of food production

Although, as already stated, potential sources of nourishment are "there for the taking" in many underfed areas, innumerable technological, sociological, psychological and political problems combine to create a situation in which these sources are being tapped only very gradually. As we have said, the products which form these sources are often regarded as waste matter; in the case of groundnut residue, for example, this attitude may result in the formation of moulds, giving rise to lethal aflatoxin.

Another important aspect is the need to organize large scale production of such nutrients in the countries concerned and at very low costs. This is imperative if these new sources of food are to be properly matched to the local economic system.

Among the greatest of all the problems concerned is that of presenting such protein foods in a form in which the consumer will accept them. Psychological

considerations are of considerable importance in this respect. The marketing of TVP (soya meat) in the affluent countries of the Western world is aimed partly at eliminating later suspicions on the part of people in the under-developed areas that they are being asked to accept inferior substitutes. Only when such types of food have been fully accepted by developed nations will the remainder accept them.

Traditions

Similarly, it will be necessary to break down local traditions, which are very strong in many of the countries involved. The peoples of Asia are rice-eaters by tradition and it will take a great deal to convince them that other, equally worthy forms of nourishment exist. All too often we hear of allegations of "irrational" dietary habits based on religious considerations on the part of the peoples of the--materially--underprivileged countries. Vegetarianism and the opposition to the slaughter of cows in India is a typical example. Frequently, however, "religion" is a form of experience sublimated over thousands of years, and thus many "irrational" customs have a logical explanation.

Among these are the vegetarianism and protection of cows in India. In all probability the people of that country learned at an early point in their history that an animal calorie is very costly, requiring about seven times the area of land needed to produce one vegetable calorie. After all, an animal is the last link in a chain of processes in which thousands of calories are consumed; the plant, which builds up its proteins directly from soil, light, and air, forms the initial link. Many more mouths can thus be fed with a vegetarian diet; meat is a luxury which the world as a whole cannot permit itself. Viewed thus, the "religious" diet of the Indian becomes a custom based on purely practical motives.

As for the sacred cows, they largely eat foodstuffs which are not suitable for human consumption, e.g. indigestible grasses growing on land where nothing else will flourish. These grasses are converted into meat, but also into dung, a vital commodity in India, not only as a fertilizer but also as a fuel; indeed, such is the importance of this type of "fuel production" to the local economy that its cessation would have incalculable consequences.

The sacred cow thus also serves a purpose, albeit the importance of this is diminishing rapidly in the light of modern technological developments. Nevertheless, it will be anything but a simple task to banish customs evolved through thousands of years of experience and replace them with modern ideas in a few decades.

The function of flavour

Hunger is the best sauce, people used to say (and some still do). With this pronouncement, the flavour of food, as a functional property, was given secondary importance and made to look something of a luxury. But this attitude is rapidly giving way to one which could be summed up in the words, "Flavour sets the stage for digestion". Among the effects of the flavour or aroma of a dish is the stimulation of the digestive juices, and in this role it is indispensable for efficient digestion.

It is against this background that the flavour industry has a part to play in all "protein projects". Naarden, for example, is concerned with a groundnut project in India, its role being to impart shape and flavour to proteins obtaining from this source with a view to making them acceptable to the consumer as full-bodied foods. As already mentioned, one of the principal facets of this and similar operations is an extremely low price.

The forms in which these sources of nourishment have been presented so far are a "health drink", biscuits and toffees. In addition, groundnut residue has been reconstituted and given the shape of the original nut, and has been marketed in salted or coated form.

Among the flavour types employed so far are nut (including almond), orange and chocolate. Meat flavours do not, of course, lend themselves to these applications. But in spite of all the efforts, the new edible products have not yet found favour with the mass of the Indian people. Price and adherence to local tradition are the principal obstacles. However, it is confidently anticipated that these new foods will soon meet with the same degree of acceptance as their forerunners, such as Incaparina in Central and South America, Pronutro in South Africa and Vicasoy in Hongkong, three types of food rich in proteins, made from local ingredients and selling fairly satisfactorily.

Willingness by the affluent nations to invest in such projects to an adequate degree and on an economically warrantable basis will make it possible to restructure the mechanism of world food production in such a manner that sufficient quantities can be produced in the areas where they are required. This is the only alternative to playing into the hands of those pessimists who are predicting a food catastrophe in the coming decades, and with it a rebalancing of the world population ... not as a result of a declining birthrate, as postulated at the beginning of this article, but as a result of mass death from hunger.

We can but hope that this contribution will focus attention on the existence of large potential stocks of food, and on the fact that if the world is willing and able to utilize these, hope is not lost. Even so, a great deal of hard work will be required to develop the production of food where the need is greatest.

ORIENTAL FERMENTED FOODS[1]

H. L. Wang and C. W. Hesseltine
Northern Regional Research Laboratory,[2] Peoria, Illinois 61604

For centuries the people in Asia have used fermented products made from soybeans and cereals to add pleasure and variety to their vegetable and rice diet. The preparation of these fermented foods, however, was a natural process and household art. Americans and Europeans know little about these products and their involved technology. It was not until the late 1950's that studies on Oriental food fermentation were begun in the United States at the Northern Regional Research Laboratory and at the New York State Experiment Station, Geneva. Since then we have conducted a modest research program on Oriental food fermentation. We have examined the various processes from a scientific standpoint and applied modern microbiological and biochemical principles to them, to their products, and to the improvement of both. A few of these products with which we have had some experienc in the laboratory are miso, hamanatto, sufu, natto, and tempeh. We have also examined fermented foods for their nutritional value and for any mycotoxin contamination.

MISO

Miso is a Japanese food prepared from rice, soybeans, and salt. The miso fermentation is a two-step process (1). The first step involves the fermentation of rice with Aspergillus oryzae followed by fermentation of molded rice along with soybeans and salt involving yeast and bacteria. Misolike products are also produced in other countries of the Orient. The product has the consistency of peanut butter and has the color and flavor of soy sauce. It is used widely for adding flavor to a great many foods. In Japan, miso is used principally to make soup with vegetables that takes the place of our hot cereals for breakfast.

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[1] *To be published in Part I of Seminar on Protein Food Promotion, November 22-December 1, 1970, Institute of Food Research and Product Development, Bangkok, Thailand.*

[2] *This is a laboratory of the Northern Utilization Research and Development Division, Agricultural Research Service, U.S. Department of Agriculture.*

HAMANATTO

A fermented whole soybean product known as hamanatto by the Japanese and toen-si by the Chinese is also widely used. The cooked whole soybeans are coated with parched wheat flour and inoculated with the mold A. oryzae (2). After 3 or 4 days of growth, the molded beans are packed into earthen jars with salt or other spices, such as ginger slices, and then aged for a few months. The final product is blackish in color and somewhat soft. Although it has its own characteristic flavor, it has the taste of miso and soy sauce. Again it is used to add flavor to other foods or eaten as an appetizer.

SUFU

Sufu or fu-ju is a Chinese name for a fermented product made from soybean curd (tofu) by the action of mold. Westerners often refer to this product as Chinese cheese. It is a soft cream, cheese-type food that has a mild characteristic flavor and salty taste. Traditionally, it is served as a relish. Sufu fermentation consists of three steps: preparation of soybean milk and soybean curd, molding, and brining (3). Actinomucor elegans, Mucor hiemalis, Mucor silvaticus, and Mucor subtillissimus are the molds that can be used to make sufu having good quality. Among them, A. elegans seems to be the best organism and is the one selected commercially. The basic brine solution contains NaCl and wine. The added salt imparts a salty taste to the product and also retards mold growth and growth of contaminating microorganisms. In addition, the NaCl brine solution serves to elute the enzymes from mycelia (4) which in turn penetrate into the molded soybean curd and act upon the substrate protein. Other additives to give either color or flavor are frequently incorporated into the brine.

NATTO

In Oriental soybean fermentations, molds usually are the organisms used, but natto is an exception. The bacterium Bacillus subtilis is the organism for this fermentation (5). Cooked whole soybeans are inoculated with the bacteria. After a day the product is ready to eat. Natto has a strong odor of ammonia, a musty flavor, and is covered with a viscous sticky polymer produced by the organism. Even though it is well known in Japan natto is not so popular and widely consumed as other fermented foods.

TEMPEH

Tempeh is an Indonesian fermented soybean product. Unlike the other fermented foods that usually have a very strong flavor and act as flavoring agents,

tempeh has a very mild flavor and is consumed as the main dish. Tempeh fermentation is rather short and simple. The process is carried out in almost every household in Indonesia. From samples of tempeh we have received from Indonesia, we have isolated and identified the mold Rhizopus oligosporus as the organism responsible for the fermentation. In preparation of soybeans for fermentation in the laboratory (6), they are first soaked overnight so that the seedcoat can be easily removed by hand. The soaked and dehulled beans are boiled, drained, cooled, mixed with spores of R. oligosporus, and then packed in a petri dish which is then inoculated at 30° C. for 18 to 20 hours. At that time, the soybeans are bound together by mycelia and yield a cakelike product. It is usually sliced into thin slices, dipped in salt solution, and then deep fried. Fried tempeh tastes like shoestring or french fried potatoes. We also found that tempehlike products can be made from wheat, barley, oats, rice, and their combination with soybeans (7).

NUTRITIONAL VALUE OF FERMENTED FOODS

From their experiences, the Orientals consider fermented soybean products as nourishing and easily digestible foods; the nutritional value of those fermented foods, however, has never been adequately investigated. Not until the 1960's were a number of studies made on tempeh. These studies showed that protein efficiency ratio (PER) and digestibility of soybean protein were not improved by fermentation, although the PER of mixed wheat and soybeans is increased by fermentation with R. oligosporus (8). All the studies emphasized the protein value. But let us look at these Oriental foods from another viewpoint.

1. The Oriental diet consists mainly of rice and vegetables which can be rather bland. The strongly flavored fermented foods not only add taste to the rice-vegetable diet, but also through stimulating appetite contribute nutritional value to people who may otherwise not consume enough food to meet their caloric requirements.

2. Tests have shown that the vitamin contents of some of those fermented foods greatly exceed those of unfermented soybeans (9, 10). This increase in vitamin content has a great nutritional significance to the people of those countries whose food industries do not enrich their foods with vitamins as we do in the United States.

3. Most recently, we have found that the mold used in tempeh fermentation produces an antibacterial compound (11). The compound does not have a wide antibiotic spectrum, but it does inhibit the growth of many Gram-positive bacteria, including some Clostridium species commonly found in the intestinal tract. Similar

antibacterial compounds are also produced by A. elegans and molds isolated from ragi and peh-yüeh, which are commercial starters for rice fermentation (12). It is well established that antibiotics in addition to minimizing infection also stimulate the growth of animals particularly those whose diets are deficient in either vitamins, proteins, amino acids, or other growth factors. Our finding that antibacterial compounds are produced by R. oligosporus and other molds used in Oriental food fermentation possibly offers a clearer understanding of the true value of tempeh in the diet of Indonesians and perhaps that of fermented foods in the diets of all Orientals.

ABSENCE OF AFLATOXIN IN FERMENTED FOOD PRODUCTS

Recently, aflatoxins have been found in agricultural commodities, especially peanuts. The toxins are formed by certain strains of A. flavus, a relative of the A. oryzae mold used in Oriental food fermentation. Some people have expressed concern over the possibility of toxins in fermented foods. In addition to testing strains of A. oryzae, we have also made tests for aflatoxins on extracts of mold-fermented food products and have found them all negative for aflatoxin (13).

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M.Sc. (TAUGHT) COURSE IN FOOD SCIENCE

Qualifying Year

REPORT FOR THE SESSION 1969-70

This Report has been prepared primarily for the information of national or international agencies responsible for the sponsorship of overseas graduates in the Department of Food Science in the University of Reading. The Report is being distributed also to the directors and officers of various institutions and industrial establishments who have co-operated with the Department in the training programme.

Special thanks are due to the Trustees of the Leverhulme Trust Fund who agreed in 1969 to support for a five year peiod two additional senior members of staff to undertake tutorial responsibilities for the overseas graduates in the Department.

Acknowledgement is made of the assistance given by many directors or managers of scientific and industrial organizations in different parts of the United Kingdom. Particular mention should also be made of the assistance of Mrs. Marjorie Mumford, Secretary of the Overseas Service Committee of the University, Mr. Simon Thorne of the Registrar's Office and Mr. Jeremy Hughes of the British Council.

UNIVERSITY OF READING
THE DEPARTMENT OF FOOD SCIENCE

The Department of Food Science of the University of Reading, was established in October 1968 to continue and develop within a wider framework the activities of the older University Department of Dairying. This came into being as a professorial department in 1938 and was the first such university department concerned with foodstuffs (as distinct from agriculture) in the United Kingdom; its origins go back to the 1880's.

The Food Science Department is within the Faculty of Agriculture and Food and works in close conjunction with other departments in this and other Faculties, and with research establishments such as the National Institute for Research in Dairying.

The Department is responsible for teaching and research activities including:

- 3 or 4 year courses for the B.Sc. Hons. Food Science.
- Taught course leading to the M.Sc. in Food Science.
- Research leading to the MPhil or Phd.
- Post-doctoral or other research projects.
- Vacation courses.

M.Sc. (TAUGHT COURSE) IN FOOD SCIENCE

This M.Sc. course was established in 1968; it is designed primarily as a conversion course to enable graduates in chemistry, biochemistry, agriculture or veterinary science or other appropriate subjects, to study food science. A two year programme has been worked out to begin in October each year. The first or qualifying year enables the student to follow courses in chemistry, biochemistry, microbiology and other subjects, chosen from the B.Sc. Hons. Course. Before admittance to the second year, students must pass a qualifying examination usually towards the end of the Summer term in the first academic year.

The second year or M.Sc. course proper- may be taken as a general course or with the possibility of specialisation in one of three options, namely (i) dairy science, (ii) food analysis and (iii) public health aspects (nutrition and toxicology) of food science. Under certain circumstances students with good honours degrees in suitable subjects (e.g. biochemistry) may be admitted directly into this second year.

Throughout the two year programme emphasis is given to the importance of close connections between the agricultural (and fisheries) sector of a national economy and the conservation and utilisation of agricultural produce for food purposes. Emphasis is given also to nutritional concepts and the contribution of the food industries to national nutrition and public health programmes.

This report is concerned with the arrangements made in the session 1969/70 for a group of students in the qualifying year.

UNIVERSITY OF READING
THE DEPARTMENT OF FOOD SCIENCE

TEACHING STAFF

Professor and Head of the Department:

Francis Aylward PhD.DSc (Liverpool) F.R.I.C.

Senior Lecturers

F.H. Grimbleby BSc (Leeds) PhD (Reading) F.R.I.C.

R. Scott. BSc (Nottingham) PhD (Reading) MInstR.

Leverhulme Senior Fellows

R. Harper. MSc (Manchester) PhD (Reading)

I.D. Morton. MSc (New Zealand) PhD (Cantab) F.R.I.C.

Lecturers

E.C. Apling. BSc (London) MChemA F.R.I.C.

W.F. Harringan. BSc (Birmingham) PhD (Glasgow)

A.L. Lakin. BSc (Reading) MSc (Nottingham) A.R.I.C.

J. Rothwell. BSc PhD (Reading)

RESEARCH WORKERS

Nestlé Foundation Research Fellow

J. McDowell. L.R.I.C.

Agricultural Research Council Grants

D. Croker. BSc (Wales) MSc (Warwick)

Mrs. S.A. Caister. BSc (Reading)

J. Owen. BSc (Liverpool)

Sainsbury Centenary Fund

G.P. Jones. BSc (Wales)

G.H. Parsons. BSc (Hull)

Sponsored by Overseas Governments and Agencies

Government of Venezuela : R.G. Oyon. BSc (Cal.Poly) MSc (Reading)

Greek State Scholarship Foundation: C. Pappas BSc (Athens) MSc (Reading)

Government of Turkey : O.C. Tekinsen. BSc (Ankara) MSc (Reading)

Government of Thailand: N. Tongsiri. BSc (Bangkok)
Columbo Plan

M.Sc. COURSE - OUTLINE OF ARRANGEMENTS

The programme can be considered in five sections:

During period October - June (i.e. the academic year)	(1) Study in the Department of Food Science.
	(2) Contacts with sc ientific and technical bodies.
	(3) Day visits to research and industrial centres in Reading and Southern England.
	(4) Scottish Tour during the Easter vacation.
During period July-September	(5) Eight weeks or more training in an industrial concern or other centre.

Some details of (1) to (5) are given in the following pages but a few introductory notes may be helpful to explain the objectives.

(1) *Study in the Department* The primary objective is to provide the student with a sound basis of chemical and physical principles and of aspects of biochemistry and mico-biology of importance in the understanding and practice of food science.

(2) *Contacts with Scientific Bodies* Overseas students are encouraged to attend meetings of appropriate scientific and technical bodies and organisations, so as to establish contacts which can be maintained on their return to their home countries.

(3) *Visits in the Reading area and Southern England* These visits arranged on a one day basis during the academic year are designed to follow up (2) by providing an introduction to the food industries in Britain and to the relevant governmental bodies and research organisations (see apprendix 1 and 2).

(4) *Scottish Tour* A ten-day tour was organised during the Easter Vacation 1970 to enable students to visit several industrial, research and educational centres in Scotland.

(5) *Industrial or External Training* Arrangements were made for each student to spend periods (Totalling approximately 8 weeks) in industrial concerns (factories or laboratories) or in other centres outside the University. In arranging this external programme full account was taken of the type of work likely to be undertaken by the overseas student on his return to his own country.

STUDY AT THE UNIVERSITY

Summary of Time-Table

1. *Autumn Term:* *October 3rd - December 11th 1969*

Course	*Hours/Week*	
	Theoretical/Lectures	*Practical*
1. Food Chemistry	2	4
2. Quality Appraisal including Sensory Evaluation and Statistics	3	-
3. Food Physics	1	3
4. Food Microbiology	2	6

11. *Lent Term:* *January 9th - March 19th 1970*

1. Food Chemistry	1	3
2. Quality Appraisal including Sensory Evaluation and Statistics	3	-
3. Food Physics	2	3
4. Food Microbiology	1	6

111. *Summer Term:* *April 24th - July 2nd 1970*

1. Analytical Chemistry	3	-
2. Food Chemistry Practical	-	7
3. Food Microbiology	1	2
4. Seminars	2	-

Qualifying Examination Summer 1970

Paper A: Chemistry including Colloid Chemistry and Biochemistry.

Paper B: Microbiology.

Paper C: General, including: Physics, Quality Apprais Sensory Evaluation and various special topics

NOTES

(1) VISITING LECTURERS

In addition to the above courses given by members of the staff of the department, special courses were given by visiting lecturers (e.g. on fisheries).

(2) OTHER UNIVERSITY DEPARTMENTS

The M.Sc. qualifying year students are based in the Department of Food Science, but arrangements were made for them to see something of the work of other departments and institutes, within or associated with the Faculty of Agriculture and Food of the University.

These centres included:

Department of Agriculture : University farms.
Department of Horticulture : University Horticultural Station.
The National College of Food Technology, Weybridge.
National Institute for Research in Dairying.

(3) LABORATORY COURSES

In the laboratory courses special efforts have been made to provide the students with training in basic chemical and biochemical analytical techniques and in basic micro-biological techniques which are particularly important to a food scientist who on returning to his own country may have to assume responsibility for the quality appraisal of products, and also for the training of junior technical staff. In the second year of the course the laboratory techniques will be closely linked to problems of food strage, preservation and processing.

(4) TUITION IN THE ENGLISH LANGUAGE

Several of the overseas post-graduates had little previous experience in following lectures in English. A special language course was initiated in the Autumn

of 1969 and continued throughout the Session- 2 hours lecture and 2 hours practical per week. Supplementary training was provided for some of the students.

CONTACTS WITH SCIENTIFIC AND TECHNICAL BODIES

The scientific meetings attended during the University year included those organised by the Food Group/Nutrition Panel of the Society of Chemical Industry on the effects of modern processing on the nutritive value of foods.

DATE	TITLE	SPEAKER
October 8th, 1969	1. Influence on protein quality of meat and eggs.	Dr. D.H. Shrimpton (B.O.C.M. Ltd.)
November 12th, 1969	11. Soy protein synthetic meat.	Mr. J.A. Church (Spillers Ltd.)
December 10th, 1969	111. The effect of UHT processing and subsequent storage on the nutritive value of milk.	Dr. J.W.G. Porter (National Institute for Research in Dairying)
February 4th, 1970	1Va. The Nutritive value of Modern Bread.	Dr. G.A.H. Elton (Flour Millers and Baking Industries Research Assoc.)
	1Vb. Contributions of the plant breeder to the improvement of wheat varieties in British Agriculture.	Dr. F.G.H. Lupton (National Institute for Agricultural Botany)
May 13th, 1970	V. Eating sea food, aesthetics and nutrition.	Mr. H.W. Symons (Birds Eye Foods

Some of the students attended other lecture arranged by the S.C.I. and other bodies.

EXTERNAL VISITS AND VACATION TRAINING

(a) Reading and Southern England

These visits included the following:-

GOVERNMENT AND LOCAL GOVERNMENTAL: DEPARTMENTS AND LABORATORIES	Ministry of Agriculture, Fisheries and Food. Laboratory of the Government Chemist Ministry of Technology. Tropical Products Institute (Ministry of Overseas Development)- centres in London, Slough, Bucks. and Culham, Berks. Borough of Reading Sewage Works.
INDUSTRIAL RESEARCH STATIONS	Fruit and Vegetable Preservation Research Association. British Food Manufacturing Industries Research Association. British Industrial Biological Research Association.
INDUSTRIAL ESTABLISHMENTS	Huntley & Palmers Ltd., Associated Biscuits Ltd., Reading. H.J. Heinz Company Ltd., Hayes Park, Middlesex. A.P.V. Co., Ltd., Crawley, Sussex.

(b) Scottish Tour

The visits included the following:-

GOVERNMENTAL AND GOVERNMENT SUPPORTED RESEARCH ESTABLISHMENTS	Hannah Dairy Research Institute, Ayr. Rowett Research Institute, Aberdeen. Torry Research Station, Aberdeen. Marine Biology Laboratory, Aberdeen. (Department of Agriculture for Scotland).

EDUCATIONAL CENTRES	University of Strathclyde, Department of Food Science. West of Scotland Agricultural College, Auchincruive, Ayr.
INDUSTRIAL AND RELATED ESTABLISHMENTS	Scottish Milk Marketing Board Creamery, Stranraer. Unigate Foods Ltd., Kirkmichael. Unilever Research Laboratory (Colworth), Aberdeen.

(c) Summer Vacation Training

The organizations listed below made training and other facilities available for periods up to 8 weeks for the post-graduate students.

Beecham Products (UK)
Research & Development (Foods)
Slough, Bucks.

J. Bibby & Sons Ltd.,
Animal Nutrition Centre,
Willaston, Wirral, Cheshire.

Cadbury-Schweppes Ltd.,
Marlbrook Factory,
Leominster, Hereford.

Cliffords Dairies Ltd.,
Bracknell, Berkshire.

Co-operative Wholesale Society Ltd.,
Canning & Preserved Food Factories,
Lowestoft, Suffolk.

Express Dairy Co., (London) Ltd.,
- Central Laboratories, London.
- Staplemead Factory, Frome, Somerset.

Midland Counties Dairy Ltd.,
Birmingham.

Unigate Foods Ltd.,
- Central Laboratories, London.
- Scrubbs Lane & Vauxhall Processing and Bottling Factories (London)
- Whitland, Carmarthen, South Wales.

APPENDIX 1

FOOD RESEARCH CENTRES IN THE UNITED KINGDOM RECEIVING SUPPORT FROM GOVERNMENTAL GRANTS.

Sponsoring Ministry or other official body	Centres controlled by Ministry	Supported through Ministry or related body
Agricultural Research* Council (or equivalent body in Scotland)	Food Research Institute Norwich.	National Institute for# Research in Dairying, Shinfield, Reading.
	Meat Research Institute Bristol.	Hannah Dairy Research# Institute, Ayr, Scotland.
Ministry of Technology	Torry Research Station Aberdeen, Scotland.	RESEARCH ASSOCIATIONS sponsored by industry but with some financial support from the State.
	Laboratory of the Government Chemist, London.	British Food Manufacturing Industries R.A. Leatherhead, Surrey.
		Fruit & Vegetable Preservation R.A. Chipping Campden, Glos.
		Flour Milling & Baking R.A. St. Albans/Chorleywood.
		British Industrial Biological R.A. Surrey.
Ministry of Overseas Development	Tropical Products Institute (London; Slough, Bucks; and Culham, Berks.)	
University Grants Committee/ Department of Education & Science	-	Food Science Depts. at Leeds, Nottingham, Strathclyde & Reading. Food Technology at U. of Reading /Weybride (M.C.F.T.)

Some other agricultural research centres (e.g. Rowett R.I. Aberdeen, Long Ashton R.I., Bristol; East Malling R.I., Kent) are concerned with food storage and other problems.

The Dairy Institutes are concerned in part with food (as well as agricultural) problems.

FOOD RESEARCH CENTRES IN THE UNITED KINGDOM CLASSIFIED BY COMMODITIES.

	PRODUCTS	CENTRE	SPONSORING MINISTRY OR AGENCY
ANIMAL PRODUCTS	Milk and Dairy Products	National Institute for Research in Dairying. Hannah Dairy R.I.	A.R.C. or equivalent.
	Meat Poultry	Meat R.I. Food R.I.	A.R.C.
	Meat Products	B.F.M.I.R.A.	Ministry of Technology
	Fish	Torry Research Station	Ministry of Technology
PLANT PRODUCTS	CEREALS		
	Milling Baking	Flour Milling and Baking R.A.	Ministry of Technology
	FRUITS & VEGETABLES		
	(a) Canning Quick Freezing Dehydration	Fruit and Vegetable Preservation R.A.	Ministry of Technology
	(b) Post-harvest storage	East Malling R.I.	A.R.C.
	(c) Fruit Juices and Cider	Long Ashton Research Station	A.R.C.
	(d) Jams and Pickles	B.F.M.I.R.A.	Ministry of Technology
	(e) Chocolate and Sugar Confectionery	B.F.M.I.R.A.	
	GENERAL	Tropical Products Institute	Ministry of Overseas Development
GENERAL	Both Plant and Animal Products	Food Research Institute	A.R.C.
		Laboratory of Government Chemist British Industrial Biological R.A.	Ministry of Technology

NOTE. The University departments are concerned with both plant and animal produce and have specialised equipment and research programmes in different commodity fields

INDICATIVE WORLD PLAN FOR AGRICULTURAL DEVELOPMENT
Nutritional Digest

by

M. Autret and J. Perisse
Nutrition Division, FAO

(original text in French)

The following article singles out from the Indicative World Plan for Agricultural Development (IWP) a number of food aspects of particular interest to the nutritionist.

BASES AND ASSUMPTIONS

The study takes as a basis the food balance sheets for the years 1961-63 and establishes supply and demand projections for the horizon years 1975 and 1985. Food demand targets for 1975 and 1985 are arrived at by econometric techniques (the consumption function and coefficients of demand elasticity) and in the light of the population and income assumptions of the model. Methods of establishing standard diets capable of satisfying nutritional requirements at the lowest economic cost are not considered.

Countries are classified into three groups:

A. North America, Western Europe, Japan, Oceania, Republic of South Africa

B. U.S.S.R., Eastern Europe, mainland China

C. All developing countries (excluding mainland China).

For the world population trend the IWP adopts the average United Nations assumption. The Zone C countries included in the study today represent over 1,500 million inhabitants, 60 per cent of whom are in Asia; this figure will be 2,200 million in 1985.

The importance of this population for the world's economic life cannot be over-emphasized. During the period 1961-63, the agricultural sector of the developing countries (excluding mainland China) represented 30 per cent of the gross domestic product (GDP) plus 30 per cent of the total exports and directly supplied the needs of two-thirds of the world's population.

During the period 1955-65, the gross value of agricultural commodities in developing countries grew at the rate of 2.8% per annum, while for population

the figure was 2.6%. The volume of food production grew by about three per cent both in developing countries and in developed countries.

The per caput improvement in food production was 1.5% per annum in A countries compared with 0.4% in C countries because of the smaller population growth in the former. (Food disparities between A and C countries have therefore simply increased.)

The IWP assumes that growth rates for the gross domestic product in Zone C countries will lie, according to the country, between 4.9% and 5.9% per annum from 1962 to 1985 (whereas they varied between 3.8% and 4.8% over the last decade); growth rates in terms of gross value of agricultural production should be 3.2% to 3.8% compared with 2.8% before. It is already known that growth rates in Asia and Africa between 1963 and 1967 did not accord with the IWP's assumptions.

THE IMPLICATIONS

If agricultural production were simply left to grow at 2.6 to 2.8% annually compared with the forecast 3.9% increase in demand, the supplies available for consumption in 1985 would be only 82% above the 1962 level while the figure for demand would be 142%. Assuming that imports could be relied on to bridge the gap in the underdeveloped world, this would mean, in monetary terms, an outflow of 30,000 million dollars compared with four thousand million today- an unrealistic assumption!

Local agriculture in Zone C must therefore manage to meet the demand, and must thus increase much more rapidly from 1965 to 1985 than it did between 1955 and 1965. In fact, as the forecast growth rates between 1962 and 1967 did not materialize, it may be affirmed that the average growth rate should rise from 2.6% in 1962 to 4.2% now.

In view of this, the IWP defines four major objectives for the countries of Zone C:

1. To secure the food production required by a population which is growing at a rate of 2.5 to 3% per annum and which has leeway to make up.
2. To ensure an improvement of the diet as a result of increased demand and of the need to combat certain dietary deficiencies.
3. To earn and save foreign exchange for investment and capital formation in non-agricultural fields.
4. To provide additional employment by intensifying agriculture and setting up new agro-allied industries.

Only the first two objectives will be considered here.

THE QUANTITATIVE FOOD PROBLEM

Countries in Zone A and Eastern Europe have calorie supplies of around 2900 to 3000 calories per day per person. Zone C countries and mainland China have less than 2200 calories. For Zone A countries, consumption exceeds requirements by 15%. However, in Zone C Latin America has 9% more than it needs while the other regions show a deficit ranging from 10% for Asia and the Far East to 5% for Africa and 8% for the Near East.

These averages obviously conceal wide inter-country differences. Thus, in Latin America, which is apparently in surplus, there are, side by side with countries that are greatly in surplus, twelve countries representing 48% of the population of the region which have a deficit in excess of 10%.

How will this situation develop between now and 1985 if real per caput income rises in accordance with the assumptions and if food supplies grow according to the projected demand increase? (see Graph 1.)

In the countries of Zone A and Eastern Europe, the average calorie level will rise little, not more than 5%. In a fair number of countries (North America, Australia, New Zealand) it will not increase at all, but it will increase by 10% in Southern Europe and Japan. In these countries, supply will match demand.

In the countries of Zone C, the calculated increase in average calorie level will be around 10% between 1962 and 1975 and 9% between 1975 and 1985. On this assumption, the average level of demand for the whole zone would exceed requirements by 4% in 1975 and by 13% in 1985.

This increased demand resulting from the increase in population and purchasing power will not be fully met by supply because of production constraints on certain commodities (meat, fish, milk, animal fats and vegetable oils). Supplies in 1975 will be barely sufficient to meet, on average, the level of requirements in Zone C.

Because of distribution inequalities between regions, countries, zones of a country and socio-economic groups, much of the population will still be undernourished in 1975. As the population will have grown from 1,400 million in 1963 to 2,000 million in 1975, it is probable that, even though the proportion of undernourished human beings will have diminished, the absolute number will still be what it is today. If even this figure is to be reached in thirteen years, a 52% increase in overall calorie supplies will be necessary.

In 1985, to achieve the proposed targets, calorie supplies should have reached an index of 209 (i.e. over double in 23 years); the level of calorie supplies would then be 10% over requirements.

Theoretically, this safety margin should meet the requirements of the majority of countries. Here again, however, about ten countries (the Andean zone and the arid regions of Africa and the Near East) will probably not reach or will only just reach the level of requirements because of the inter-country distribution and the disparity between socio-economic groups. At the same time, overpopulated areas in Asia will not be safe from regional or seasonal deficits.

Thus, while the hunger problems will not be solved in 1985, the size of the deficit zones will at least be much smaller and will be reduced to proportions which could easily be tackled by efficient international aid.

THE QUALITATIVE FOOD PROBLEM

How can the quality of the diet, its protein content and nature be varied during the period of the IWP?

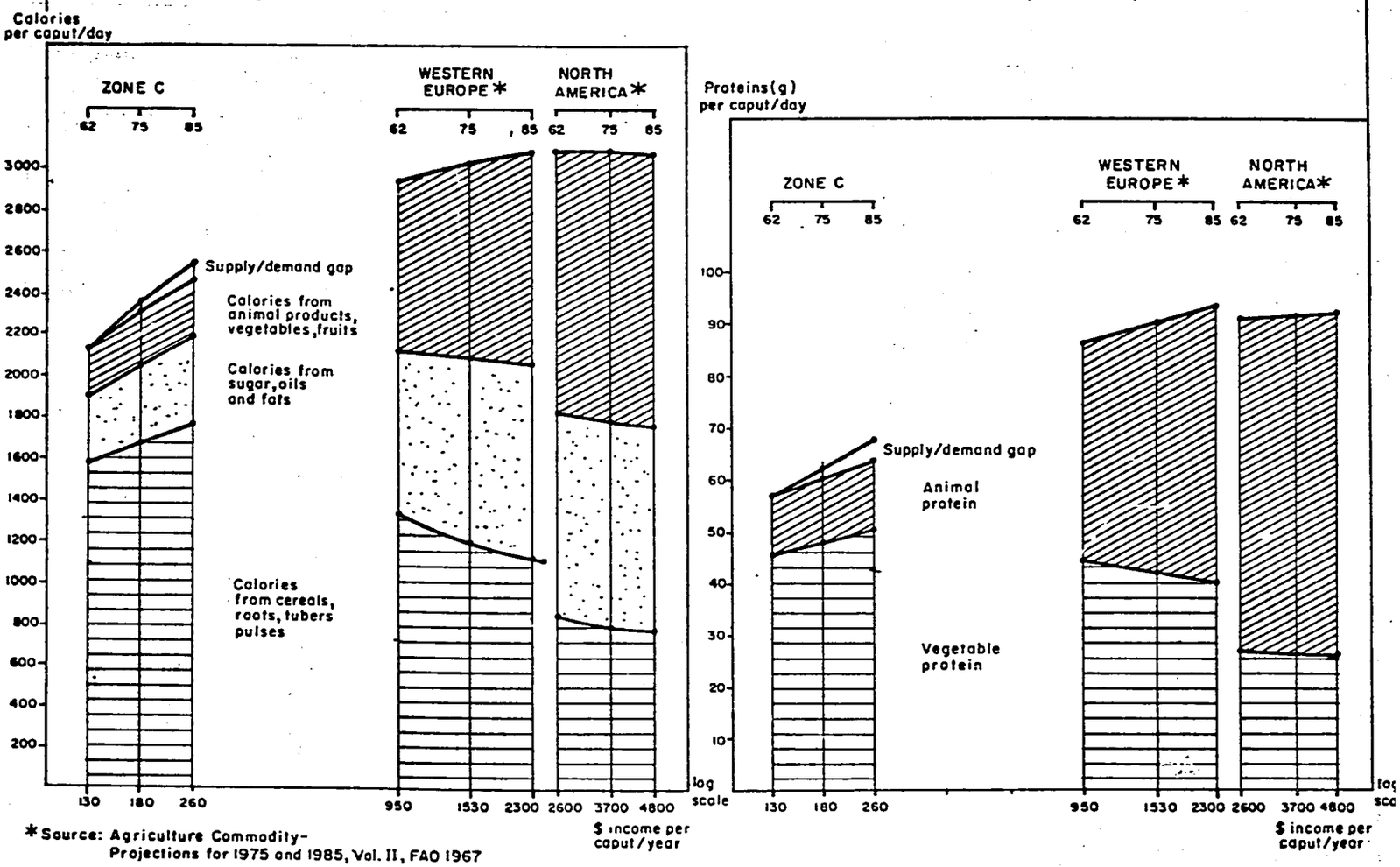
Developed countries have a daily intake of around 85 g. of protein and developing countries 50 to 70 g. (average 57 g.) while some of them, especially in central Africa, have hardly more than 40 g. Disparities in animal protein supplies are even greater. Whereas available supplies range from 40 to 60 g. daily in rich countries, they are only 5 to 25 g. per day in developing regions (avarage 11 g.). In developing countries as a whole, vegetable protein therefore represents 81% of the protein intake, cereals alone 57% and pulses, oilseeds and nuts 17%.

According to FAO 1/ projections (see Graph 1):

- in the countries of Zone A, the total protein intake, which was already high in the base period, continues to rise and is increasing from 85 to 92 g. This is due, despite a decline in vegetable protein intake, to the strong increase in demand for animal protein from 45 g. per person per day in 1962 to 55 g. in 1985. Thus, the percentage of animal protein in relation to total protein will rise from 70 to 72% in North America and from 48 to 57% in Europe;
- according to IWP data for the countries of Zone C as a whole (see Table 1), calorie supplies will rise from 2133 to 2477 and total

1/ *Agricultural Commodities--Projections for 1975 and 1985, Volumes I and II, FAO, Rome, 1967.*

Fig. 1 CALORIE AND PROTEIN INTAKES BY FOOD GROUPS DURING THE PROJECTED PERIOD (1962-75-85)



* Source: Agriculture Commodity-Projections for 1975 and 1985, Vol. II, FAO 1967

Table 1

ANALYSIS OF FOOD SUPPLY AND DEMAND IN ZONE C

Population (in millions)	total Zone C	study countries
1962:	1394	1172
1975:	1948	1648
1985:	2514	2132

	1962				1975						1985					
					Projected Demand	Demand Net	Proposed				Projected Demand	Demand Net	Proposed			
	Supply	Calories	Proteins	Fats			Supply	Calories	Proteins	Fats			Supply	Calories	Proteins	Fats
	kg/year	no/day	grams/day		kg/year	percent	kg/year	no/day	grams/day		kg/year	percent	kg/year	no/day	grams/day	
Cereals: Rice	76.7	506	9.5	1.1	83.3	100	83.4	550	10.3	1.2	86.0	100	86.0	569	10.7	1.2
Wheat	36.6	296	9.4	1.2	39.8	102	40.6	328	10.4	1.3	42.0	103	43.1	345	11.0	1.4
Other	52.3	446	12.6	4.2	54.1	98	53.2	456	12.7	4.2	54.8	98	53.6	460	12.8	4.3
Starchy products	65.9	160	1.9	0.4	67.6	100	67.4	164	1.9	0.4	68.2	100	67.9	164	2.0	0.4
Sugar/sweets	20.4	199	0.3	-	24.0	100	23.9	234	0.2	.-	28.5	99	28.3	275	0.2	-
Pulses, nuts, seeds	20.8	173	9.8	4.2	22.8	100	22.8	189	10.6	4.7	25.1	100	25.2	208	11.8	5.2
Vegetables	38.4	23	1.4	0.2	44.2	101	44.4	27	1.7	0.3	51.1	100	51.2	31	1.9	0.3
Fruit	30.1	38	0.5	0.3	35.8	100	35.9	44	0.5	0.4	42.3	100	42.3	52	0.6	0.5
Vegetal oils	3.9	96	-	10.8	4.8	100	4.8	117	-	13.2	6.2	97	6.0	147	-	16.6
Misc. plant products	0.8	7	0.3	0.3	1.0	100	1.0	8	0.3	0.4	1.1	100	1.1	10	0.4	0.4
Meat and products	12.1	71	4.6	5.6	14.2	90	12.8	75	4.8	6.0	17.1	82	14.0	81	5.2	6.6
Eggs	1.1	4	0.3	0.3	1.4	100	1.4	6	0.4	0.4	1.8	94	1.7	7	0.5	0.5
Fish/shellfish	5.6	10	1.7	0.3	7.2	92	6.6	13	2.1	0.4	9.7	75	7.3	14	2.3	0.5
Milk & products, whole	35.9	66	3.4	3.9	44.6	79	35.4	66	3.4	3.8	55.5	70	38.6	72	3.7	4.2
Milk & products, skim	8.5	9	0.9	0.1	10.9	90	9.8	10	1.0	0.1	13.9	73	10.1	11	1.0	0.1
Animal oils and fats	1.3	29	-	3.3	1.5	87	1.3	28	-	3.2	1.9	68	1.3	31	-	3.5

	Nutritional indicators: supply			Nutritional indicators: Demand		Demand Net %	
	1962	1975	1985	1975	1985	1975	1985
Calories: total	2133	2315	2477	2348	2554	99	97
of plant origin	1944	2117	2261	2117	2267	100	100
of animal origin	189	198	216	232	287	85	75
Proteins: total	56.6	60.3	64.1	62.2	68.0	97	94
of plant origin	45.7	48.3	51.4	48.9	51.5	99	100
of animal origin	10.9	12.0	12.7	13.3	16.6	90	77
Fats: total	36.2	40.0	45.7	42.0	50.1	95	91
of plant origin	22.7	26.1	30.3	25.7	30.2	102	100
of animal origin	13.5	13.9	15.4	16.1	19.9	86	77
Percentage of calories from cereals, starchy products and sugar	75.3	74.8	73.2	73.7	71.1		
Protein/calorie ratio	10.6	10.4	10.4	10.6	10.6		
Fat/calorie ratio	15.3	15.6	16.6	16.1	17.7		
Calories as percent of requirement	94.4	102.4	109.6	103.9	113.0		
Proteins supply as percent of requirement	93.2	99.3	105.6	102.5	112.0		

protein from 56.6 to 64.1 g., but animal protein supplies will increase only from 10.9 to 12.7 g. The percentage of animal protein in relation to total protein will therefore increase only slightly and will rise from 19.3 to 19.8%. Calories from cereals, starchy foods and sugar as per cent of total calories will decrease slightly, passing from 75.3 to 73.2%. Conversely, the fat colorie ratio will rise from 15.3 to 16.6. These modifications in the nutritional indicators agree with what is known of the effects of income on the structure of the diet [1]

according to projected demand, the protein calorie ratio remains constant at 10.6% for the whole of Zone C. On the other hand, when considering the level of projected supply, it declines and falls from 10.6 in 1962 to 10.3 in 1965 owing, as will be seen later, to constraints on the production of animal products. This decline is particularly marked in Asia. The protein calorie ratio decreases from 10.3 to 9.9.

For Zone C as a whole, it is estimated that the supply deficit in relation to demand will continue to get worse. The deficit will be about 2 g. of animal protein per person per day in 1975 and will rise to 4 g. in 1985. In other words, on the assumption of constant prices, the supply level expressed in animal protein will fall below demand level by 23% in 1985.

This deficit is considerable and represents 3,600,000 tons of animal protein, or more than the consumption of animal products of the Common Market countries in 1962 and the aggregate consumption of Africa south of the Sahara, Latin America and the Near East. The targets, therefore, even if reached, do not satisfy the nutritionist. The fact is that at the level of development of most of the countries in Zone C, demand does not have a decisive effect on diet diversification. In industrialized countries, when income rises the proportion of calories derived from cereals, roots and tubers with respect to total calories decreases relatively and even absolutely (Graph 1). Indeed, for many of these commodities demand elasticity is negative (e.g. Europe and America). Hence, there is room in the diet for other foods (sugar, fats and oils, animal products, fruits and vegetables) which, through substitution, help to diversify the diet with no appreciable increase in

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[1] *Périsse, J., Sizaret, F. and Francois, P. -Effect of Income on the Structure of the Diet- FAO nutrition Newsletter, Vol. 7, No. 3, July-September 1969.*

calorie intake.

In certain countries of Zone C which reached a satisfactory calorie level in the base period, this decline in the proportion of staple foods has already started (Mexico, Argentina, Uruguay and Taiwan). In other countries currently near the level of requirements, the increase in demand for staple foods will be modest and will reach saturation level, subsequently falling off slightly during the period considered.

On the other hand, in the many countries with a low calorie intake level, it is reasonable to think that, on the assumption of constant prices, higher food demand will bear primarily on staple foods, which are the only ones capable of filling the calorie deficit at the least cost. In such countries, the demand for calories from staple foods as a group with respect to total calories will doubtless decrease slightly in relative terms but will increase in absolute terms, as shown in the graph for Zone C as a whole; this will limit the room left in the diet for sugar and oils, fruits and vegetables and especially foods of animal origin. Despite a high demand elasticity for these prestige commodities, their initial share in the diet is too small for this to result in a significant modification of the dietary pattern.

Hence, at this pre-take-off stage of the economy, the dietary pattern suffers from a rigidity that hampers the solution of malnutrition problems. From the particularly worrying point of view of protein, the staple foods are of major importance in the demand perspective and remain the chief sources of protein. It follows that in the projection period the protein characteristics of the diet will be just as dependent on the kind of staple food as they were in 1962. In other words, the protein inequalities and calorie/protein imbalances observed today will persist. The forecasts are based on observation of past facts. It remains to be seen whether demand in these countries can be influenced by nutritional education of the consumer. In any case, such education would call for programmes of considerable scope and its effect on demand levels cannot be calculated.

AN OUTLINE OF THE OPTIONS

The IWP foresees no major difficulties with roots and tubers, fruits and vegetables and oilseeds. The key to the solution will be found in:

a) increasing cereal production;

b) improving the protein quality of the diet.

a) Calories

If cereal production grew only at the rate of 3% experienced during the 1955-65 decade and imports continued as over the last few years (11% per annum in Asia and 9% in North Africa and the Near East), 70 and 22 million tons of cereals would have to be bought by Asia, North Africa and the Near East respectively to meet their deficit, representing 7,500 million dollars in 1985. These are impressive figures.

If cereal productivity remained what it has been to date, an extra 68 and 26 million would have to be placed under cereals in those countries by 1985, or 50% and 100% respectively more than today. Such areas do not exist in the already overpopulated regions of Asia.

The only solution, then, is to increase yields. No one can be unaware today of the promising results already achieved with the new varieties of hybrid maize throughout the world, of dwarf wheat in Mexico, India and Pakistan, of rice in the Philippines and of sorghum in India and Uganda, while numerous tests are being carried out in many other countries. The solution to the calorie problem has certainly been furnished by American researchers and the Rookefeller and Ford Foundations. It therefore seems appropriate for FAO to have placed this task at the head of its five areas of concentration. The eradication of undernourishment from the world may be said to depend first and foremost on the progress in cereal production expected of the new high-yielding varieties. This inevitably means the employment of various technical and economic measures (inputs).

b) Protein Quality

It should first be noted that since cereals furnish an average of 57% of the protein ration in developing countries, any increase in supplies will produce a marked improvement in the protein ration, especially in maize and wheat countries. In addition, once energy requirements have been met, or even before in some countries, part of the land under cereals can be devoted to other essential activities in order to diversify the diet, for example, pulses and stock breeding, apart from the fact that some cereal production will doubtless be used for animal feed.

One solution, and probably the most efficient solution, to the protein problem would be to replace some of the high-yielding cereals by varieties of higher protein content (rice) or of better protein quality, such as the Opaque 2 and Floury 2 maize varieties and wheat varieties containing over 4% lysine, which have proved suitable for the growth of animals and infants without any protein supplement. This

is undoubtedly the solution to the protein problem, especially as some of the new varieties of high protein quality seem likely--without attaining the maximum yields of the very high-yielding varieties--to exceed the yields from the traditional varieties by an ample margin.

During the period considered, special attention should be devoted to pulses, which contribute greatly to the calorie/protein balance of the diet in Latin America and Asia. It is essential to develop high-yielding pulses, otherwise the cultivation of traditional varieties will be ousted by cereals of high productivity. Similarly, measures must be taken to promote their consumption over and above the demand perspectives.

Meanwhile, what of animal protein, which is the most sought after but which suffers the most from production constraints? How will its production develop?

Annual growth rates in animal production, which were 1.5 to 2% in the base period, should rise, in accordance with the IWP's targets, to 2.9% between 1962 and 1975 and 3.8% between 1975 and 1985. Even at these rates, Zone C would have to import 8 million tons of meat and 34 million tons of milk in 1985.

To deal with the situation, two alternatives are proposed directed at meeting the overall demand for meat by increasing the production of short-cycle species (poultry and pork). This would produce an additional 850,000 tons of animal protein provided- amongst other things- animal feed supplies were increased by 27 million tons.

With regard to fishery products, catches today amount to 60 million tons and projected demand could reach 106 million tons in 1985, two-thirds of which would be for human consumption and one-third for animal feed. It should be noted that the potential from conventional sources (sea and fresh water) does not exceed 140 million tons and costs will become extraordinarily high when the catch level approaches the potential level. The 8% annual rate of increase in 1958-62 had already fallen to 5.7% in 1965 and the IWP has been able to forecast only an average annual growth rate of 3.5% which, in 1985, will meet only 75% of demand.

At the rates of increase given in the IWP, the gap between supply and effective demand will carry on widening; protein supplies, which would represent only 90% of demand in 1975, would be only 77% in 1985. Because of constraints on meat, milk and fish supplies, the supply/demand gap would amount to 3,600,000 tons of total protein in 1985 for Zone C and to 2,750,000 tons if the pig-poultry alternative could be implemented. These constraints, which affect prices, are therefore liable to increase consumption inequalities.

In particular, the increase in supplies of milk and milk products will be only just able to meet the increase in population, so per caput consumption will remain stationary (see Table 1).

High-protein foods or food mixtures must be developed for the partial or total replacement of milk in infant feeding. Subsidized supplementary feeding programmes ensuring a fair distribution of milk according to the needs of young children in the less well-off socio-economic groups must be established on a wide scale and must go hand-in-hand with programmes to educate mothers. Failing these measures, the incidence of infant malnutrition is likely to progress at a rate at least equivalent to the rise in population.

The IWP also lays stress on the need to align demand with national food production by suitable consumer information.

The function of food preservation, storage and processing is also amply covered and an important place is given to new foods capable of partly filling the protein deficit in human diet either directly or by use in animal production.

The protein deficit as established on a world, regional or national basis, helps to define production targets. However, the margin between national requirements and supplies does not show who has a protein-deficient diet or where and when. The IWP is concerned primarily with supplies and production targets. Food distribution between countries and the regions of a country according to season, socio-economic group and age-group remains one of the most important problems even when national supplies are equal to or higher than national requirements. It is therefore necessary to identify the population liable to protein deficiency, their numbers and distribution by age-group, socio-economic group and geographical area, if it is desired to evaluate the size of the protein deficit and its location in space and time and to determine where and how to apply curative and preventive measures.

The IWP is a critical study of the food problem and of the lines to be followed and means to be employed to solve it in the period 1970-85 if the reasonable targets assigned therein for agricultural production and trade are to be achieved. It is a unique and innovating international exercise in forward planning which points the way to general national and international strategies.

The IWP demonstrates that the economic development of developing countries will depend primarily on local agriculture and that the latter will depend, first and foremost, on the attention and resources allocated to it by the countries themselves.

Furthermore, the IWP stresses the role of agriculture in the creation of financial resources for economic investment in the non-agricultural sector. However, these resources will not be sufficient to ensure the expected rate of growth and must be amply supplemented by external aid and foreign investment.

Notes and Articles

PROTEIN VALUE OF DIFFERENT TYPES OF DIET IN THE WORLD: THEIR APPROPRIATE SUPPLEMENTATION

by

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(original text in French)

Experimentation on animals is generally used to determine accurately the biological value of proteins in mixed diets; by appropriate supplementation it is also possible to identify the limiting factor of protein efficiency. This method is easy to apply when standard diets for animals are studied. Things are different in man. Here, in addition to the constraints inherent in experimentation as such, there is another difficulty- defining the representative diet of the population under study.

Food intake, in fact, varies greatly as a result of numerous factors- ecology, ethnic groups, level of income, social environment, family size, consumer's age, season, etc. Thus, there are many reasons why protein intake varies from day to day, from place to place, from group to group and even among the consumers of the same family. It is, therefore, difficult to gain an overall view of a country's food intake and analyze its diverse features, and be certain that the results closely correspond to the actual physiological situation. It is the aim of our study to estimate, by theoretical calculation, the protein value of different types of diet in the world and how they can be supplemented.

To this end, it is intended to identify the amino acids that are the limiting factors of the diet, determine the protein score in relation to the proteins of whole hen's egg taken as reference proteins, and to show the factors of variation affecting food consumption.

National household food consumption surveys which would make it possible to isolate the different factors and to increase the precision of the analysis, are available only in very few countries. To grasp the protein problem as a whole, it is therefore necessary to study food consumption at national level as it appears in food balance-sheets.[1] The second part of this paper shows how the results of certain

consumption surveys complete these results.

I. METHODOLOGY

The study of the protein value of the various types of diet has been based on FAO food balance-sheets. It covers 84 countries with 60 per cent of the world population (excluding mainland China) (see Appendix I). Some of these balance-sheets are in process of publication. They have been drawn up within the framework of the FAO study entitled "Indicative World Plan for Agricultural Development" and are subject to modification. The study of food intake, by socio-economic groups, season, age group, and day by day, is based on the results of food surveys involving family groups or individuals.

The values referring to the amino acids composition of foodstuffs have been taken from the FAO document to be published in 1969 and entitled "Amino Acids Content of Food and Biological Data on Proteins".

In keeping with recommendations by the Joint FAO/WHO Expert Group on Protein Requirements (1963), the protein score has been calculated with whole hen's egg as the reference protein (1). This Expert Group did not adopt the essential amino acid pattern provisionally proposed by the FAO Committee on Protein Requirements (1955) and known as "FAO reference protein" (2). Some research had shown that the rates of lysine, tryptophan and sulfur-containing amino acids were probably too high. Consequently, it is the combination of essential amino acids of whole hen's egg, adopted by the Joint FAO/WHO Expert Group, that has been used for reference purposes in this study. We shall return to this point in another paper to see whether the problem can be defined in greater detail.

In this study, the chemical scores of essential amino acids and the protein score of the amino acid that is the limiting factor of food intake have been calculated according to the method of Block and Mitchell (3)[2].

The rate of protein calories[3] is calculated by using the conversion factor 1 g of protein = 4 calories[4]. Operative net protein utilization (NPUop) and the calories derived from net dietary proteins in per cent of total calories (NDpCal%), which we are going to call more simply the rate of net protein calories, have been calculated on the basis of the protein score, in line with the suggestions Miller and Payne. (4) (5)[5].

Before analyzing the results, the methodological limitations of the study should be stated. The food supplies given by the balance-sheets refer to big aggregations. For instance, wheat consumption is indicated globally but that of wheat

products (bread, semolina, food paste) is not listed. As a result, it is impossible to take into proper account the changes proteins undergo in industrial or small-scale processing, or the effects of cooking, which may considerably modify the availability of certain amino acids, lysine, for example.

By the law of averages, national balance-sheets indicate per caput consumption per day, even for foods that are not eaten daily. likewise, seasonal variations or regional features of nutrition affecting and modifying the nature of the diet cannot be taken into consideration. Thus, in calculating the protein score, a supplementation is effected artificially which, in actual fact, does not exist. The results are therefore approximate and, in our calculations, the values of primary and secondary limiting factors are higher and more concentrated than they doubtless are in reality.

II. PROTEIN INTAKE AND REQUIREMENTS

In Figure 1, the countries are arranged in seven groups, according to the nature of their protein sources, and within these groups in decreasing order of total protein intake in g per person and per day. A cross in the diagram indicates protein requirements[6] expressed in g of local proteins per person and per day. The quantities of essential amino acids[7] of food intake are indicated by solid lines in the figure. Dotted lines denote non-essential amino acids and non-proteinic nitrogen.

Protein intake decreases sharply as we pass from industrialized countries with big consumption of animal products to countries of the equatorial regions where roots and tubers are the staple food.

Protein requirements range from 83 to 51 g per person and per day. While some industrialized countries enjoy a large margin of safety, 43 out of the 84 countries under review show an average consumption level below estimated requirements. These 43 countries total 900 million inhabitants. Considering unequal distribution among socio-economic groups, it may be assumed that a considerable part of the population in these countries has quantitatively inadequate protein intakes. It will only be possible to know this if national household food consumption surveys become available in most countries to show consumption levels by socio-economic groups.

It should be noted that the intake of essential amino acids shows very prominent differences between developed countries and some developing countries. Total protein intake in some tropical countries with roots and tubers as the staple food is barely higher than the intake of essential amino acids in industrialized countries.

Considering the difference in diets, the share of essential amino acids

in relation to total proteins is remarkably constant. It represents about 40 per cent of total proteins (35 to 43) both in countries with a small protein allowance of vegetable origin and in countries with a high protein allowance rich in animal proteins (see Appendix I).

III. PROTEIN SCORE AND LIMITING AMINO ACID OF FOOD INTAKE BASED ON NATIONAL FOOD BALANCE-SHEETS

The different diets, as evidenced by the food balance-sheets, show great variety as to the nature of the foods consumed and the relative importance of these foods. An effort has been made to class the countries in homogeneous groups with main emphasis on the origin of protein intakes. Seven types of diet have been adopted. The first type includes countries where protein intake stems mainly from animal products. Types 2, 3, 4, 5 and 6 (wheat, millet and sorghum, maize, rice and wheat + maize + rice) group the countries where protein intake is provided mainly by cereals. The seventh type covers countries where roots and tubers play a preponderant role. Within each group, the countries have been classed according to the score of the limiting acid, in decreasing order.

A. Countries where Animal Products are the Main Source of Proteins, Table 1

The group (19 countries) comprises the countries with high monetary income in Western Europe, North America, Oceania and the River Plate countries with large-scale animal husbandry.

In these diets, animal products (meat, eggs, fish, dairy produce) furnish 54 to 70 per cent of the proteins of food intake. Protein calories make up 10.3 to 13.9 per cent of total calorie intake. The protein score is high and varies within narrow limits (65 to 68). In nearly all cases, sulfur-containing amino acids are the limiting factor of protein efficiency, but isoleucine shows a very close score if it is not itself the limiting factor.

For the average Canadian diet, as reflected by the 1964 balance-sheet, Ballantyne and McLaughan have determined NPU experimentally in growing rats (6). The standard NPU value is 67, that is, a value identical to the protein score found here by calculation. The composition of this food mixture, analyzed by column chromatography, shows that, compared with egg, the sulfur-containing amino acids are the limiting factors, and that for the various amino acids the values found are remarkably close to those obtained by us by calculation on the basis of the tables. This confirms the validity of our estimates.

B. Wheat Countries, Table 2

FIGURE I - PROTEIN INTAKE AND REQUIREMENTS (g) BY COUNTRY, ACCORDING TO TYPE OF DIET

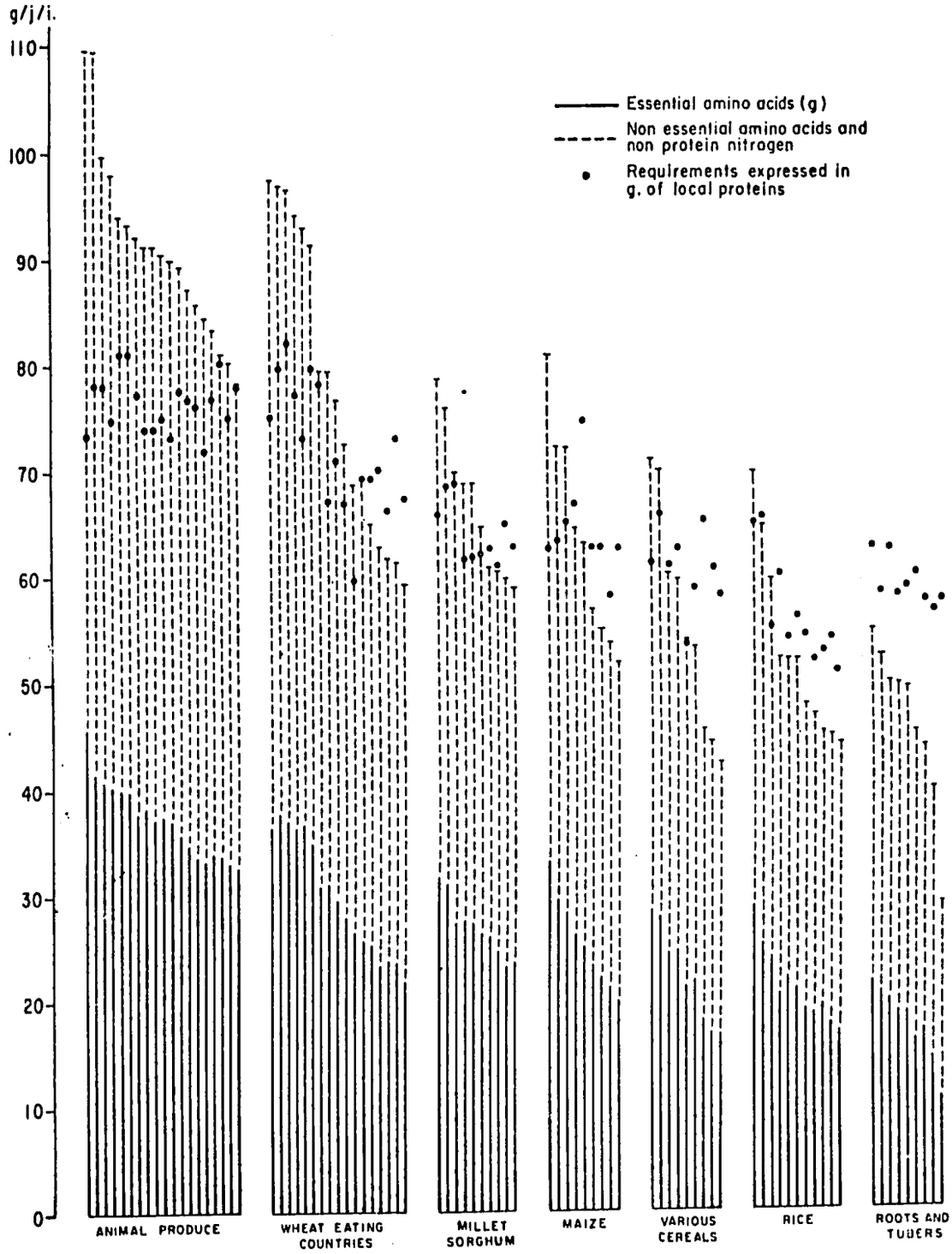


Table 1 - Countries having Animal Products as Main Source of Proteins

	Cal.	Tot. Prot.	Prot. Cal. Ratio	NPU op	NDp Cal. %	Chemical Score Iso	Leu	Ly	MC	Phen	Tyro	Threo	Tryp	Val	Protein Sources in % A.P.	Wheat	P.
N.Zealand[1]	3490	109,4	12,5	59	7,3	68	91	98	68	81	84	79	77	70	68	23	1
Australia[1]	3140	89,8	11,4	60	6,9	68	90	97	68	80	82	79	76	70	66	24	1
Uruguay[2]	3140	109,4	13,9	56	7,8	67	90	97	68	81	81	77	75	69	67	25	2
Canada[1]	3020	91,3	12,1	58	7,1	68	90	98	67	81	84	78	76	71	66	20	1
Belg.Lux.[1]	3040	85,3	11,2	60	6,7	67	89	88	67	81	80	75	76	70	54	33	2
U.K.[1]	3280	89,0	10,8	60	6,5	68	89	92	67	82	81	76	76	71	60	26	3
Sweden[1]	2990	82,7	11,1	60	6,7	68	91	99	67	82	85	80	76	74	66	24	1
U.S.A.[1]	3100	91,2	11,8	59	6,9	70	92	104	67	81	87	81	76	73	70	14	2
France[1]	3050	99,4	13,0	56	7,3	67	89	91	66	81	81	75	74	71	56	30	2
Austria[1]	2970	86,8	11,7	58	6,8	66	88	87	67	81	80	75	77	69	55	21	1
Argentina[2]	3040	97,9	12,9	57	7,3	66	89	93	68	79	78	75	72	67	59	30	1
Germ.F.R.[1]	2960	80,3	10,9	59	6,5	68	89	96	66	81	83	79	77	72	61	19	1
Netherld.[1]	2950	78,0	10,6	60	6,3	67	90	92	66	82	83	76	77	72	59	27	1
Norway[1]	2930	81,3	11,1	59	6,6	66	90	93	66	82	82	77	76	72	60	25	2
Switzld.[1]	3220	90,3	11,2	59	6,6	66	90	90	67	82	83	75	76	71	57	28	1
Ireland[1]	3490	91,9	10,5	60	6,3	67	90	91	66	83	82	77	79	70	60	26	1
Denmark[1]	3370	93,3	11,1	58	6,5	68	90	100	65	81	84	81	75	74	62	22	3
Finland[1]	3110	93,9	12,1	57	6,9	65	90	92	65	83	83	77	76	71.	58	20	1
Israel[1]	2820	84,2	11,9	57	6,8	65	86	77	69	82	75	69	72	69	43	42	5

1 Food Balance Sheets 1960-62, Rome 1966

2 Indicative World Plan, provisional results in print

A.P. = Animal Products

P. = Pulses

Table 2 - Countries having Wheat as Main Source of Proteins

	Cal.	Tot. Prot.	Prot. Cal. Ratio	NPU op	NDp Cal. %	Chemical Score Iso	Leu	Ly	MC	Phen	Tyro	Threo	Tryp	Val	Protein Sources in % *Wheat	A.P.	Other
Italy[1]	2730	79,6	11,7	56	6,5	63	87	75	67	82	75	69	72	68	44	37	4L
Hungary[1]	3030	91,7	12,1	55	6,7	63	83	75	66	80	71	70	73	66	46	41	2L
Poland[1]	3350	92,9	11,1	57	6,3	63	85	79	64	81	74	73	75	69	44	40	10P 1L
Chile[2]	2510	72,3	11,6	56	6,5	63	85	76	65	81	72	69	73	65	44	37	7L
Spain[1]	2800	76,7	11,0	56	6,2	62	83	73	64	80	71	69	73	66	41	31	6L
Greece[1]	2940	96,3	13,1	53	7,0	62	80	74	62	79	81	71	71	68	50	33	7L
Romania[1]	3155	97,3	12,3	54	6,9	62	89	70	62	79	81	72	69	67	42	31	17M 6L
Afghan.[1]	2060	68,5	13,3	52	7,0	61	87	60	64	78	79	68	68	67	53	22	14M
Yugosl.[1]	3030	94,0	12,4	53	6,6	61	90	63	66	83	72	66	69	65	52	24	9M 6L
Iraq[1]	2140	61,9	11,6	54	6,3	61	79	69	62	77	75	69	73	67	55	29	5L
Lebanon[1]	2360	64,8	11,0	54	6,0	60	85	68	65	82	71	66	70	65	50	24	10L
Iran[1]	2050	59,6	11,6	54	6,2	60	78	61	64	78	77	67	72	66	65	22	7R 3L
Syria[1]	2340	68,1	11,6	54	6,2	60	78	63	62	79	74	67	73	65	64	18	10L
Jordan[1]	2230	62,4	11,2	53	6,0	59	78	60	63	79	70	65	71	64	60	17	7L
Turkey[1]	3110	97,5	12,5	52	6,5	59	78	60	62	78	76	67	68	64	66	16	6L
U.A.R.[1]	2690	79,0	11,7	53	6,2	59	92	62	63	79	77	68	68	66	42	15	19M 8L
Morocco[3]	2170	61,6	11,4	52	6,0	58	83	61	65	81	75	68	75	66	65	18	14L

1 Food Balance Sheets 1960-62, Rome 1966

2 Indicative World Plan, provisional results in print

3 Disponibilités, besoins et carences alimentaires au Maroc, INRA, Rabat, July 1966

* Including rye, barley, and oats

L = Pulses

P = Potatoes

M = Maize

R = Rice

P.A. = Animal Products

Table 3 - Countries having Millet and Sorghum as Main Source of Proteins

	Cal.	Tot. Prot.	Prot. Cal. Ratio	NPU op	NDp Cal. %	Chemical Score Iso	Leu	Ly	MC	Phen	Tyro	Threo	Tryp	Val	Prot. Sources in % Millet	Sorgh.	A.P.	Other
Niger[2]	2160	78,2	14,5	52	7,6	63	110	66	68	83	77	74	86	73	65	18	15L	8M
Senegal[2]	2280	64,5	11,3	56	6,4	63	106	71	64	80	76	69	75	71	31	28	13R	
Sudan[1]	2030	69,3	13,7	53	7,2	65	116	79	62	85	81	75	78	73	41	33	14L	
Gambia[2]	2300	60,5	10,5	57	6,0	62	109	65	64	80	73	68	77	72	39	20	25R	
Ethiopia[2]	2040	68,8	13,5	53	7,1	62	99	72	65	85	72	73	76	70	45*	22	18L	8M
Tanzania[2]	2100	58,6	11,2	54	6,0	60	116	68	60	82	75	71	69	69	38	16	18L	18M
U.Volta[2]	2020	69,9	13,9	51	7,0	60	114	61	60	84	74	68	74	69	56	8	27L	6M
Chad[2]	2180	75,8	13,9	51	7,1	61	119	64	60	84	75	69	73	70	56	16	24L	
Mali[2]	2120	64,3	12,1	52	6,2	62	121	60	63	82	74	69	76	71	55	17	12L	
Nigeria[2]	2180	59,4	10,9	54	5,9	59	105	62	61	81	73	69	77	68	48	9	17L	17T

Table 4 - Countries having Maize as Main Source of Proteins

S.Africa[1]	2820	80,2	11,4	56	6,3	63	108	79	65	80	87	77	62	69	Maize 39	39	14B	
Mexico[1]	2610	71,9	11,0	55	6,1	63	108	78	61	84	83	75	64	69	46	32	14L	
Honduras[1]	2080	53,7	10,3	55	5,7	61	110	73	60	81	83	72	60	70	43	23	12L	
El Salv.[1]	2030	56,7	11,2	54	6,1	62	119	71	60	85	84	74	61	69	51	26	14L	
Zambia[2]	2280	71,8	12,6	52	6,5	59	116	64	59	84	82	71	61	68	40	14	21L	
Kenya[2]	2120	64,4	12,2	51	6,3	61	114	75	58	85	82	74	61	69	37	19	22L	
Dahomey[2]	2130	51,9	9,8	53	5,2	58	106	66	56	81	77	71	62	66	33	11	14L	21T
Guatem.[1]	2080	55,4	10,6	51	5,4	59	119	62	61	83	84	72	55	66	60	16	8L	
Malawi[2]	2090	62,9	12,1	46	5,6	57	118	64	55	87	85	71	51	66	62	5	23L	

1 Food Balance Sheets 1960-62, Rome 1966

2 Indicative World Plan, provisional results in print

* including teff

B = Wheat

L = Pulses

T = Roots and tubers

P.A. = Animal products

M = Maize

R = Rice

The 17 countries of this group are generally situated in the Mediterranean area, the Near East and Central Europe. In these diets, wheat and other secondary grains (rye, barley, oats) are the main protein sources and represent 42 to 66 per cent of total proteins.

Although consumption of animal proteins is markedly lower, the rate of protein calories is as high as, if not higher than, in the industrialized countries, ranging from 11.0 to 13.3 per cent. This good protein-calorie balance is mainly due to the fact that fats, sugar and tubers (potatoes) have a less important place in the diet than in the first group, while protein intake is much the same because of the high wheat consumption. However, this protein intake is of lesser quality. The protein score ranges from 58 to 63, depending on the country. It decreases as cereals augment their share in food intake and the share of animal proteins declines. Isoleucine is the primary limiting factor in the food intake of all these countries. The score of sulfur-containing amino acids is close to that of isoleucine in the countries at the top of the list where consumption of animal products and pulses is relatively high, while lysine appears as a secondary limiting factor in the countries classed at the bottom of the table in which protein intake stems mainly from grains.

C. Millet-and-Sorghum Countries, Table 3

These ten countries are in the Sudanese zone of Africa. It is of interest that in these diets, despite a very low level of income, the rate of protein calories is high (10.9 to 14.5 per cent) and bears comparison with that of wheat diets or of industrialized countries. This is due to the fact that millet and sorghum are rich in proteins, pulses are relatively important in the diet, and part of the population, the nomadic stock-breeders, eat quite big quantities of animal products (especially dairy produce). The protein score is in general comparable to that of the wheat countries (59 to 63). In most cases, isoleucine is the first limiting factor, but sulfur-containing amino acids and lysine (when the effect of cereals receives slight correction by intake of pulses) are very close. It should be noted that leucine contributed in large quantity by sorghum shows a very high score.

D. Maize Countries, Table 4

These nine countries are in Central America and Africa. The rate of protein calories (9.8 to 12.6) and the protein score (51 to 62) are lower than in the foregoing diets because maize has a lower rate of calories of protein origin and a lower protein score than wheat, millet and sorghum. Sulfur-containing amino acids and tryptophan generally are the limiting factors, but isoleucine also shows

Table 5 - Countries having Various Cereals (Wheat, Maize, Rice) as Main Source of Proteins

	Cal.	Tot. Prot.	Prot. Cal. Ratio	NPU op	NDp Cal. %	Iso	Leu	Ly	MC	Phen	Tyro	Threo	Tryp	Val	Prot. Sources in % Cereals, of which: tot.	B	M	R	P.A.	L
Venezuela[2]	2260	59,5	10,5	59	6,2	65	96	89	66	83	82	76	70	69	37	17	15		45	9
Colombia[2]	2210	53,5	9,5	59	5,7	65	101	90	63	81	86	78	70	70	33		22		48	
Surinam[1]	1980	44,5	9,0	60	5,4	64	89	79	67	81	75	70	74	72	51	22		29	34	
Costa Rica[1]	2430	53,9	8,9	60	5,3	63	94	83	63	81	78	73	71	68	34	14	11		34	
Paraguay[2]	2730	71,1	10,6	58	6,0	65	91	92	63	78	77	76	69	66	28	15	11		47	12
Bolivia[2]	1790	45,3	10,2	56	5,7	61	97	71	63	79	77	71	69	67	53	20	24		27	
Ecuador[2]	1850	42,0	9,1	58	9,1	62	92	85	61	79	79	74	71	69	37	8	15		33	13
Peru[2]	2270	60,1	10,6	56	5,9	62	88	79	61	79	75	72	72	67	42	19	11	11	31	
Brazil[2]	2830	69,6	9,8	55	5,4	63	93	86	59	81	76	74	70	68	36	11	13		31	25

Table 6 - Countries having Rice as Main Source of Proteins

															Rice	A.P.	Other
Malaysia[2]	2340	52,1	8,9	61	5,5	65	89	81	66	80	75	72	77	74	39	30	13B 10L
Philipp.[2]	1870	43,8	9,4	60	5,6	64	93	77	66	77	76	72	75	73	37	30	13M 5L
Thailand[2]	2130	46,5	8,7	61	5,3	64	89	73	65	78	73	70	80	76	61	21	9L
Japan[1]	2230	69,3	12,4	56	6,9	65	88	80	64	88	75	73	79	73	34	23	11B 18L
China Taiw.[2]	2400	59,2	9,9	58	5,8	64	85	77	63	77	73	69	78	72	42	27	11B 12L
Mauritius[1]	2330	47,2	8,1	61	4,9	63	90	77	63	83	75	70	76	72	38	26	17B
Ceylon[2]	2050	44,8	8,7	59	5,1	62	86	73	62	78	71	69	75	73	41	19	11B 16L
Madagascar[2]	2320	51,9	8,9	59	5,2	63	90	73	62	78	72	69	78	73	56	18	8T 9L
Pakistan[2]	1940	46,5	9,6	58	5,6	62	88	71	62	80	76	69	76	71	37	22	22B 10L
S.Korea[2]	2210	64,3	11,6	53	6,1	59	84	66	62	83	87	72	81	70	37	9	11B 6L 29or
India[2]	1980	52,2	10,5	53	5,7	61	93	70	58	85	73	69	72	69	22	10	15B 24L 16MS

1 Food Balance Sheets 1960-62, Rome 1966

2 Indicative World Plan, provisional results in print

B = Wheat
M = Maize
L = Pulses
R = Rice

A.P. = Animal products
MS = Millet and sorghum
or = Barley
T = Roots and tubers

very close values. On the other hand, the leucine score is high because maize, like sorghum, is very rich in this amino acid.

E. Countries with Various Cereals (Wheat, Maize, Rice), Table 5

These nine countries are in Latin America. Cereals as a whole are the main source of proteins. Here, in contrast with the countries of the other groups, grain consumption is more diversified at national level. Wheat, maize and, to a lesser extent, rice are the staple grains, but their distribution within the countries depends on ecological and ethnic factors. The protein score ranges from 59 to 65. Sulfur-containing amino acids or isoleucine, depending on the country, are the limiting factors. Their values are always very close, while the score of other essential amino acids is markedly higher. The rate of protein calories is close to 10, that is, an intermediate value between the wheat countries and the rice countries of the following table.

F. Rice Countries, Table 6

These eleven countries are mainly in Southeast Asia. Isoleucine or methionine-cystine are the limiting factors and show very close scores.

In seven of these countries (Malaysia, Philippines, Thailand, Taiwan, Mauritius Island, Ceylon and Madagascar) where rice is really predominent, the rate of protein calories is low (8.1 to 9.9), but the protein score is relatively high (62 to 65), higher than that of the wheat, millet-and-sorghum and maize countries. The explanation is that rice has a good balance of amino acids. But this qualitative advantage conferred by rice protein on the diet makes up only to a small extent for its protein rate which is lower than that of the other cereals, with the result that rice diets have a low rate of net protein calories.

In the other countries, rice is not a national staple food. It is a staple food in certain areas, while wheat, millet and sorghum, and barley are basic foods in others. This applies to certain regions of India, Pakistan and Korea. It illustrates the difficulties in determining the limiting factor at national level when the type of diet closely depends on ecological conditions.

Although rice is the main protein source in Japan, the country has a high protein-calorie rate (12.8), comparable to that of countries with animal products and wheat. This is due to a decline of rice in favour of wheat and to big consumption of animal products and pulses, while the shares of sugar and fats are small.

G. Countries with Roots, Tubers and Plantains as Staple Food, Table 7

The nine countries of this group are in the equatorial zone of Africa.

Table 7 - Countries with low Protein Supply having Roots and Tubers as Staple Food

	Cal.	Tot. Prot.	Prot. Cal. Ratio	NPU op	NDp Cal. %	Chemical Score Iso	Leu	Ly	MC	Phen	Tyro	Threo	Tryp	Val	Protein Sources in % T.	A.P.	Other
Gabon 2	2140	43,9	7,8	61	5,0	63	77	96	66	75	74	75	70	64	27	51	7L
Ivory C.[2]	2300	52,2	9,1	57	5,2	60	94	70	62	79	78	70	69	68	23	20	19M 15R
Ghana[2]	2160	48,6	9,0	56	5,1	59	91	75	62	78	77	71	72	68	32	22	13L 11M 13MS
Cameroon[2]	2130	54,5	10,2	65	5,6	59	104	66	61	81	79	70	72	68	17	18	24MS 16M
Congo Br.[2]	2130	38,9	7,3	58	4,3	59	75	84	60	72	73	69	70	64	28	38	15L 11B
Uganda[2]	2060	49,5	9,6	55	5,3	59	92	80	60	80	76	72	73	67	20	19	30L
Togo[2]	2210	49,1	8,9	56	4,9	58	102	65	59	80	76	68	67	66	19	12	22L 22MS16M
C.A.R.[2]	2170	44,8	8,2	55	4,5	56	85	73	59	74	71	67	71	62	27	21	27L 12MS
Congo K.[2]	1920	28,8	6,0	57	3,4	56	82	77	57	74	73	68	64	61	25	26	22L 14M

2 Indicative World Plan, provisional results in print

R = Rice
L = Pulses
M = Maize
T = Roots & tubers
B = Wheat
MS = Millet and sorghum
A.P. = Animal products

Table 8 - Frequency of Limiting Factors

Limiting Factor	Iso-leucine	Methio. cystine	Lysine	Trypto-phan	Valine	Threo-nine
Primary	55	39	2	4		
Secondary	27	30	7	2	6	
Tertiary	3	10	9	4	46	11
	85	79	18	10	52	11

Table 9 - Grading of Diets

Type of Diet	Prot.Cal. Ratio	Chemical Score	NPUop	NDp Cal. %	Limiting Factor
Animal Products	10,5 - 13,[illegible]	65 - 68	56 - 60	6,3 - 7,8	M.C. Iso. Valine
Wheat	11,0 [illegible]	58 - 63	52 - 57	6,0 - 7,0	Iso. M.C. Lys. Val.
Millet, sorghum	1[illegible] 14,5	59 - 63	51 - 57	5,9 - 7,6	Iso. M.C. Lys.
Maize	[illegible],6 - 12,6	51 - 62	46 - 56	5,2 - 6,5	M.C. Iso. Trypt.
Rice	[illegible],1 - 12,[illegible]	58 - 65	53 - 61	4,9 - 6,9	Iso. M.C. Threo.
Roots & tubers	[illegible],0 - 10,2	56 - 63	55 - 61	3,4 - 5,6	Iso. M.C. Valine

Starchy foods (roots, tubers, plantains) are the main source of calories but, in contrast with the preceding diets, these staple foods play only a secondary role in regard to protein intake because their protein content is low (taro, yam) or very low (plantain, cassva). As a result, these diets based on roots and tubers show a very marked protein-calorie imbalance. The rate of protein calories is mediocre (less than 8) in countries with a strict tuber diet (Gabon, Congo-Brazzaville, Congo-Kinshasa). It improves and approaches 10 as maize partly replaces tubers or in countries with savannah areas where the population has millet and sorghum as staple food. The protein score is low (56 to 63), but not lower than that of maize diets. Isoleucine is the limiting factor of protein efficiency in all cases, with sulfur-containing amino acids and valine the second and third limiting factors, respectively.

IV. GRADING OF DIETS

In the above protein diets based on balance-sheets, isoleucine is the limiting factor 55 times, sulfur-containing amino acids 39 times, tryptophan 4 times, and lysine twice. Table 8 lists these data and shows that sulfur-containing amino acids and isoleucine also act as a secondary limiting factor, and valine and threonine as a third limiting factor.

Numerous investigations on animals show that lysine, methionin-cystine, tryptophan and threonine really limit the protein efficiency of diets. By contrast, isoleucine and valine generally are not regarded as having a particular role in this field.

Therefore, it may be asked whether the protein of whole egg used as reference protein does not result in over-estimation of the importance of certain amino acids, especially isoleucine. The frequent role of methionine-cystine as limiting factor of certain notoriously satisfactory diets leads one to ask the same question in regard to sulfur-containing amino acids.

It is certain that egg protein, like others which have also been proposed (human milk, cow's milk, FAO protein), remains controversial and does not seem entirely satisfactory in judging the protein quality of human food. Moreover, recent analyses based on more precise methods have shown that the chemical composition of egg protein differs from that given for egg by the FAO/WHO Expert Group on Protein Requirements (1963). The present values observed by Cresta (7) would produce markedly different results for limiting amino acids. We are going to study this in a future paper devoted to reference protein. While waiting for experiments and possibly mathematical analysis to suggest a new reference protein more in line with biological data, we have deemed it reasonable to keep to widely accepted terms of

reference.

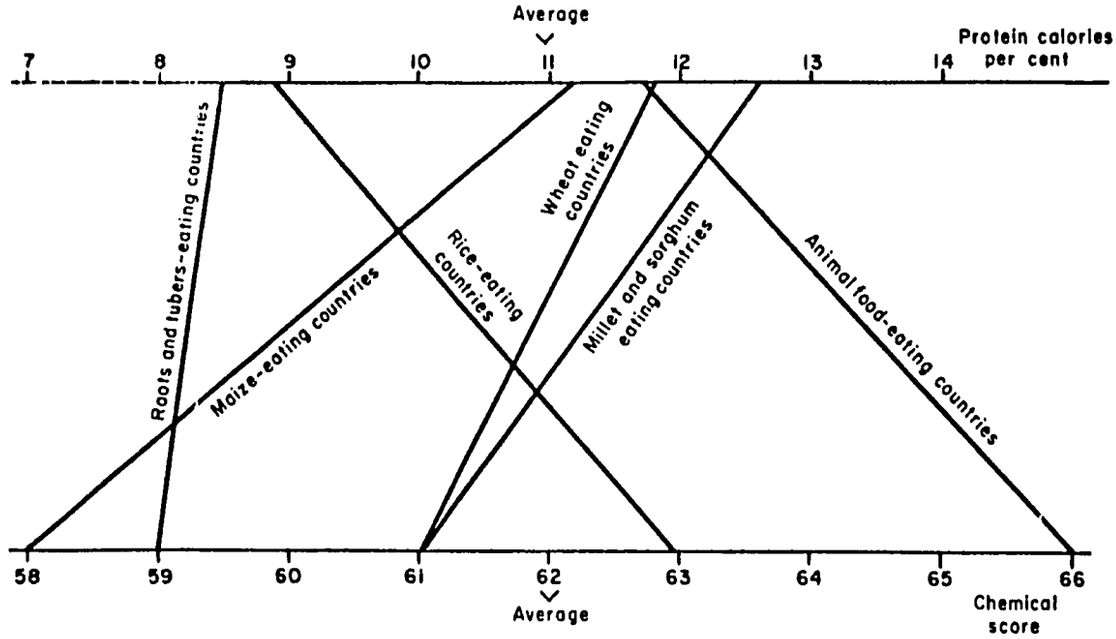
On the basis of the data in the foregoing tables, the diets have been graded from the protein point of view. This classification is based on the rate of net protein calories (NDpCal%), a value that integrates the quantitative aspect (rate of protein calories), the qualitative aspect (protein score), and takes into account the fact that the lower the rate of protein calories (NPU operative), the higher is the protein efficiency.

The extreme values of these indicators, by types of diet, are set out in Table 9.

Although the diets of these 84 countries differ widely in quality and quantity, the table shows that the protein score varies within fairly narrow limits (51 to 68); on the other hand, the protein-calorie rate shows a big margin of variation (6.0 to 14.5).

Figure 2 depicts schematically the data of Table 9. The line representing the type of diet is determined by the average rate of protein calories and by the average protein score[8].

FIGURE 2



It should be noted that, despite strong consumption of protein-rice foods, the countries with animal products have an extremely average protein-calorie rate comparable to that of many grain countries where consumption of animal proteins is low. The phenomenon is explained by the important place of fats and sugar-containing

products in the diets of industrialized countries.

Compared with the other grain countries, the rice countries are strongly handicapped in their protein-calorie balance. A good protein score partly makes up for this handicap. This is due to the fact that rice is poor in protein but these proteins are of good quality. The countries with roots and tubers as staple food have a low rate of protein calories and a low protein score.

Intergration of these two indicators, in the form of the rate of net protein calories (NDpCal%), makes it possible to grade the country groups in the following order:

1. Countries with animal proteins;
2. Wheat countries and sorghum countries;
3. Maize countries;
4. Rice countries; and
5. Countries with roots and tubers.

In short, these diets rank to a very large extent according to the protein hierarchy of their staple food.

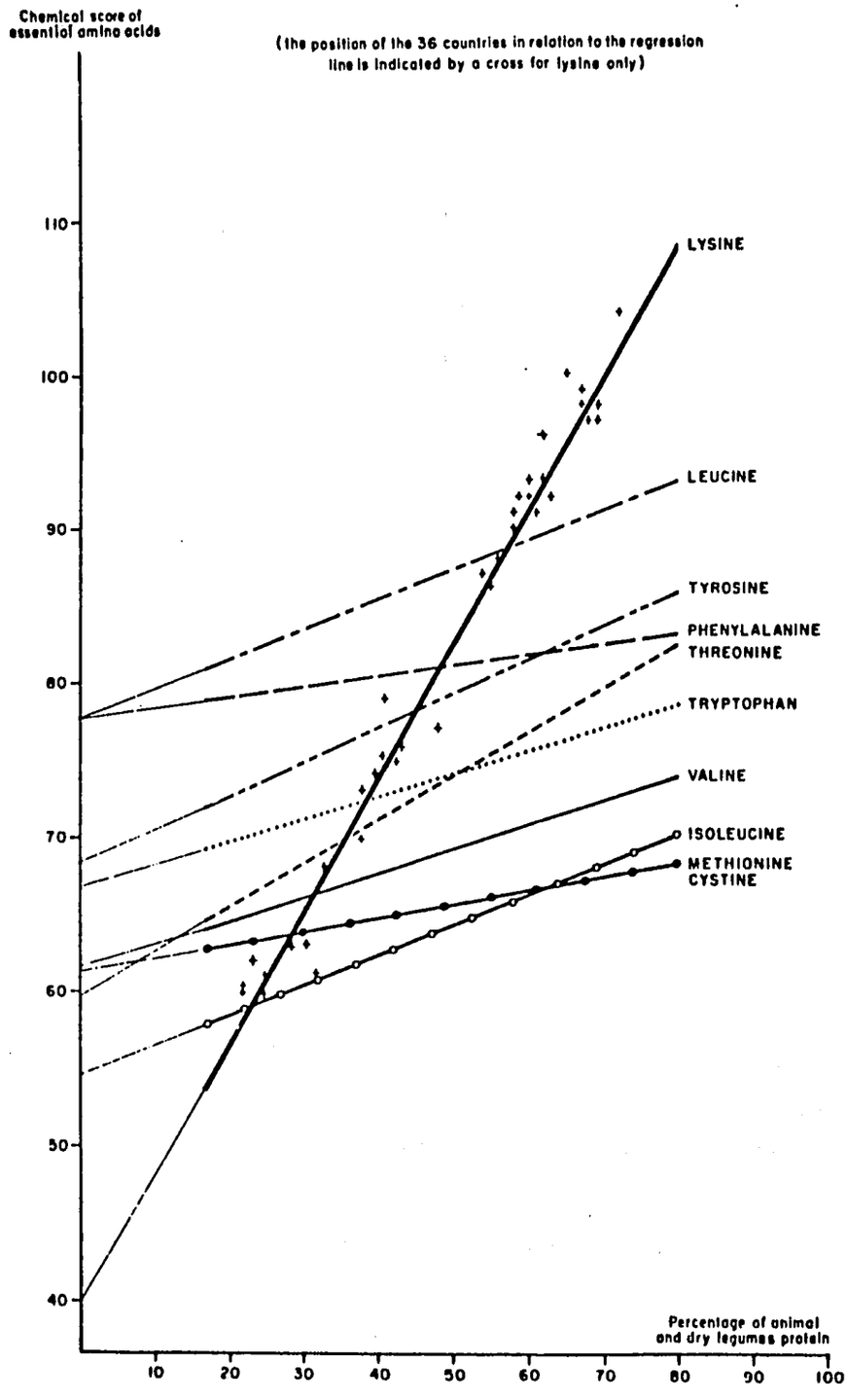
V. SUPPLEMENTAL EFFECT OF ANIMAL PRODUCTS AND PULSES

The supplemental effect of animal products and pulses on cereal diets is studied here by means of inter-country comparison. To bring out this phenomenon, only the countries of Groups 1 and 2 have been considered. These countries differ widely from the economic point of view because they include highly industrialized nations and developing countries. As a result, consumption of animal products and pulses presents a wide range of variations, but their common characteristic is that they have wheat as the staple grain.

We, therefore, have a series of relatively homogeneous countries in which protein intakes are largely of the same nature, differing only in quantity. An analysis of this kind would obviously be of great interest for rice or maize countries. It could not be undertaken at the level of food balance-sheets: the number of these countries is too small and their level of development is such that the intake of animal products and pulses varies within too narrow limits to produce any significant results.

In Figure 3, each country is classed in the abscissa according to the percentage of animal proteins and leguminous proteins in relation to the total proteins of food intake[9], and in the ordinate according to the chemical score of the essential amino acids[10].

FIGURE 3- CHEMICAL SCORE OF ESSENTIAL AMINO ACIDS IN RELATION TO THE PERCENTAGE OF ANIMAL FOODS AND DRY LEGUMES IN THE DIET



For each amino acid and for the countries as a whole, we obtain points whose representative lines are determined by regression. For all amino acids, except for phenylalanine, we observe a satisfactory correlation between the percentage of animal products and pulses and the chemical score of food intake. The highest correlation coefficient is obtained with lysine (r = + 0.97).

The chemical scores of amino acids improve from country to country in different degree as the relative share of pulses and animal products grows in the diet. The line of adjustment of lysine is clearly marked off from the others by a very strong angular coefficient. For the other amino acids, evolution of the scores is less marked while clearly showing improvement, except for phenylalanine and methionine-cystine.

The left part of the figure shows that lysine has every chance of being a limiting factor in diets whose protein intake from animal products and pulses is less than 22 per cent of total proteins. In fact, in wheat countries, apart from Afghanistan, the share of complementary foods is higher than this figure. This explains why lysine does not appear as a limiting factor in the national average food intake of these countries.

Between 22 and 60 per cent, isoleucine limits the protein efficiency of the diet and corresponds to the situation in Mediterranean and Near Eastern countries, as well as in part of the European countries. Beyond 60 per cent, the countries consuming animal products generally have methionine-cystine as the limiting factor. As the line representing the score of sulfur-containing amino acids has a very gentle slope, large quantities of animal products are necessary to improve the protein score of food intake in these countries by a few points.

Thus, from this point of view, high-quality proteins are being wasted in countries with very high incomes because the resultant qualitative improvement is slight and out of proportion to the financial effort made to ensure very high levels in the consumption of animal products. (Italy consumes 30 g of animal protein per caput and Denmark 58. As a result, the lysine score rises from 75 in Italy to 100 in Denmark, but this has no effect on protein efficiency. The protein score of the limiting factor has the same order of magnitude in both countries, 63 and 65, respectively.)

VI. PROTEIN SCORE AND LIMITING AMINO ACID OF FOOD INTAKE BASED ON CONSUMPTION SURVEYS

The results of the first part, established on the basis of average national food supplies representative of large population aggregates have methodological

limitations. They do not permit us to grasp the actual situation at consumer level. It may be assumed that what is observed among countries with different protein levels applies also to socio-economic groups within a given country. Differences may even exist among the members of one family. This is particularly important in the case of children. It is already known that they generally do not receive the share of the family's food they should receive. Finally, in view of seasonal and even daily changes in food intake, one may ask how these variations affect the limiting factor and the protein value of diets.

Such a study is only possible on the basis of family consumption surveys that are representative of the country under review and take into account the variou factors capable of influencing the protein value of the diet: ecology, ethnic grou income, family size, consumers' age, season, day, etc. Such surveys are still extremely rare. However, there are some that can give an objective picture of one or the other of the above mentioned factors.

A. Variation of Limiting Amino Acid Depending on Income

It would be interesting to see if the qualitative modifications brought out by the comparison among wheat countries (Fig. 3) are also to be found among the socio-economic classes within one of these countries. This study could not be made because, as far as we know, surveys permitting a correct correlation of the economic standard of households and their consumption are not yet available in low-income countries with high wheat consumption.

But one may assume that what is observed (Fig. 3) among the countries of Groups 1 and 2 with different protein levels and incomes, probably also applies to socio-economic groups within a given country. In the wealthiest families, sulfur-containing amino acids will be the limiting factors of protein efficiency because of the considerable share of animal products in the diet. Lysine will be the limiting factor in the poor classes in which wheat is the main source of protein. According to the diagram of Fig. 3, between these extremes the diets of the middle classes will show very close protein scores for lysine, isoleucine and methionine-cystine. Polysupplementation will therefore be necessary if the protein scores of these diets are to be improved. For the poor classes, the addition of lysine-rich complementary foods to the diet will make it possible to improve the protein score very rapidly to a level close to 60. Above that, as in the preceding case, the qualitative gains will be much slower.

However, this analysis, in terms of income, could be made for a rice

country, based on a survey of 5,000 families representative of rural households in Madagascar (8).

In Figure 4, the families are classed according to monetary income. In all groups, methionine-cystine and isoleucine have close scores and are the limiting factors of protein efficiency. This is in line with the results obtained on the basis of the food balance-sheets of rice countries (Table 6). The protein score of these amino acids improves as monetary income goes up, but it does so within narrow limits (methionine-cystine 60 to 68, isoleucine 61 to 70). The other amino acids show a higher score and change very little as a result of income. Only the lysine score grows very fast (from 69 to 100) with rising income, mainly because of increased intake of animal products.

This illustrates the remarkable ability of these foods and of pulses to supplement the staple cereal with lysine. The wealthiest class if only a tiny fraction (1 %o) of the population. At this level alone, the share of rice, which was roughly constant, drops sharply in favour of wheat and foods of animal origin. As a result, the rate of protein calories rises to 12.8, and sulfur-containing amino acids are the limiting factors. Thus, this high-income group shows the dietary features of industrialized countries (see Table 1).

Rice, like the other cereals, has lysine as the limiting factor, but the margin separating this amino acid from isoleucine (or from methionine-cystine) is narrow. On the other hand, rice is relatively poor in proteins.

Consequently, lysine-rich complementary foods (animal proteins, pulses) will easily make up for the lysine deficit because, even in small doses, they represent here a relatively more important part of protein intake than in the wheat, sorghum or maize diets. This explains why even among the low-income classes the few grams of animal proteins that appear in food intake can fill the lysine deficit.

In conclusion, while it is conceded that animal products and pulses have a marked supplemental effect in regard to cereal diets, it would seem that in the case of rice diets in which the lysine deficit is not prominent, they will have limited impact from the qualitative point of view. On the other hand, they can effectively raise the rate of protein calories of rice diets.

B. Seasonal Variation of the Limiting Factor

This aspect is studied on the basis of the results of a survey carried out by EURATOM-CEA*(9) in eleven areas of the six countries of the European Community

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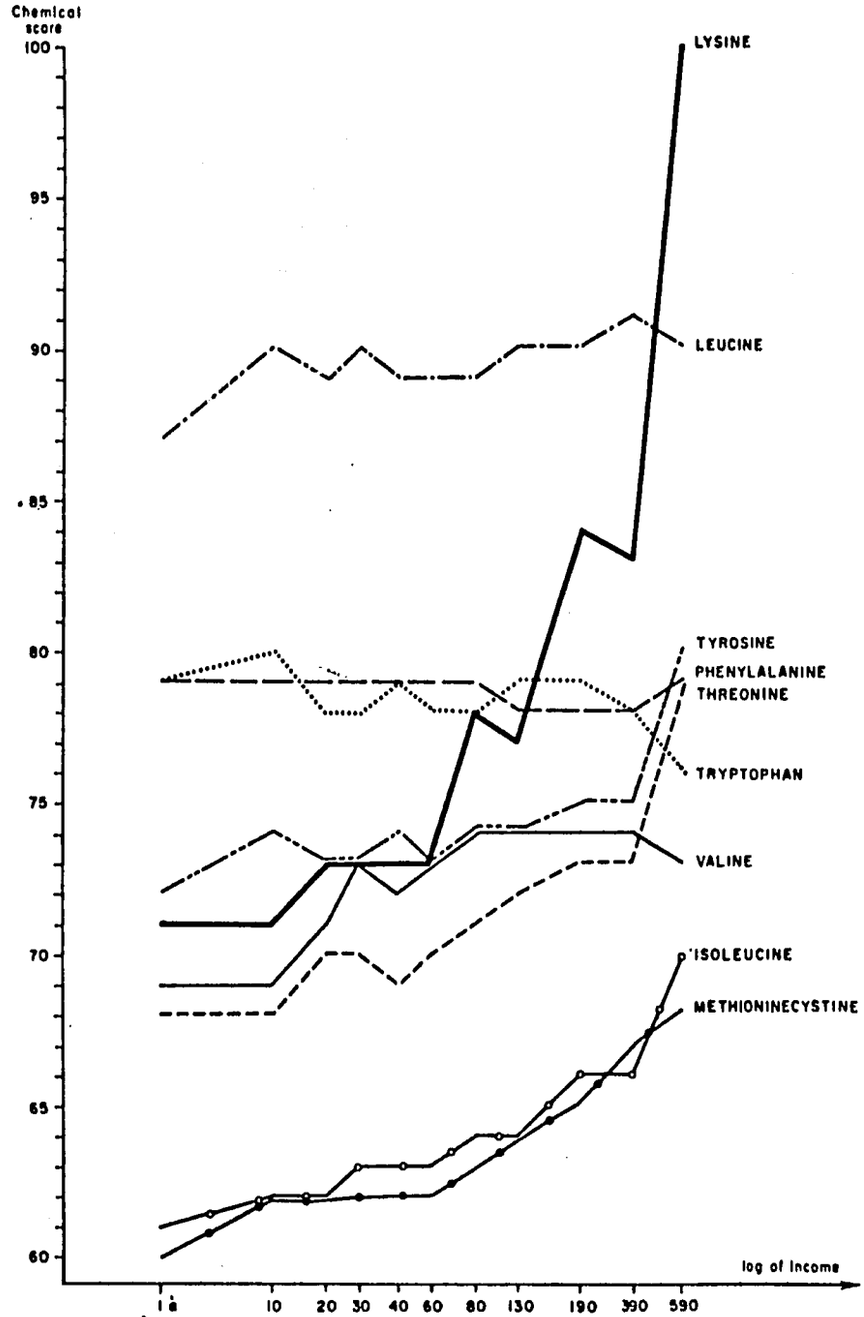
* *Commissariat a l'Energie Atomique = Atomic Energy Commission*

FIGURE 4 - MADAGASCAR. HOUSEHOLD FOOD CONSUMPTION SURVEY CHEMICAL SCORE VARIATIONS



		1 à	10	20	30	40	60	80	130	190	390	590
Income in thousand francs FMG		10	20	30	40	60	80	130	190	390	590	et
Family percentage		21.4	33.3	17.3	10.4	7.3	3.6	3.8	1.5	0.8	0.3	0.1
Protein calories per cent		9.3	8.5	9.4	9.6	9.3	9.9	10.4	10.0	11.0	10.6	12.8
	Total proteins in gr.	49.8	45.9	53.9	54.5	52.7	55.5	61.2	59.1	64.6	65.3	71.2
percent of total proteins	Animal proteins	11	5	15	17	17	18	25	26	34	36	61
	Dry legumes	7	7	7	8	7	5	5	3	3	3	0.4
	Rice	65	64	58	56	61	58	55	57	54	54	30

Campania (Italy) has been chosen because of the similarity of its diet to that of the wheat countries in Table 2. The scores of amino acids have been established month by month throughout the year on the basis of average consumption by 30 families (Fig. 5).

Some amino acids (phenylalanine, tryptophan, methionine-cystine) show a relatively constant score throughout the year. Others rise in the first half of the year and decline in the second half. As a result, protein intake shows a low score in winter, with a minimum in January (54) and relatively higher values in summer, with a maximum in June (63). The qualitative improvement of the diet in spring and summer is due to resumption of work in vegetable canneries which brings about a seasonal improvement of family income. During the periods of econommic difficulties when the share of pulses and animal product is less than 27 per cent, lysine appears as the limiting factor. In the period of abundance, it reaches very high values, and isoleucine appears as the limiting factor.

The seasonal variations of the limiting factor here are strongly dependent on changes in monetary income. In the following example, taken from a consumption survey in a Togolese rural area (10), the variation of the limiting factor is closely linked to the cultivation schedule and to socio-cultural choices of basic foods (Table 10). This type of diet is based on cassava and maize. In the pre-harvest period ("hungry season" - May), when cassava is the mainstay of food intake, the limiting factor is isoleucine. In September, after the first grain harvest, maize partly replaces cassava. Tryptophan then becomes the limiting factor, and the protein score drops. In January, after the second harvest, maize becomes preponderant, and the chemical score of tryptophan worsens even more.

However, the gradual replacement of cassava by maize entails a very clear increase in protein intake which more than makes up for the qualitative degradation.

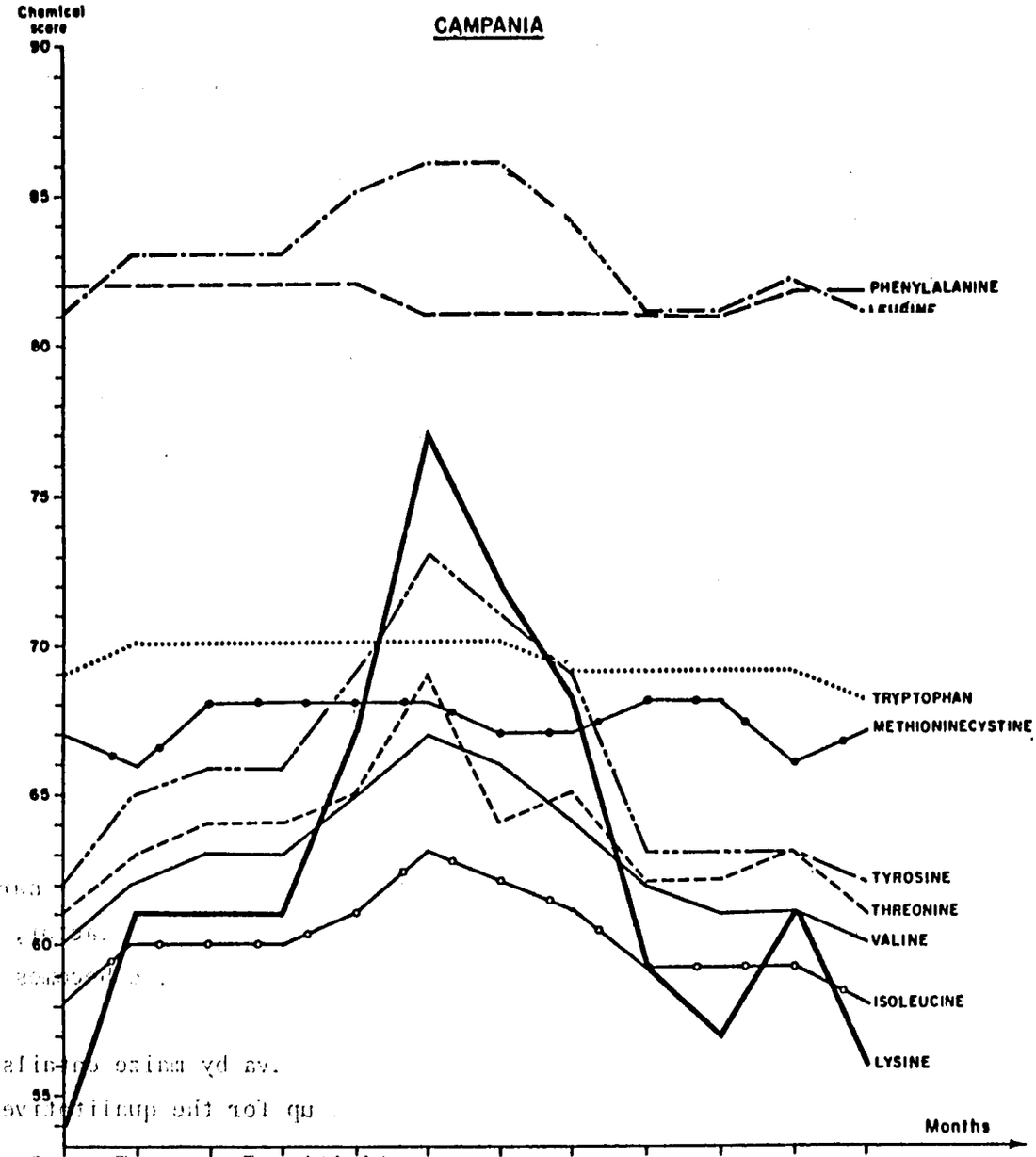
Table 10 - Seasonal Variation of the Limiting Factor - Togo, Ouatchis Village of Attitogon

	Cal.	Prot.	Prot. Cal. Rate	NPU	NDp Cal. %	Iso	Leu	Ly	MC	Phen	Ty	Threo	Tryp	Val	Prot. Sources in % of tot. prot. A.P.	Maize	C	P
May	1,830	26.4	5.8	60	4.5	59	99	80	60	73	75	74	62	66	26	37	19	9
Sep	2,070	40.7	7.9	58	4.6	60	109	79	64	76	80	77	59	69	31	47	12	3
Jan	2,090	46.5	8.9	54	4.8	59	114	73	61	78	81	75	56	68	20	52	8	10

A.P. = Animal Products C = Cassava P = Pulses

FIGURE 5 - SEASONAL VARIATIONS OF CHEMICAL SCORE

CAMPANIA



	J	F	M	A	M	J	J	A	S	O	N	D
Protein calories per cent	12.2	11.8	11.6	12.0	12.7	12.6	12.0	11.7	12.9	12.3	12.3	11.7
Total proteins	78.1	69.8	61.6	70.5	81.6	77.9	73.8	79.3	73.8	77.4	76.8	75.4
% of proteins: Wheat	71	62	63	62	58	48	52	55	65	67	63	68
% of proteins: Dry legumes	8	8	6	6	6	3	4	5	6	7	10	8
% of proteins: Animal proteins	15	21	24	24	30	43	37	33	21	18	20	16

C. Variation of the Limiting Factor Owing to Consumer's Age

The foregoing survey in Campania makes it also possible to show the variations in the quality of protein intake which may arise within the family owing to the consumer's age. Five age groups have been studied in two of the eleven regions[11].

In Brittany (France) (Fig. 6), the difference between the protein scores of the various amino acids diminishes markedly in passing from children to adults. The variation is particularly prominent between the ages of one and ten. This is largely explained by a drop in the consumption of dairy produce in favour of wheat. The protein score improves in the first age class (62 to 67), but afterwards remains relatively constant. Methionine-cystine is the limiting factor in the one-year-old infant, closely followed by isoleucine; in the other classes, isoleucine becomes the limiting factor but the scores of valine and sulfur-containing amino acids remain very close.

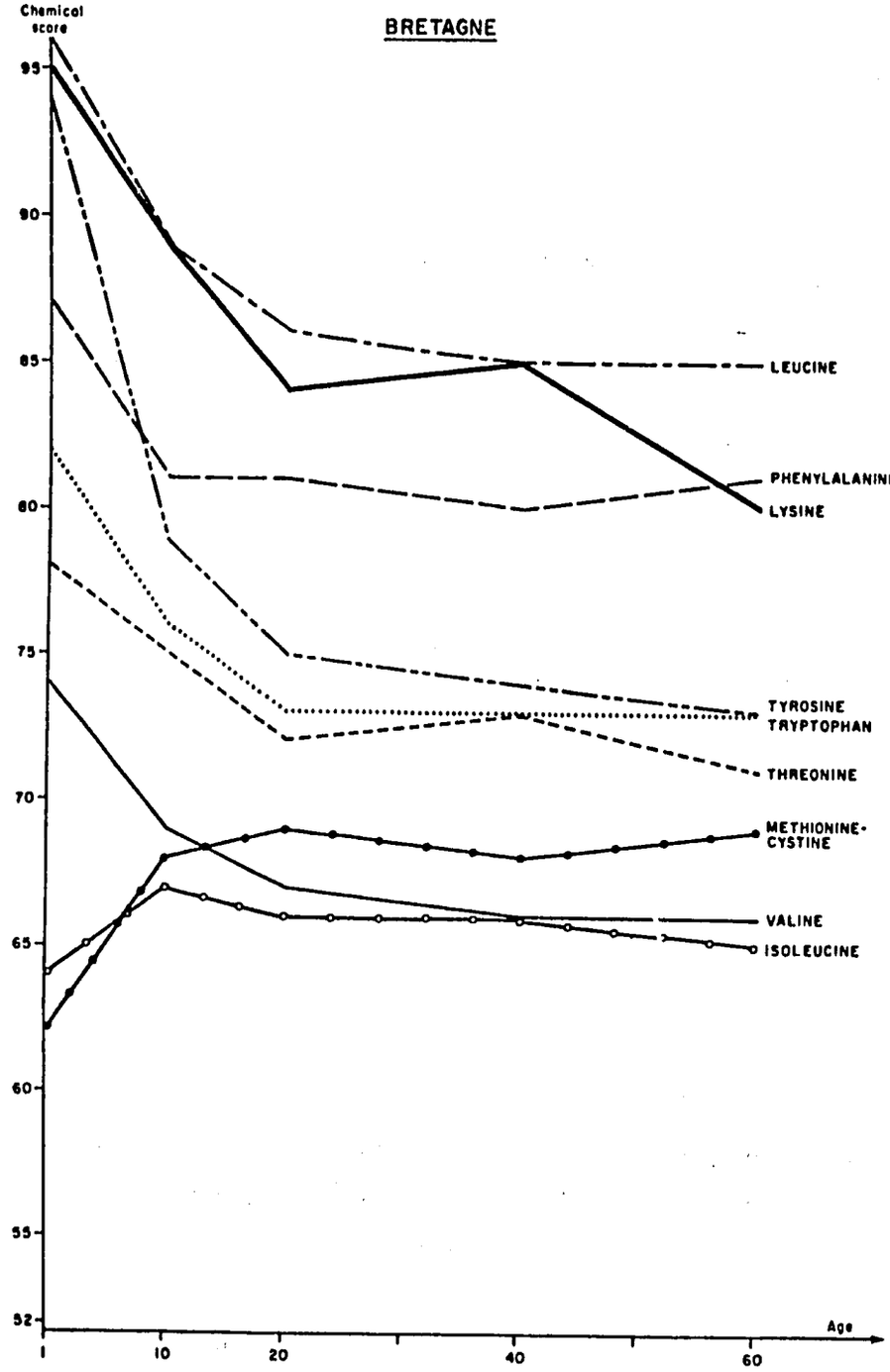
In Campania (Fig. 7), the pattern is different. It corresponds to a wheat-based diet in which animal products have a limited place (19 g of animal proteins per caput and per day, as against 47 g in Brittany). Most amino acids show slight differences among each other and are at a lower level than in Brittany. This applies particularly to lysine which becomes the limiting factor in children and adolescents. Isoleucine is the limiting factor in adults and in infancy.

In these two examples, as in the preceding analyses, it is found that improvement of the protein score can be obtained only by polysupplementation because of the slight differences generally separating a number of amino acids. These results show that the structure of children's diet differs markedly from that of adults in the special case of less-favoured rural classes (Campania), and link up with Nicol's observations among other rural groups (12). Bad distribution of small quantities of protective foods within a family may considerably degrade the protein quality of the diet in certain age groups.

D. Daily Variation of the Limiting Factor, Table 11

In the three examples below, the amino acids scores are determined day by day on the basis of the family's protein intake. This attenuates the effect of supplementation obtained artificially by the law of averages. However, at this level of analysis one could still object that this statistical bias is not entirely eliminated because the type of intake may vary from meal to meal. On the other hand, it has already been shown that the nature of the diet may vary with the consumers'

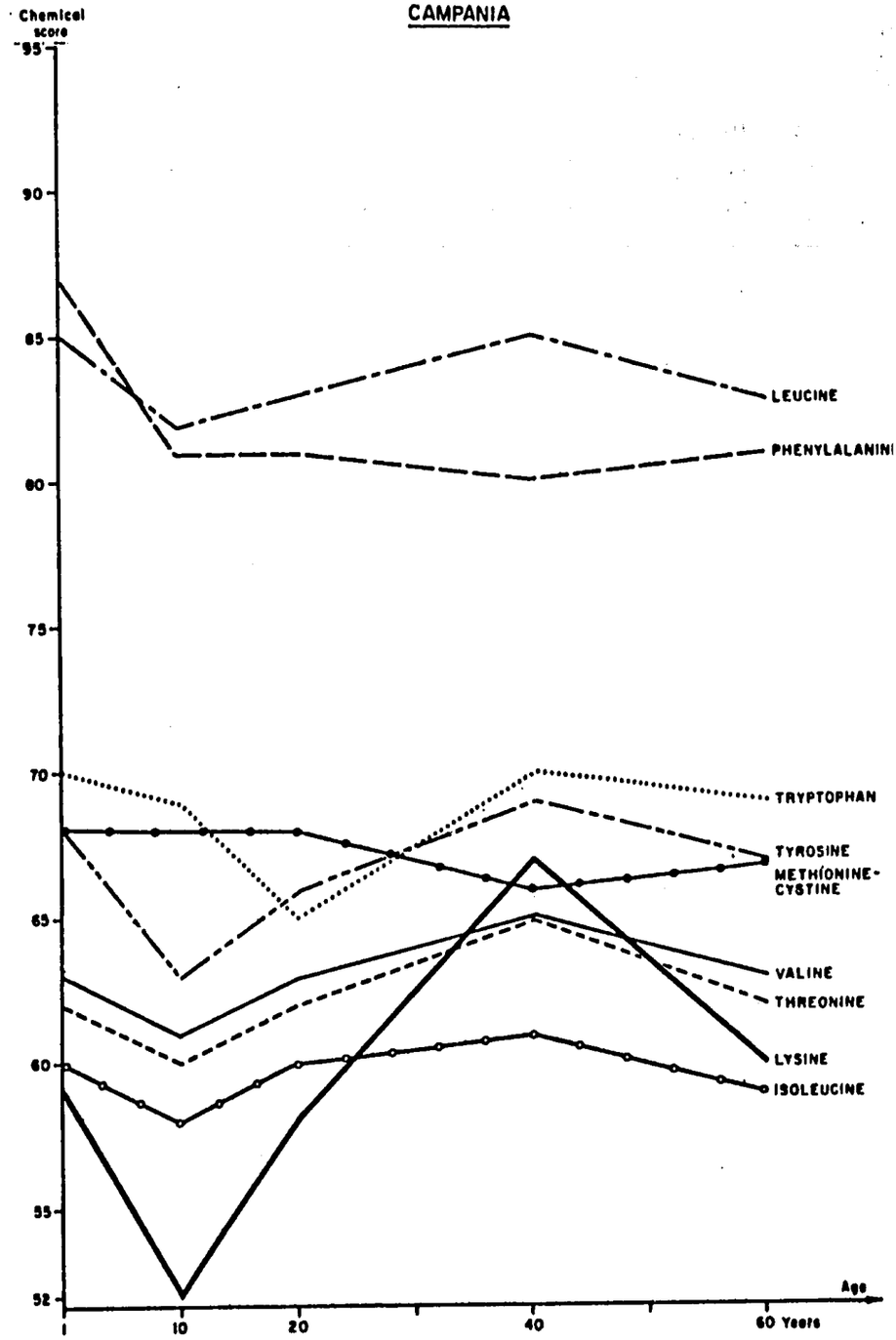
FIGURE 6 - VARIATIONS OF THE CHEMICAL SCORE IN RELATION TO AGE



Protein calories per cent		13.0	10.2	12.6	11.8	12.3
Proteins		37.1	61.2	94.5	100.4	96.7
Animal proteins	% of proteins	67	58	52	53	48
Dry legumes	% of proteins	2	1	1	1	1
Wheat	% of proteins	22	34	42	39	45

FIGURE 7 - VARIATIONS OF THE CHEMICAL SCORE IN RELATION TO AGE

CAMPANIA



		1	10	20	40	60 Years
Protein calories per cent		11.2	11.2	12.2	11.8	11.6
Total proteins		41.1	65.6	76.9	76.5	74.5
Animal proteins	% of proteins	26	16	22	29	23
Dry legumes	% of proteins	4	7	8	10	8
Wheat	% of proteins	68	74	66	56	64

Table 11 - Daily Variation of the Limiting Factor

a) Iran - Wheat Diet Province Azarbaidjan	Iso	Leu	Ly	MC	Phen	Tyro	Threo	Trvp	Val	Wheat	A.P.	P.	R. & T.
first day	56	70	50	64	74	73	63	69	61	80	11		5
second	58	72	56	62	75	72	65	68	62	75	10		10
third	55	69	56	60	74	68	65	67	59	66	6	16	5
fourth	55	68	45	63	75	69	62	67	59	87		8	1
fifth	58	71	49	64	75	74	63	64	63	82	10	4	2
average	56	70	51	63	75	71	64	68	61	78	7	6	5

b) Tunisia - Wheat Diet North Region													
first day	59	73	72	57	76	71	72	77	65	42	21	3	28
second	56	68	48	57	74	69	63	73	60	73		3	18
third	63	79	82	67	75	73	75	67	68	49	40	5	
fourth	62	77	84	66	74	74	75	67	65	43	42	5	
fifth	61	72	64	62	74	72	65	66	61	62	23	7	
sixth	60	74	77	59	73	73	72	76	63	44	31		22
average	60	73	68	60	74	72	69	72	63	52	26	4	5

c) Togo Ouatchis - Maize/Cassava Diets; Shortage Period										Maize	Cass.	A.P.	Pulses
first day	57	105	70	58	74	74	70	58	64	49	19	14	14
second	51	109	49	58	70	73	65	56	60	66	34		
third	58	100	83	57	73	72	73	59	65	38	15	22	23
fourth	52	107	51	58	72	75	66	59	62	61	28		
fifth	59	107	80	56	78	75	74	57	66	45	9	17	29
sixth	59	103	69	59	72	75	69	59	63	48	2o	20	5
average	57	104	70	58	74	74	70	58	64	51	21	12	12

A.P. = Animal products
P = Pulses

age within the family group.

In family a) in Iran (13), wheat, the staple food, is by far the main source of protein, and lysine appears as the limiting factor on four days. On the fifth day, the contribution of pulses is sufficient to make up for this deficit; isoleucine then shows the lowest score.

Likewise, in example b) of a Tunisian family (14), the relative importance of animal products in the diet is in a position to change the nature of the limiting factor three times during the six-day survey.

Example c) of a Togolese family is even more conclusive (10). During the six-day survey, the limiting amino acid changes on five days out of six. In this diet, in which tubers have a dominant place, protein intake is low (22 g a day). Thus, small quantities of maize, fish or beans, which make an irregular appearance during the week, are relatively important sources of protein for this diet and can modify the nature and score of the limiting factor.

The examples could obviously be multiplied ad infinitum. From the point of view of food policy, the real problem consists not so much in showing up this phenomenon in some arbitrarily chosen families as above all in measuring its extent in a given population.

CONCLUSION

The first part of the study (chapters II, III, IV, V) is based on an analysis of food balance-sheets. It shows that protein intake is uneven in the world, and some diets, especially those based on rice, roots and tubers, present marked protein deficits at national level. Protein allowances, not only from the quantitative point of view, as is well known, but from the qualitative point of view are very largely influenced by the kind of staple food and rank in the same hierarchical order.

In nearly all developing countries, cereals are by far the main source of protein, and complementary foods (animal products, pulses), despite limited intake, are essential factors in improving the protein characteristics. If it is true that lysine is the limiting factor of cereals, the risk of its being also the limiting factor in diets is the greater, and the need of filling the lysine deficit the more urgent, the wider the margin separating lysine from the secondary limiting factor and the higher the calorie rate of protein origin in the staple cereal.

Wheat, millet and sorghum, more than any other cereal, fulfil these two conditions. Thus, in wheat diets the protein contribution of animal products and

pulses would have to range between 1/4 and 1/5 of total protein intake in order to cover the lysine deficit.

For the same reasons, the risk of having lysine as the limiting factor will be smaller in the other cereal diets (maize, rice). It will be nil in strict tuber diets.

Thus, complementary foods (animal products, pulses) act differently in regard to these diets because their ability is twofold. Because of their high protein content, they improve the protein-calorie balance of the diets. They are also effective agents of supplementation, notably because of their high lysine content. One or the other of these two effects predominates according to the nature if the staple food. In wheat, millet and sorghum diets, these foods will have a marked effect on protein quality because of the wide margin separating lysine from the second limiting factor. On the other hand, their action on the protein-calorie rate will be moderate because these diets have a good protein-calorie balance.

In maize diets, these foods have a more moderate effect on protein quality. They would make it possible to fill the lysine deficit, which would represent a low protein gain, but also to reduce the whole tryptophan deficit or part of it. From the quantitative point of view, the improvement would be greater than in the preceding group because these diets have an extremely average protein-calorie rate.

In rice diets and diets based on roots and tubers, no considerable qualitative improvement may be expected in view of the fact that the lysine deficit is small or nil. But these foods are indispensable as suppliers of protein and can effectively correct the protein-calorie imbalance.

Owing to economic and production constraints, one cannot hope for increased supplies of complementary foods which would make it possible to solve the protein problem. It is, therefore, necessary to act on the staple food itself. A very definite improvement can be achieved by the introduction of new high-yielding varieties of cereals which would increase supplies, thus improving the intake of calories and proteins. But it would be a mistake to confine oneself to this. The protein hierarchy of diets shows that research must also be aimed at a better protein value of cereals.

For wheat, millet and sorghum, priority in research should be given to lysine-rich varieties because there is a wide margin of manoeuvre between the first and second limiting factors, rather than to high protein content because it has been seen that these diets already have a satisfactory protein-calorie rate.

For rice, priority in research is the other way round. Improvement in

the lysine rate would produce a very limited gain; on the other hand, it is advisable to concentrate efforts on protein content for a considerable increase in the protein-calorie rate of rice diets.

Maize is in an intermediate position. A notable gain in protein efficiency can only be achieved by developing varieties rich in lysine and tryptophan, as has been done for the Opaque 2 variety. An increase in protein content is also desirable to improve the protein-calorie balance of maize diets.

For roots and tubers, and contrary to efforts aimed solely at yields, research should deal with an improvement of protein content and, in addition, in the case of cassava, with improvement in protein quality. However, the diets based on roots and tubers have such a high protein deficit that their gradual replacement by cereals is to be recommended.

These two aspects justify the choice of "concentration zones" for FAO's work in the next few years, in which high-yielding varieties of food plants, especially cereals, and increased production of protein foods have a prominent place.

The second part (chapter VI) is based on the results of consumption surveys. The facts emerging from them greatly complicate the average picture of the protein value of diets furnished by national balance-sheets.

While, on the whole, this second study confirms the first one, it shows the need for consumption surveys to express the diverse conditions within a country and to grasp the real state of nutrition.

Two kinds of practical conclusions emerge. Some confirm the ideas set out in the first part about general policy in the field of food production, but call for its application in a specific manner to ecological zones and socio-economic groups. Others correct views prematurely proclaimed by some people and should govern the attitude to be taken in regard to amino acid fortification of foods, especially fortification of cereals with lysine.

The study shows, in fact, that great caution is needed in the implementation of programmes of enrichment by industrially prepared amino acids because it demonstrates the following points:

- Amino acid deficiencies of diets at consumer level are not always necessarily those of the staple food. In fact, the limiting factors of the staple food are also those of the diet only under certain conditions of very great premodinance of the staple food imposed by low income, seasonal shortages, or ignorance in the matter of nutrition.
- The limiting amino acid varies with income, seasons, age groups, days, as

a result of the nature and amount of complementary foods. Thus, lysine enrichment of wheat, even in a country with high wheat consumption, would be useful only for part of the population, in certain seasons and on certain days.

- The protein score of the limiting factor moves away only rarely from the scores of two or three other amino acids, with the exception of poor socio-economic groups with wheat diets.
- Comparatively modest quantities of complementary foods (animal products, pulses) are sufficient to supplement the proteins of the diet and, in particular, to eliminate lysine from the group of limiting amino acids.
- When supplementation is necessary, it must mostly be polyvalent. In the present state of industrial production and cost of amino acids, this can be economically envisaged only at the level of large population groups in the form of addition of natural protein supplements to the staple food or to the diet.

However, the study of family consumption day by day, season by season, according to income and age group, makes it possible to define better the nature and frequency of the primary limiting factor and the margin separating it from the secondary and third limiting factors. It also makes it possible to identify the part of the population (socio-economic strata or age groups) whose food intake shows this limiting factor and which may have access to enriched food, considering its degree of integration in the monetary economy.

Such studies make it possible to determine where, when and for whom artificial supplementation by the amino acids usable at present (lysine-methionine) has a chance of producing nutritional benefits, and to evaluate the coast of enriching the staple food in relation to the actual beneficiaries. This is the only way of envisaging the cost and profit study of the enrichment operation, a study every government should make before launching large-scale programmes.

APPENDIX 1

	Population in thousands	Total Prot. Intake	E.A.A. in % of Tot.Prot.	NPUop
N.Zealand	2 430	109,4	42	59
Uruguay	2 569	109,4	38	56
France	46 625	99,4	41	56
Argentina	21 328	97,9	41	57
Turkey	27 810	97,5	37	52
Romania	18 550	97,3	39	54
Greece	8 393	96,3	38	53
Yugoslavia	18 652	94,0	38	53
Finland	4 495	93,9	41	57
Denmark	4 632	93,3	42	58
Poland	29 997	92,9	39	57
Ireland	2 824	91,9	41	60
Hungary	10 024	91,3	38	55
Canada	18 429	91,2	42	58
U.S.A.	181 000	91,2	42	59
Switzerld.	5 611	90,3	41	59
Australia	10 602	89,8	42	60
U.K.	53 028	89,0	41	60
austria	7 097	86,8	41	58
Belg.Lux.	9 539	85,3	41	60
Israel	2 263	84,2	40	57
Sweden	7 561	82,7	42	60
Norway	3 626	81,3	42	59
Germ.F.R.	56 608	80,3	41	59
S. Africa	16 298	80,2	41	56
Italy	50 018	79,6	39	56
U.A.R.	26 868	79,0	39	53
Niger	3 051	78,2	40	52
Netherld.	11 721	78,0	41	60
Spain	30 564	76,7	41	56
Chad	3 197	75,8	41	51
Chile	7 843	72,3	39	56
Mexico	36 101	71,9	41	55
Zambia	3 400	71,8	40	52
Paraguay	1 763	71,1	40	58
U. Volta	4 500	69,9	39	51
Brasil	71 897	69,6	39	55
Japan	94 284	69,3	41	56
Sudan	12 470	69,3	40	53
Ethiopia	21 500	68,8	39	53
Afghanistan	14 561	68,4	38	52
Syria	4 720	68,1	37	54

	Population in thousands	Total Prot. Intake	E.A.A. in % of Tot.Prot.	NPUop
Lebanon	1 839	64,8	39	54
Senegal	3 249	64,5	40	56
Kenya	8 600	64,4	40	51
Mali	4 305	64,3	40	52
S. Korea	26 125	64,3	39	53
Malawi	3 644	62,9	40	46
Jordan	1 685	62,4	37	53
Iraq	6 430	61,9	38	54
Morocco	11 705	61,6	38	52
Gambia	304	60,5	40	57
Peru	10 326	60,1	38	56
Taiwan	11 691	59,2	40	58
Iran	20 323	59,6	37	54
Venezuela	7 616	59,5	41	59
Nigeria	53 514	59,4	38	54
Tanzania	9 927	58,6	40	54
El Salvador	2 536	56,7	41	54
Guatemala	3 889	55,4	40	51
Cameroon	4 915	54,5	39	55
Costa Rica	1 228	53,9	39	60
Colombia	16 417	53,5	41	59
Honduras	1 897	53,7	40	55
India	451 700	52,2	38	53
Ivory Coast	3 375	52,2	39	57
Malaysia	7 376	52,1	42	61
Madagascar	5 756	51,9	39	59
Dahomey	2 200	51,9	38	53
Uganda	7 016	49,5	39	55
Togo	1 523	49,1	38	56
Ghana	7 148	48,6	38	56
Mauritius	661	47,2	40	61
Thailand	27 995	46,5	40	61
Pakistan	95 800	46,5	39	58
Bolivia	3 865	45,3	39	56
Ceylon	10 169	44,8	39	59
C.A.R.	1 280	44,8	35	55
Surinam	285	44,5	40	60
Gabon	453	43,9	38	61
Philippines	28 324	43,8	38	60
Ecuador	4 469	42,0	39	58
Congo Braz.	800	3,9	37	58
Congo Kinsh.	14 797	28,8	36	57

NOTES AND REFERENCES

1 Per caput net food supplies obtained on the basis of national balance-sheets take into account the figures of production, imports and exports. Storage losse and possibly the quantities used for seed, animal feed and industrial purposes are deducted; nutritive value is calculated on the basis of net food supplies per person and per day, taking into account inedible waste and, for cereals, the extraction ratio.

2 The essential amino acid content of proteins in the food intake is calculated. The quantity of each essential amino acid of the food intake is then divided by the total nitrogen of the food intake. One obtains the essential amino acid content per g of nitrogen of the food intake, which is compared with that of the corresponding essential amino acid in hen's egg. The amino acid showing the lowest percentage is called the limiting factor of protein efficiency of the food intake. This figure is the protein score.

3 In the food composition tables, conversion of nitrogen into protein is effected for cereals on the basis of specific conversion coefficients, for instance, 5.95 for rice. For maize, millet, sorghum and roots and tubers, the general coefficient 6.25 has been used although the specific coefficient is probably lower. This introduces a systematic error by excess into the evaluation of protein content and of the protein-calorie rate which is certainly not negligible

4 The FAO tables for determining the calorie value of foods use specific conversion factors. In calculating protein calories in relation to total calories, it would, strictly speaking, be necessary to use the specific coefficients for the numerator as well. Use of the coefficient 4 for all foods leads to overestimation of the rate of protein calories, which increases with the share of vegetable proteins in the food intake.

5 It may be asked whether the protein score is representative of the protein quality of food intake. There is, in fact, no strict concordance between this score and the values of net protein utilization (NPU) obtained by animal experimentation. However, the FAO/WHO Expert Group on Protein Requirements considers

it legitimate to use the protein score for determining protein quality, especially in mixed diets, if NPU cannot be determined experimentally.

6 Protein requirements have been calculated according to the recommendations of the report by a Joint FAO/WHO Expert Group (1963). They take into account provisional data on body weight and the sex and age groups of the population. Protein requirements per kg of body weight are those listed in Column III of Table 10 of this report. This protein requirement, expressed in g of reference protein (NPU = 100), has been expressed here in g of local protein, having regard to Operative Net Protein Utilization of food intake in the country under consideration, in keeping with the suggestions of Miller and Payne (4). These recommended allocations are considered adequate to meet the needs of 97.5 % of the population.

7 The total of essential amino acids has been obtained by adding up for each food the following amino acids: Isoleucine, leucine, lysine, methionine, phenylalanine, tyrosine, thronine, tryptophan and valine. Cystine is also included in the total.

8 These mean values for each type of diet are based on country values.

9 See Table 1, columns 16 and 18; Table 2, columns 17 and 18

10 See Tables 1 and 2, columns 7 to 15.

11 The evolution of consumption in terms of age on the basis of family data has been established by a statistical callculation with the help of a mathematical model, the methodology of which is defined in a report of the EURATOM- CEA, Rapport CEA-R-3434 (11).

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(10) Périssé, J. - Bull. Inst. Nat. Hyg., Vol. 13, No. 4, pp. 945-1020

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Notes and Articles

EFFECTS OF INCOME PROJECTION ON THE PROTEIN STRUCTURE OF THE DIET[1]

(Example based on a low income rice consuming country)

by

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(original text in French)

1. Econometric research in the developed countries has shown the role played by income in food consumption variation. The trends observed for a long time in these countries have implied that action to influence income levels was a necessary and adequate means of creating diet improvements or changes where needed.

2. Actually, it is one thing to describe the influence of income in diversified money economies and quite another to observe its impact in developing economies having a high degree of subsistence farming and undergoing structural change.

3. We must therefore ask whether the econometric conclusions drawn from developed countries are applicable as they stand to the countries of the Third World. In other words, for the specialist in food economics concerned with the future of low income countries a number of basic questions arise which may be summarized as follows:

1) Assuming a real income growth rate compatible with the constraints of the country's economy, is the expected rise in purchasing power likely to result in sufficient propulsive effects either to produce substantial improvements in diets or else a radical change in the dietary pattern when the latter is desirable?

2) If so, how much time is necessary for change to occur, allowing for a number of economic constraints?

4. What is at stake is important, whether an adequate rise in incomes is considered the sufficient determining factor in improvement of nutrition and a "laissez-faire" policy is then advocated, or we reach more highly differentiated conclusions which require economic options and specific food policies.

5. It is impossible to answer these two questions in the abstract, in view of the differences in the economic conditions of the Third World. We have therefore preferred to take a rice and livestock producing country (say country A) as a point of reference. For the sake of simplicity we will confine ourselves to an examination of protein consumption among the rural population as a function of income.

6. However, the approach proposed here is general, and can readily be transposed in other countries insofar as adequate statistical data exists.

I. INCOME GROWTH HYPOTHESIS FOR COUNTRY A

7. The National Plan foresees a total growth in household incomes of 4.8 % per year for the period 1962-75. Given a population growth rate of 2.5 % per year, the rise foreseen in per caput income will be only 2.3 % per year.

8. To be realistic we must also study the breakdown in urban and rural inhabitants and the balance of migration movements, since the difference in food behaviour of these two types of human community is considerable, and will so remain in the projection previews.

9. In 1962 the natural growth rate of the rural population was 2.5 % per year; however, the net migration observed from rural areas to the towns was estimated at 0.3 %. Considering this as an acceptable medium-term trend, the National Plan sets the growth rate of the population remaining in the countryside at 2.2 % per year.

10. Likewise, due to the contribution from rural migration, the urban population[2] should increase by 5 % per year, a reasonable figure in line with our knowledge of other comparable countries.

Table I - Income Growth Hypothesis[3] (Δ I)

	Total Δ I. per year	Population Δ per year	Per caput Δ I. per year
Urban population	7.4 %	5.0 %	2.4 %
Rural population	3.9 %	2.2 %	1.7 %
Total national population	4.8 %	2.5 %	2.3 %

11. Since the National Plan calculates the differential growth rates of total income for the urban and for the rural populations, it can be deduced from the

demographic constraints that if the nationwide per caput income should increase by 2.3 % per year, population movements would result in a rise in per caput income of 2.4 % for the urban population against only 1.7 % for the rural population.

12. In the following pages we shall evaluate the repercussions on protein consumption of reasonable hypothesis formulated by planners. To do this we shall use two approaches: the classical approach through calculations of elasticities and mean values, and the approach based on frequency distributions.

II. PROJECTIONS TO 1975 - THE CLASSICAL APPROACH

13. On an average, in 1962 the calorie requirements in the daily diet of the rural population were covered as the intake was estimated at 2,220 calories. Carbohydrates accounted for 84.4 % of calories, fat for 6.3 % and proteins for 9.3 %. The low protein-calorie ratio is here due to high consumption of rice, which is one of the cereals poorest in proteins.

14. From the quantitative standpoint, in 1962 the average protein content in the diet was 51.9 g per caput per day, or a minimal deficit (about 5 %) compared to the requirements.

It should be noted that most of the proteins were of vegetable origin, with animal proteins constituting only 7.9 g, or 15.3 % of total proteins.

15. An econometric analysis for 1962 in terms of total per caput income suggests some demand functions. We have included some of them in the table below, given together with the quantity-elasticity calculated for average per caput income ($ 52)

Table II - Demand Functions for Calories and Proteins

	Function	Formula	Correlation	Mean Elasticity
Calories	Log-inverse	$L_n \; Y = 7.99 - \frac{0.962}{X / 1000}$	R = 0.94	$\eta = 0.074$
Total proteins	semi-log	Y = -50.50 + 10.99 L X	R = 0.90	$\eta = 0.205$
Animal proteins	semi-log	Y = -70.85 + 8.41 L X	R = 0.98	$\eta = 0.992$
Vegetable proteins	semi-log	Y = 20.35 + 2.58 L X	R = 0.44	$\eta = 0.057$

With Y as consumption, X as average per caput income and L_n as Napierian logarithms.

16. Total protein consumption is a function of income, and this appears to account for 90 % of the variation observed using a semi-logarithmic model. Elasticity at the meanpoint ($ 52) is low, equalling 0.21.

17. Animal proteins are much more subject to income influences. On a semi-log function, 98 % of animal protein variation are due to variation in income. Elasticity at the meanpoint is high, equalling 0.99.

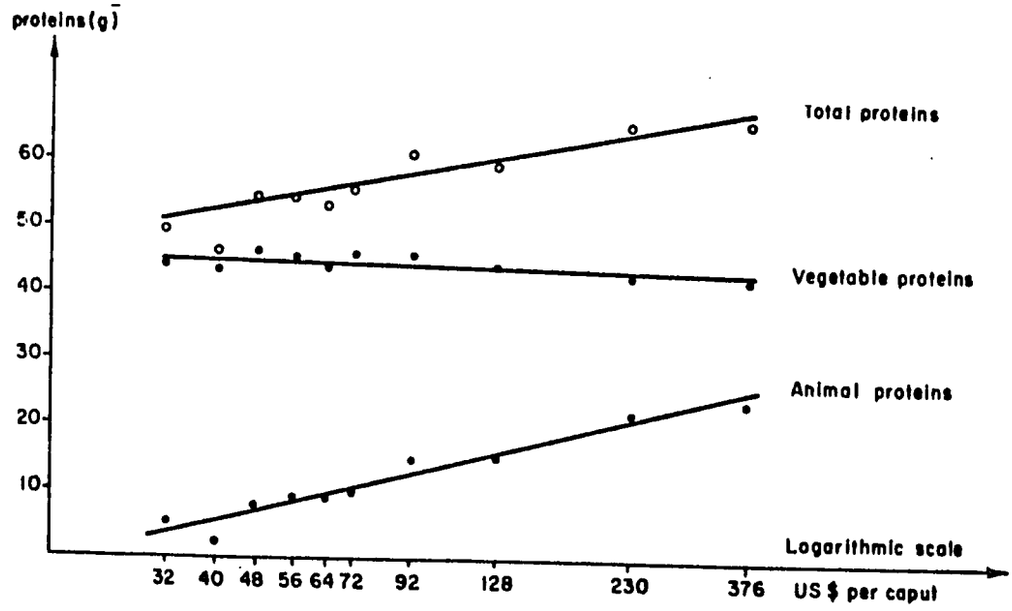
18. This leaves the problem of vegetable proteins. The correlation between consumption and income is poor, and at the aggregate level selected it would appear that the influence of income levels is secondary. In fact, although the amount of vegetables remains stationary in absolute value in the protein intake and decreases in relative value, its origin changes as a function of income under the effect of substitution phenomena.

In the low income groups in particular, we observe a progressive replacement of cassava by rice; then, at a higher income level, there is a shift from pulses as primary protein sources towards livestock products and an introduction of breed in the diet.

19. In short, protein consumption is linked to income and in view of the stable consumption of vegetable proteins in the diet, any increase in the protein demand is the result of a high demand for animal proteins (see graph I hereunder).

Graph 1

STRUCTURE OF PROTEIN CONSUMPTION AS A FUNCTION OF PER CAPUT INCOME



20. From 1962 to 1975, according to the hypothesis of a per caput income rise of 1.7 % per year, the average income of the rural population should increase from $ 52 to 65, or a gain of 24 %. What will be the resulting increase in average demand?

21. Average per caput consumption of calories should rise by only 1.5 % during this period, but we may observe a comparative fall in the proportion of carbohydrates and an increase in fat and proteins.

Table III - Demand Projections per caput 1962 - 1975

		1975-hypothesis ΔI = 1.7 %			1975-hypothesis Δ I = 3 %		
	Data in 1962	Increase over 13 years	Annual Increase	Data in 1975	Increase over 13 years	Annual Increase	Data in 1975
Calories	2223	1.5 %	0.15 %	2256	2.5 %	0.20 %	2279
coverage %	+ 0.4 %	--	--	+ 1.9 %	--	--	+ 2.9 %
Tot. Proteins	51.9 g	4.7 g	0.36 g	54.3 g	7.9 g	0.55 %	56.0 g
coverage %	- 4.8 %	--	--	balance	--	--	+ 2.7 %
Vegetable Prot.	44.0 g	1.3 %	0.10 %	44.6 g	2.2 %	0.18 %	45.0 g
Animal Prot.	7.9 %	22.7 %	1.60 %	9.7 g	38.1 %	2.51 %	11.0 g
An. Prot. / Veg. Prot. x 100	15.3 %	--	--	17.9 %	--	--	19.6 %
Protein-calorie ratio	9.3 %	--	--	9.6 %	--	--	9.8 %
Per caput Income	$ 52	24.5 %	1.7 %	$ 65	46.8 %	3 %	$ 76

22. Total proteins per caput would increase under hypothesis 1.7 % of annual income increase by 4.7 % and animal proteins by 22.7 %. Changes in vegetable protein intake would be very small. At this aggregate level, we see that an income growth rate of 1.7 % per year does not produce any very striking results. The protein-calorie ratio improves by only 0.3 % for the whole period, and the proportion of animal proteins in total protein content only rises from 15.3 to 17.9 %.

23. We might suppose that this general situation would be far better if we were to

take an income growth rate of 3 %, for example, as a hypothesis. In reading Table III, we must recognize that this rise in income (46.8 % in 13 years at constant prices) would not lead to any very substantial improvements of protein content in the diet. The structures of the diet would appear to have considerable resistance (in general) to the expected influence of income.

24. It should be mentioned here that when we demand a development effort by the national economy to attain an annual per caput income increase of 1.7 %, we must bear in mind the influence of the demographic constraint. In fact, since the rural population increases by 2.2 % per year, the overall effort required of the economy is in practice an annual rise of 3.9 % in income.

25. In the second hypothesis where per caput income would rise by 3 % per year, an overall growth of 5.2 % would be necessary to absorb the population growth. The latter rate is in fact unrealistic for an agricultural environment, and has not been accepted by the national plan.

26. Since a growth rate of the agricultural economy equivalent to a 1.7 % rise in per caput income has been accepted as plausible by overall and sector economy studies, we must see whether the resulting demand will be met. In other words, will food resources be sufficient to attain equilibrium at the demand level? This means that the planner must consider the constraints bound up with production, exports and imports.

27. Without going into details, we may say that in the present case the food demand can be covered except for animal proteins. In fact, the per caput demand for animal products is rising by 1.6 % per year (Table III), whereas production and imports will only be able to increase their supplies to the market at the rate of 1.1 % per year in view of their own technical and financial constraints.

28. Thus, during the period there will be price adjustments between supply and demand and, at best in 1975, the animal protein intake will be established at 9.2 g per day instead of 9.7 g. Although this daily per caput deficit of 0.5 g appears very small, when extended over the year and to rural areas as a whole, it accounts for 1,254 tons of proteins, or the equivalent of 9,200 tons of carcass-meat.

29. If an adjustment between supply and demand occurs through prices (which seems logical), the deficit estimated here may be even higher, in the light of the foreseeable competition between the urban and rural populations. Under the Plan, the former should have an increase in income of 2.4 % per caput per year. Because of the

pressure on supply, the rise in prices will probably be disproportionately high and, in view of the disparity of income increases in the city and country, this will be detrimental to the poorest demand sector, i.e., most of the rural population.

30. What conclusions may be drawn from this exercise in projection?

On the whole, elasticity curves show that income influences diet levels; but among low-income populations (average here $ 52) population growth carries such weight that the overall effort required of the economy to raise income will, at best, result in a small annual increase per caput.

Consequently, *on the average* income produces only an insignificant improvement in diet. In 13 years total protein content will increase by only 4.8 % and the structural deficits, represented here by the protein-calorie ratio, will remain sizable. Moreover, we have seen that the constraints on production and imports will further diminish the effects of income, due to price adjustment between potential demand and possible supply.

31. This set of observations indicates that: the economic and demographic context for low income groups appears such that, under a "laissez-faire" food policy, the nutritional structures of the traditional diet are in general rigid. In general, too, we observe that the expected increase in purchasing power does not produce any marked propulsive effects which themselves seem slowed down by production structures

32. This analysis and the resulting conclusions are based on a classic method of approach using elasticity calculations and mean values. We may legitimately ask whether the reasoning process based on simple average data does not tend to blur phenomena which are more highly differentiated than that shown above. With this in mind, it is worth trying another analytical approach, no longer drawing on averages alone, but on the frequency distributions which, on principle, they summarize.

III. PROJECTION TO 1975 - FREQUENCY DISTRIBUTION APPROACH

33. The demand curves given in Table II allowed us to standardize trends as functions of income. A study of the base data in Table IV shows the presence of fluctuations (not necessarily in sampling) which prohibit analysis by income group and require a fairly comprehensive evaluation.

34. It is clear that although a breakdown by per caput income group provides a detailed summary of the rural diet, it includes related phenomena acting as "parasites", so to speak, on distribution.[4]

In fact, while income is undoubtedly a criterion of homogeneousness in terms of

Table IV - Protein Structure of the Diet by per caput Income Groups

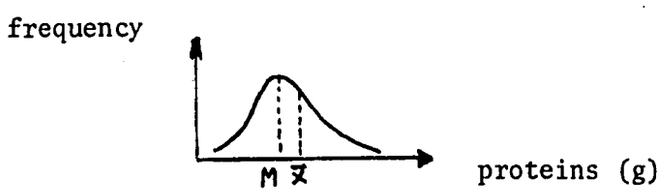
Per caput Income Groups in $	0/00 people	Total Proteins g / day	Animal Proteins g / day	Vegetable Proteins g / day	Origin of Proteins in %					Protein Calorie Ratio %	Protein Quality Index	Coverage of Requirements %
					Rice	Pulses	Animal Prod.	Others	Total			
< 28	1	—	—	—	—	—	—	—	—	—	—	—
28 - 36	178	49.8	5.5	44.3	55	7	11	27	100	9.3	60.5	- 8.4
36 - 44	323	45.9	2.3	43.6	64	7	5	24	100	8.5	61.5	- 15.6
44 - 52	175	53.9	8.1	45.8	58	7	15	20	100	9.4	62.0	- 1.4
52 - 60	115	54.5	9.3	45.2	56	8	17	19	100	9.6	62.0	balance
60 - 68	83	52.7	9.0	43.7	61	7	17	15	100	9.3	62.0	- 2.0
68 - 76	43	55.5	10.0	45.5	58	5	18	19	100	9.9	62.5	+ 2.0
76 - 108	49	61.2	15.3	45.9	55	5	25	15	100	10.4	63.5	+ 11.1
108 - 148	19	59.1	15.4	43.7	57	3	26	14	100	10.0	64.5	+ 7.0
148 - 316	9	64.6	22.0	42.6	54	3	34	9	100	11.0	65.5	+ 16.0
316 - 436	4	65.3	23.5	41.8	54	3	36	7	100	10.6	67.0	+ 21.4
> 436	1	—	—	—	—	—	—	—	—	—	—	—
	1,000											
Average	—	51.9	7.9	44.0	57	7	15	20	100	9.3	62.0	- 4.8

the diet it adds ecological, professional and socio-cultural differences which are responsible for most of the variations appearing here.

35. As an example, in the $ 28 - 36 group, we find many stockraisers who eat cassava, but who also drink milk. Thus the protein-calorie ratio is better here than in the next group which includes small rice farmers and many coffee planters from some of the poorest areas from the standpoint of animal protein resources.

36. In terms of total proteins it has been found that the $ 28 - 44 groups, comprising 50 % of the total population, have low average consumption levels. Here we must consider the significance of these averages transposed within the statistical frequency distribution approach.

37. Current nutrimetric research is indicating that,[5] in a given population, sufficiently homogeneous in economic aspects, total protein consumption is very generally distributed over a bell-shaped curve, most often with skewness to the right. In this case study, the distribution average ($\bar{x}$) is influenced by the highest consumption levels and no longer represents half the population (median M). In other words, average consumption frequency is higher than the median ($\bar{x} > M$). As this is the case in all income groups examined here, this means that over 50 % of the population does not attain the total protein intake levels given in average proteins (g).



38. In the income groups above $ 44, consumption is still distributed on a skew, but due to a rapid shift of curves as a function of income increase, there is only a progressively smaller fringe of people not covering their protein requirements.

39. Thus it appears that the problem of low total protein intake levels arises mainly below $ 44. We have therefore adopted this figure as the total protein sub-consumption threshhold. For purposes of analysis we then tried to establish the level of per caput income at which the improvements in the structure of the diet could be considered substantial. The apparent threshhold of diversification of the diet has been set, somewhat artificially perhaps, at $ 76. Above this limit, animal proteins account for 25 % and more of total protein intake; requirements are amply covered; and the protein-calorie ratio as well as the protein quality index are much more positive. Finally, more detailed study of the foods in the diet has shown the

appearance of diversification in the sources of animal protein (eggs, milk, meat, fish) and increased consumption of fats and vegetable. It should also be noted that above $ 76, subsistence farming has lost its importance since the great majority of foods are purchased on the market.

40. The framework of the analysis is thus reduced to three groups: a threshhold of protein sub-consumption; a thresshold above which diversification of the diet begins; and, finally, the intermediate group.

41. How can income frequency distribution (graph II) be projected to the year 1975 according to a general hypothesis of a growth rate of 1.7 % per caput per year?

A bell-shaped curve of density fits the histogram of incomes in 1962:

$$f(x) = \frac{1}{\sigma (x-x_o) \sqrt{2\pi}} - \frac{1}{2} \left[\frac{L_n (x-x_o)-m}{\sigma}\right]^2$$

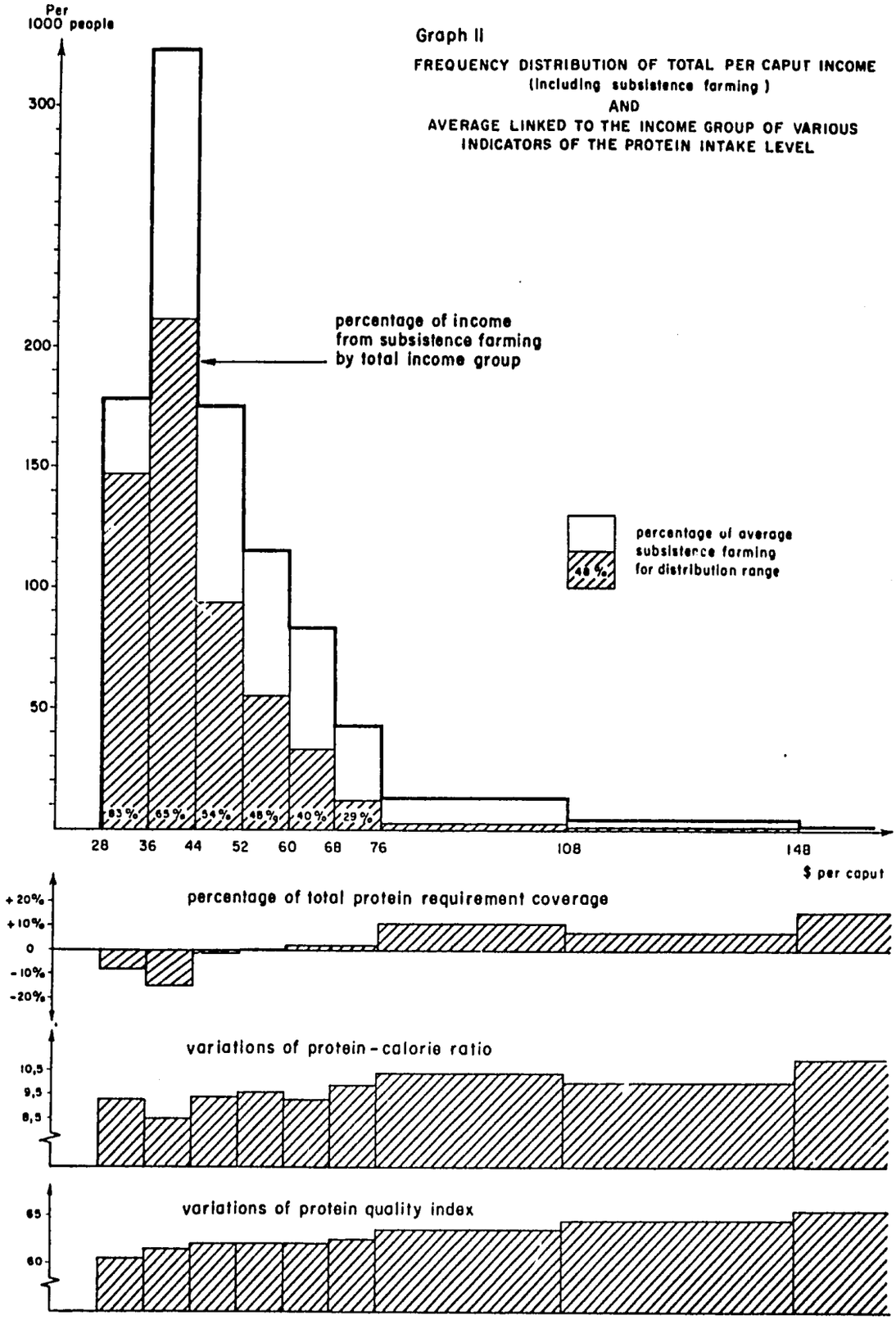
Using a logarithmic scale on the x-axis and a normal scale on the y-axis for the cumulated percentage of people, the cumulative function:

$$F(x) = \Pi \frac{\left[L_n (x-x_o)-m\right]}{\sigma}$$

can be drawn as a straight line[6] (graph III).

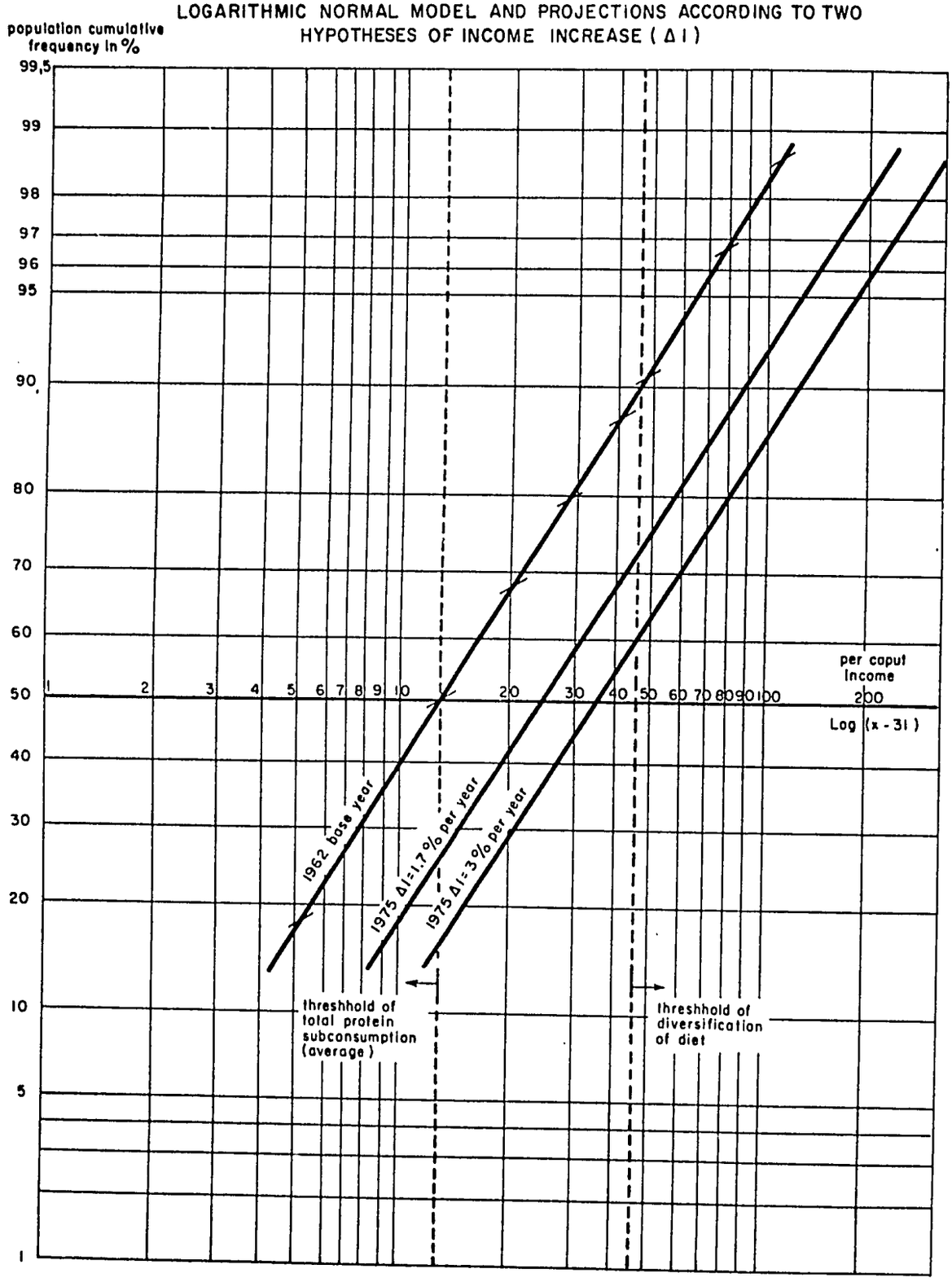
42. The median or amount reached by 50 % of the people was taken as the reference in the hypothesis of a rise in income. As is customary among planners, it may be assumed that the income frequency distribution will not undergo a deformation in time but simply a shift resulting from the increase in income. Therefore, the application of a growth rate to the median determines the point[7] starting from which, by drawing a simple parallel to the first straight line, we can deduce the cumulative distribution function of income in the target year of the projection.

43. According to two growth hypotheses, one for 1.7 % and the other for 3 % per year, the cumulative distribution functions corresponding to 1975 have been drawn on graph III. By this approach it is possible to follow the repercussions of an improvement in purchasing power on the rural population. In fact, the intersection of these straight lines with the threshholds of $ 44 and $ 76 respectively, permits us to read the new population distribution in ordinates. The results are set forth


Per 1000 people
Graph II
FREQUENCY DISTRIBUTION OF TOTAL PER CAPUT INCOME
(including subsistence farming)
AND
AVERAGE LINKED TO THE INCOME GROUP OF VARIOUS
INDICATORS OF THE PROTEIN INTAKE LEVEL
300
200
150
100
50
percentage of income
from subsistence farming
by total income group
percentage of average
subsistence farming
for distribution range
83 %
65 %
54 %
48 %
40 %
29 %
28
36
44
52
60
68
76
108
148
$ per caput
+20%
+10%
0
-10%
-20%
percentage of total protein requirement coverage
variations of protein-calorie ratio
10,5
9,5
8,5
variations of protein quality index
65
60

Graph III

TOTAL PER CAPUT INCOME FREQUENCY DISTRIBUTION FITTED TO A LOGARITHMIC NORMAL MODEL AND PROJECTIONS ACCORDING TO TWO HYPOTHESES OF INCOME INCREASE (Δ I)



in the table below.

Table V - New Population Distributions according to Two Hypotheses of Shifts of Income Distribution

Income Growth Rate per Year	Population Distribution	Population below Protein Sub-Consumption Threshhold $ 44			Intermediate Population			Population above Diversification Thresshold $ 76		
		1962	1975	1985	1962	1975	1985	1962	1975	1958
1.7 %	in %	50.2	26	16	41.6	48	46	8.2	26	38
	in 000	2610	1785	1370	2160	3300	3930	430	1785	3240
3.0 %	in %	50.2	16	7	41.6	46	35	8.2	38	58
	in 000	2610	1100	600	2160	3160	2990	430	2610	4950

44. With respect to the protein sub-consumption threshhold, in 13 years at an income growth rate of 1.7 % per caput per year, the percentage of people on the deficit side falls from 50.2 % to 26 %; however, allowing for a population increase of 2.2 % per year, the number of those below this threshhold total 2,610,000 in 1962, and still come to 1,785,000 in 1975.

Thus in 23 years the mere effects of income can reduce the part of the population whose protein status is unsatisfactory by only half. Improvement appears to be slow, therefore, and we have calculated the projections to 1985 to show sufficiently that we cannot expect miracles of the income factor within the space of one single human generation (see graph IV).

45. Undoubtedly, if we were to adopt an income growth rate of 3 %, the results would be more substantial. However, as we have seen previously, such a rate--which corresponds to a total increase of 5.2 % per year--is deemed unrealistic and therefore cannot be accepted.

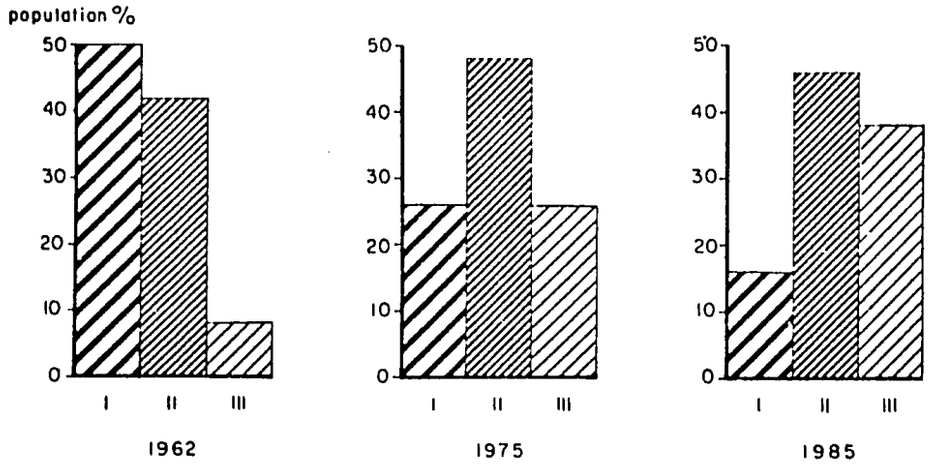
46. Going further, we have been able to calculate that, under the present hypotheses of distribution and allowing for a growth rate of 1.7 % projected for the very long-term, it would take about 70 years for protein sub-consumption to disappear. It should be understood that this would be the case if we were satisfied with a "laissez-faire" income policy, but do we not intend to do anything else?

47. The second threshhold is that of diversification of the diet combined with the

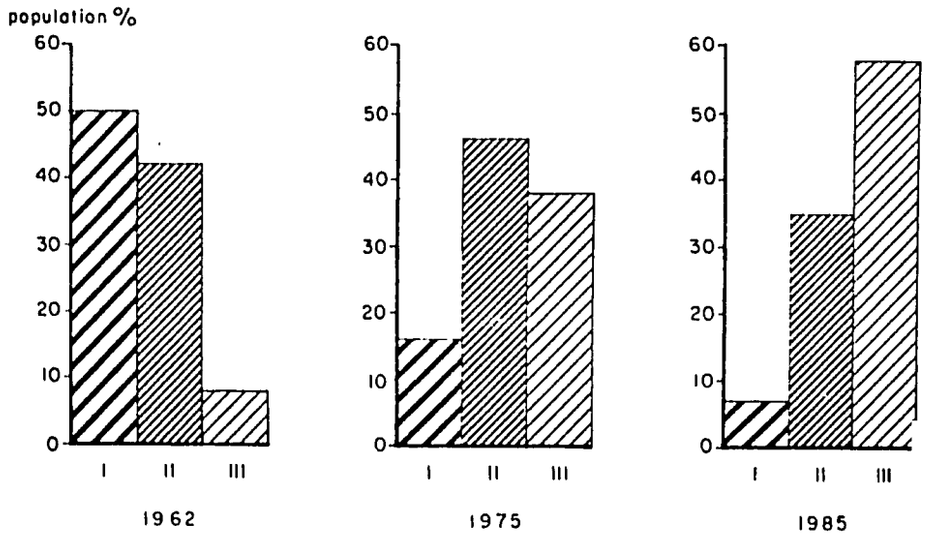
Graph IV

NEW POPULATION DISTRIBUTIONS ACCORDING TO TWO HYPOTHESES OF SHIFT IN INCOME DISTRIBUTION

income growth rate 1,7% per caput per year



income growth rate 3% per caput per year



I. population in the income groups where average proteins deficit is observed

II. population in the income groups just attaining coverage of protein requirements

III population in the income groups where diversification of the diet begins

progressive reduction of subsistence farming. In view of the right-skewness of the logarithmic normal curves, the percentage of the population corssing this thresshold is rapidly increasing: 8.2 % in 1962; 26 % in 1975; and 38 % in 1985. Or, in absolute terms allowing for the demographic trend, a rise from 430,000 to 3,240,000 people in 23 years.

48. Thus the income effect is expressed by an intensification of the process of change for the income groups already having the best nutrition and for those close to the second threshhold, whereas where there are many people, in the low income groups, the improvement observed in the diet does not make it easy to combat sub-consumption.

IV. CONCLUSIONS

49. The case examined above cannot be considered as generally valid as would be that of a country with a marked calorie deficit. In the example discussed here, by hypothesis the majority of the population has reached an adequate calorie intake level. The problem is one of adjustments in the diet, primarily of animal proteins. Hence, increased income has a positive effect on the structures of the diet and especially on the protein-calorie ratio, since at the same time sugar and fat intakes are assumed to remain very small.

50. At the theoretical level, the trend models used are necessarily simplified in comparison to reality. They have the following advantages:

1) they permit, in terms of averages, a coherent approach with reference to the various economic constraints conditioning the possible level of income growth, the level of supply, and the fitting of supply to demand.

2) In terms of frequency distribution they show the disparities in the effects of income and its impact which is weaker when incomes are very low.

51. However, these models have some drawbacks which must be kept in mind for purposes of interpretation.

1) In terms of averages, we maintain a total view. Phenomena of population distribution linked to the disparity of consumption curves are not perceived, although they are of prime importance for the adjustment of food policies by population group.

2) In terms of frequency distribution, the simplifying idea which consists in applying the same income growth rate to all income groups may result in patterns not favourable enough in the case of the high incomes and overoptimistic elsewhere.

(In fact, the tendency most often seems to be to the broadening of income disparities at the development stage.)

52. The hypothesis of an income growth rate of 1.7 % per caput per year has been assumed for the total income, that is, including subsistence farming. Logically, this presupposes a speeded up monetarization, productivity gains, and even more efficient utilization of arable land. For the poorest income groups (50 % of the population below $ 44 in 1962), subsistence farming accounts for an average of 65 to 83 % of total income (see graph II). Income from subsistence farming constitutes a decreasing proportion of rising total income.[8] Therefore, if we apply an income growth rate of 1.7 % to those groups the calculations show that the per caput monetary income must increase by more than 4 % to assure a total income increase of 1.7 %. Due to low income levels, the monetarized part would rise on average to between $ 10 and $ 18 in 13 years for a subsistence farming income remaining at about $ 26 (at constant prices[9]).

53. We have pointed out a new important constraint. In a successful marketing policy, including the opening up of ecological enclave areas, the prospects outlined in Table V may be regarded as an accessible objective.

54. But unless the economy becomes really dynamic, the importance of subsistence farming will show the standstill which will affect the majority of the population. Then, only a fringe group already practising very little home-consumption in 1962 (above $ 60) will strengthen its privileges, substantially increasing dietary disparities.

55. The truth undoubtedly lies halfway between the developments shown in Table V and a standstill of the majority. From this viewpoint we are obliged to note that in 1975 a minimum of 1,785,000 out of a total 6,870,000 rural inhabitants will still be at the protein sub-consumption level if we count only on the effect of a general rise compatible with the possibilities of the economy.

56. The influence of income is slower than was supposed, probably due to the power of various constraints. It is all the more difficult to make improvements and changes in the diet in rural areas by raising the living standard inasmuch as subsistence economies must first be converted to market economies.

57. All of this indicates that a "laissez-faire" policy which does not provide for reduction of disparities in gains by improvement of small incomes is insufficient to relieve the situation of the poorest classes within a time-period of less than

one or several generations. But can any developing country afford such a policy of redistribution of income?

58. Hence the most immediate solution to be implemented should consist, for the most modest classes, in diet safeguard measures through education, through development of new foods capable of integration within the traditional subsistence farming patterns and also through specific action on high yield and high nutritional value varieties. All these measures could be supplemented by national or international food aid programmes.

NOTES AND REFERENCES

1 FOREWORD: This is a case study showing a line of approach of nutritional analysis in terms of income within the framework of national planning. This work also constitutes an illustration of the more general article published in the Nutrition Newsletter, Volume 7, No. 3, July-September 1969, entitled "The Effect of Income on the Structure of the Diet" by J. Périssé, F. Sizaret and P.J. François.

2 In view of local conditions, agglomerations of over 5,000 inhabitants have been considered urban.

3 The total income growth rate (Z) is shown as the sum of the population growth rate (Y) and of the per caput income growth rate (X). It is an approximation. As a matter of fact, the exact formula should be $(1 + Z) = (1 + Y)(1 + X)$, that is for rural population a total income growth rate of 3.93 % instead of 3.9 %

4 This touches on the econometric problems of mixed populations. There is certainly a risk of biasing elasticities through lack of homogeneousness. It is preferable at our level of demonstration, to omit this question for the present.

5 "Nutrimetric Study on Dietary Disparities", P.J. François - Nutrition Newsletter, Volume 7, No. 3, July-September 1969.

6 To obtain this straight line, a change of origin x_o = \$ 31 had to be made and the statistical variable Log (x-31) considered.

7 In 1962, M = \$ 44 is represented by Log (44 - 31) + Log (\$ 13);
In 1975, M = \$ 55 at an annual growth of 1.7 % - that is, on the graph:

Log (55 - 31) = Log (\$ 24);

In 1975, M = \$ 65 at an annual growth of 3 % - or, on the graph:

Log (65 - 31) = Log (\$ 34).

8 $Y = 16.06 - 1.04\ L_n\ X/1000$, $R = -0.92$, Y = percentage of income from subsistence farming and X = total income.

9 For 80 % of the rural population (up to \$ 60 per caput), per caput subsistence farming varies little, remaining at about \$ 26. This ensures a strong persistence of the traditional types of consumption.

Notes and Articles

THE EFFECT OF INCOME ON THE STRUCTURE OF THE DIET

by

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(original text in French)

For most people living in a money economy and for those for whom money has already made a breach in the traditional economy, the income factor can account for many changes in the structure of the diet. An attempt has been made to identify the general trends of consumption patterns as a function of income in order to determine, for planning purposes, what structural changes may be expected.

The study covers 85 countries in Europe, the Americas, Africa, Asia and Oceania, with a total of 1880 million inhabitants in 1962. The figures are based on national food balance sheets (three yearly averages for 1960-62 or 1961-63) (1) (2). Atwater's general conversion coefficients have been used to calculate, for each country, the amount of calories provided by:

- separated fats and unseparated fats of animal and vegetable origin,
- carbohydrates, while separating sugar from the others,
- animal and vegetable protein.

These values have then been expressed as a percentage of the total calorie intake.

The gross domestic product (GDP) in the same year was taken, for want of a better figure, as the independent variable to obtain per caput income (3) (see table in appendix).

In Figure 1, the countries were listed in ascending order of income on a logarithmic scale along the ordinate, while percentage of calories provided by the various nutrients is shown along the abscissa. Clusters of points were obtained for which the best fitting functions were computed and the corresponding regression lines plotted. The areas enclosed represent the calories supplied by the different nutrients in the diet as percentages of total calories. They obey semi-logarithmic functions of the type $y = a + b \log_n x$ whose different parameters are shown in

Table 1.[1]

Table 1
Equations of the Regression Line
for various Calorie Ratios
("y" gives percentages and
"x" the income in dollars)

Percentage of Calories from:	Regression Equations	Correlation Coefficient
Separated fats	$y = -14.23 + 4.14\ L_n x$	$r = 0.69$
Unseparated vegetable fats	$y = 15.51 - 1.87\ L_n x$	$r = 0.63$
Unseparated animal fats and oils	$y = -21.15 + 5.32\ L_n x$	$r = 0.72$
Total fats	$y = -19.87 + 7.59\ L_n x$	$r = 0.84$
Sugar	$y = -12.94 + 3.81\ L_n x$	$r = 0.78$
Vegetable protein	$y = 16.02 - 1.57\ L_n x$	$r = 0.74$
Animal protein	$y = -5.58 + 1.70\ L_n x$	$r = 0.77$
Total protein	$y = 10.44 + 0.13\ L_n x$	$r = 0.82$

Calories from Fats

The proportion of calories from fats (fat calorie ratio) rises steeply with income. It is below 15 percent of the total in countries of per caput incomes under US $ 100, and 30 to 40 percent in countries where this income exceeds US $ 600.

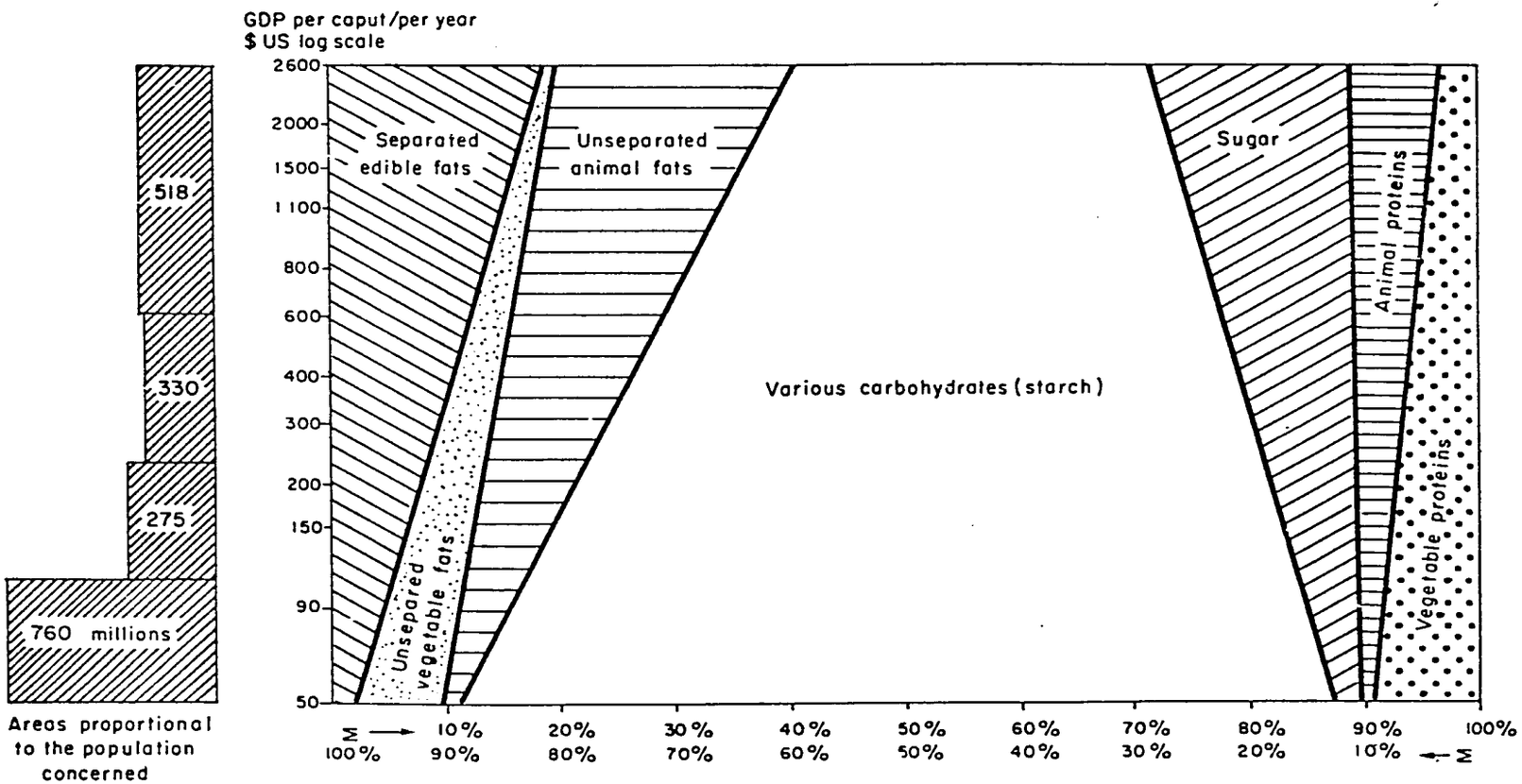
This difference is the resultant of two opposing phenomena:

- a steep rise in the consumption of separated fats (oils, butter, margarine, shortenings and lards) and of unseparated edible animal fats through increased consumption of meat, milk and fish,
- a reduction in the consumption of unseparated vegetable fats (in cereals nuts and oilseeds).

The latter constitute the major sources of fat in the low-income countries their contribution is, on the whole, negligible in the industrialized countries. In fact, the proportion of cereals in the diet varies inversely with income, and there is substitution of nuts and oilseeds by industrially prepared fats and oils, while cooking practices shift from boiling to frying.

There are, of course, deviations from this pattern. The countries of Asia

Fig 1 CALORIES DERIVED FROM FATS, CARBOHYDRATES, PROTEINS AS PERCENT OF TOTAL CALORIES ACCORDING TO THE INCOME OF THE COUNTRIES (1962)



* Correlation based on 85 countries

with rice-based diets lie to the left of the regression line. Fat intake is apparently lower, on the average, than in other countries of Zone C (28 g per caput per day) and is still very moderate in Japan (36 g) despite the higher income there, which must be attributed to dietary traditions. In the 14 countries with per caput incomes of more than US $ 1000 in 1962, daily fat consumption has reached very high levels (117-157 g per person). These countries have arrived at, or are near, the saturation level for separated fats and oils (3), but the proportion of fats goes on rising because of the sustained demand for products of animal origin which provide unseparated fats.

Calories from Carbohydrates

Unlike fats, the proportion of the calories supplied by carbohydrates declines as income rises, ranging from 75 percent in countries with per caput incomes under US $ 100 to 50 - 60 percent in those with incomes in excess of US $ 600.

This trend actually conceals two opposing phenomena linked with a rise in income: a diminished proportion of starchy staples (cereals, roots, tubers, plantains, and pulses as well) and a sharp increase in the consumption of sucrose in sugar and sugar-sweetened foods. Since the former trend is stronger than the latter, the carbohydrate calorie ratio of the diet falls when income rises.

These correlations with income point mainly to one trend. Here again, there is on either side of the regression line a scattering of points that reflects ecological conditions and dietary habits. For example, certain countries on the Saharan periphery and in the Near East, have, despite a low income, a sugar consumption in excess of 25 kg per person per year (Morocco, Mauritania, Iraq and Jordan); this is largely attributable to their tea drinking. In the tropical countries of Latin America, sugar consumption is higher than income would lead one to expect and plays a much more significant role than in the other countries of Zone C because of the former traditional attachment to crude cane sugar products, for which refined sugar is becoming the substitute.

Calories from Proteins

The proportion of protein calories of animal origin in the diet is closely linked to income. This proportion rises with income from 1 to 2.5 percent in the countries with per caput incomes under US $ 200 to over 8 percent in North America. Inversely, the proportion of calories supplied by vegetable proteins diminishes as income rises, raning from 7 to 10 percent in the low-income countries to 3.5 percent in North America. As the two trends offset each other, the proportion of calories

supplied by total protein (protein calorie ratio) at the level of aggregation of our data appears to be independent of income, and its regression line reflects throughout values close to 11 percent. Dispersion above and below this figure increases as we move from high income countries to developing ones, as shown in Table 2.

Table 2

Dispersion of Protein Calorie Ratio according to Income

Income Groups in US Dollars	Number of Countries	Protein Calorie Ratio Range	Standard Deviation
600 and over	20	10.5 - 13.0	1.00
220 to 600	22	8.1 - 13.9	1.42
110 to 220	21	7.3 - 14.4	1.64
below 110	22	6.0 - 14.5	2.14

Due to its strong positive correlation with animal protein, income certainly explains the qualitative improvement of the protein intake, but it is not the causal variable of the protein calorie ratio. For example, it is surprising to find that this figure is as high in East Africa (11.9%) where the average GDP is US $ 70 per capita, as in North America (11.8%) where income is over US $ 2000 per capita. This is because the protein calorie ratio reflects the differences in protein content of the staple foods in the diet and, hence, the ecological conditions and cultural factors governing dietary choices, all the more so since in the low-income countries plants are the primary source of protein.

Thus, in the countries of the African savannah, despite a per caput income of less than $ 100, where millet, sorghum and pulses make up the bulk of the diet, the high protein calorie ratio (13.3%) is quite comparable with those of countries with per caput incomes of over US $ 1000. On the other hand, the countries of central Africa, located in the humid equatorial zone, and hence largely dependent on roots and tubers, have a protein calorie ratio of 7.3 percent, i.e. well to the left of the regression line. Although these countries have higher per caput incomes than those of the savannah zone, they suffer a severe protein handicap imposed by their ecological situation and do, in fact, show protein deficits. The case is the same in the rice eating countries of Asia, where the protein calorie ratio is lower than 9 percent (5).

The countries with wheat-based diets of the Near East, North Africa and

southern Europe have, in spite of lower incomes, a protein calorie ratio which is equal or higher than the countries of northern Europe. Even at high income levels, ecology and cultural habits remain decisive. Though France and Western Germany both have per caput incomes of about US $ 1300, the protein calorie ratio of the average diet is 13 percent in France and 11 percent in Western Germany. In the former country the traditional preference is for cereal (wheat) products, whereas in the latter roots, tubers and fats usually rank high in the diet.

The results of the Madagascar survey, carried out in 1962 on 5000 households representative of the rural population, has enabled us to study the structure of the diet by income groups (see Table 3, Figure 2).

Table 3

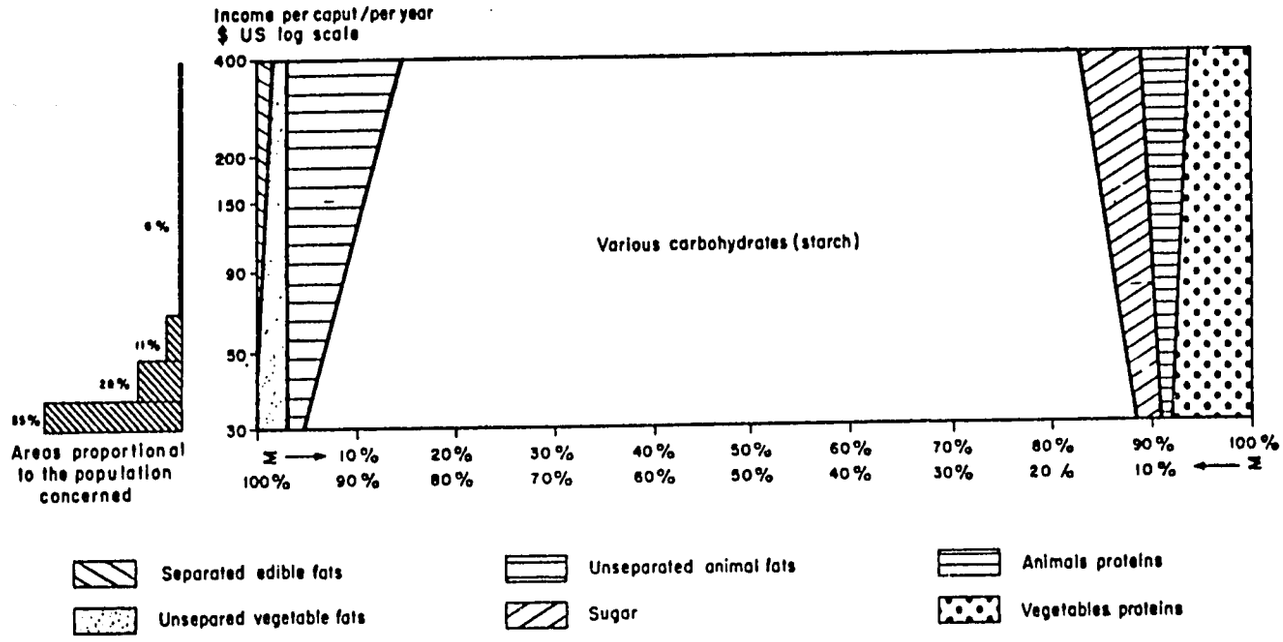
Madagascar - Rural Household

Variation in Food Consumption per capita per day

according to Monetary Income (6)

Classes in thousands of Malagasy Francs per Household/Year	1 to 20	20 to 40	40 to 80	80 to 130	130 to 190	190 to 390	390 to 590
Number of households %	54.6	27.7	11.0	3.8	1.5	0.8	0.3
Subsistence farming %[2]	83.1	70.9	68.4	67.7	55.9	35.9	30.9
Calories	2154	2292	2256	2359	2350	2341	2456
Total fats g	12.1	15.9	17.6	23.1	25.6	32.2	38.9
Separated fats g	0.1	0.4	0.6	1.0	1.2	2.7	3.9
Unseparated veget. fats g	7.6	7.9	7.3	6.9	6.8	5.1	4.9
Unseparated animal fats g	4.4	7.6	9.7	15.2	17.6	24.4	30.1
Sugar g	2.4	2.6	4.0	4.6	6.0	8.7	16.1
Total protein g	47.3	54.1	53.6	61.2	59.1	64.6	65.3
Animal protein g	5.5	8.5	9.4	15.2	15.2	21.8	23.6
Vegetable protein g	41.8	45.6	44.2	46.0	43.9	42.8	41.7

Fig. 2 - CALORIES DERIVED FROM FATS, CARBOHYDRATES, PROTEINS AS PERCENT OF TOTAL CALORIES
(MADAGASCAR RURAL 1962)



This study reveals the same trend for calories from fats, carbohydrates and protein as the between-country analysis. It should be noted that in this country the protein calorie ratio rises gradually from 9 percent for the vast majority of the population to 11 percent for the very high income groups. This improvement is cause by a displacement of rice by wheat and by an increased intake of animal protein, but it is also observed that a household must achieve a cash income 16 times higher than that of the lowest income group before it can consume three times as much animal protein. This trend model in the long run produces a dietary pattern like that of modern Japan. However, considrable gains in per caput income would have to be made and a veritable agricultural revolution wrought to change the sources of supply before such a new dietary pattern can be brought within the reach of the entire population.

Everything appears to suggest that the structural changes in progress will, in the long run, bring the protein calorie ratios of the different countries to an ultimate equilibrium position in the neighbourhood of 11 - 12 percent.

Conversion to a money economy gradually emancipates the diet from its ecological constraints. However, the improvement in protein intake that may be expected is very slow in materializing and, in most countries, largely offset by the

growth of the demand for sugar, fats and oils, which supply calories with no protein counterpart. From the Indicative World Plan studies it appears that supplies of animal products will be subject to the limitations inherent to the process of production, whereas the demand for sugar and fats is likely to be met (2). Consequently there is a risk in some countries that the protein calorie balance of the diet will be adversely affected by rising incomes, unless adequate food policies are adopted.

A time-series study for countries that have undergone rapid economic development shows the same structural shift as does the between-country analysis.

Table 4

Italy: Shift of the Dietary Structure

	Food Balance Sheets (1)							
	1948-50	1951-53	1954-56	1957-59	1960-62	1963-65	1965-66	Trend
Fat calorie ratio	19.8	21.8	22.8	24.4	26.0	27.0	27.4	↗
Carbohydrate calorie ratio	68.3	66.6	65.4	63.8	62.3	61.1	60.7	↘
Protein calorie ratio	11.9	11.6	11.8	11.8	11.7	11.9	11.9	↔
Animal protein calorie ratio	3.3	3.4	3.9	4.1	4.4	4.7	4.8	↗
Vegetable protein calorie ratio	8.6	8.2	7.9	7.7	7.3	7.2	7.1	↘

Hence, the gradual restructuring of the diet as a function of income appears to be a general phenomenon. However, each country moves in this direction from features basic to it and which reflect its dietary heritage. The speed of the evolutionary process will depend, on the national level, on the rate at which per caput income rises, but the prime movers in this evolution will be these classes which, particularly as a result of urbanization, will enter a market economy and acquire wider freedom of choice of foods.

If this model is accepted, it is natural that demand projections for individual foods and for food groups should also reflect this evolution of the dietary structure. Therefore, in the Indicative World Plan methodology, the proportions of calories from fats, carbohydrates and proteins have been used as tests of the nutritional coherence of the demand for food (2).

Notes and References

In a previous study (3) (4), the clusters of points were adjusted for functions $\log y = a + b \log_n x$. For certain nutrients such as animal proteins, these functions give better correlations ($r = 0.81$). Here, however, we have preferred to adopt semi-log functions which have the advantage of enabling one to cumulate the areas of the various nutrients by calculation and by graph. For example, the equation which determines the total fat area is found by adding the equations related to the constituent products (separated fats + unseparated vegetable fats + unseparated animal fats).

2 Consumption of home-grown food as percentage of total expenditure on food

(1) FAO. Food Balance Sheets 1960-62. (1966).

(2) FAO. Indicative World Plan for Agricultural Development to 1975 and 1985. Provisional Regional Studies Nos. 2, 3, 4. 2. (1968)

(3) FAO. Agricultural Commodities - Projections for 1975 and 1985. 1, 2 (1967).

(4) Périssé, J. The Nutritional Approach in Food Policy Planning. Nutrition Newsletter No. 1, Vol. 6, p. 30-45. (1968).

(5) Autret, M., Périssé, J., Sizaret, F. and Cresta, M. Protein Value of Different Types of Diet in the World: Their Appropriate Supplementation. FAO Nutrition Newsletter, Vol. 6, No. 4 (1968).

(6) François, P. Budgets at alimentation des ménages ruraux de Madagascar en 1962. 2 Publication Secrétariat d'Etat, chargé de la Coopération, Paris. (1968).

APPENDIX

Calories provided by Nutrients as Percentage of total Calories according to Country Incomes (1962)

		GDP per caput per year	Calories	Separated edible fats	Unsepar. vegetable fats	Unsepar. animal fats	Sugar	Vegetable proteins	Animal proteins
1	United States	2684	3100	16,1	2,5	22,5	16,0	3,5	8,3
2	Canada	1787	3020	15,5	2,5	22,4	16,6	4,1	8,0
3	Switzerland	1738	3220	14,9	4,1	17,2	14,4	4,9	6,3
4	Sweden	1689	2990	18,5	2,1	18,6	15,2	3,8	7,3
5	N.Zealand	1563	3490	14,3	2,0	24,3	13,7	3,9	8,6
6	Australia	1492	3140	11,5	2,3	24,2	17,7	3,8	7,6
7	Denmark	1381	3370	19,9	2,0	19,8	15,7	4,2	6,9
8	F.R.Germany	1338	2960	21,2	2,2	15,6	11,7	4,3	6,6
9	Norway	1318	2930	19,3	2,0	18,0	15,2	4,4	6,7
10	France	1314	3050	18,1	2,1	16,9	11,0	5,7	7,3
11	U.K.	1305	3280	17,3	1,7	20,4	16,9	4,3	6,5
12	Belgium	1255	3040	23,9	2,0	15,1	11,1	5,2	6,0
13	Finland	1057	3070	15,5	2,0	17,6	13,6	5,1	7,0
14	Netherlds.	1027	2950	24,1	2,1	13,1	17,3	4,4	6,2
15	Austria	886	2970	14,9	3,0	16,0	13,3	5,3	6,4
16	Israel	830	2820	15,3	4,1	9,6	12,4	6,8	5,1
17	Venezuela	721	2262	9,5	3,0	12,2	13,8	5,8	4,7
18	Italy	699	2730	15,2	3,0	8,2	9,4	7,3	4,4
19	Ireland	639	3490	13,8	1,7	18,4	14,5	4,3	6,3
20	Argentina	601	3038	9,8	1,8	21,0	12,2	5,3	7,6
21	Poland	594	3350	10,1	1,9	15,2	9,3	6,6	4,5
22	Uruguay	571	3143	9,1	1,3	24,4	13,2	4,5	9,4
23	Romania	550	3160	6,8	3,1	11,6	4,3	8,8	3,5
24	Japan	521	2230	5,3	5,8	3,6	7,1	9,4	3,0
25	S.Africa	480	2820	4,7	5,5	11,6	15,3	6,9	4,5
26	Chile	420	2509	8,2	2,5	9,7	13,5	7,3	4,2
27	Panama	410	2310	7,9	5,6	8,9	8,7	6,0	4,1
28	Greece	406	2940	15,4	3,9	7,7	5,6	8,8	4,3
29	Mexico	367	2610	10,3	6,0	8,4	12,1	7,5	3,5
30	Gabon	364	2135	4,2	5,1	2,1	1,1	3,9	4,2
31	Spain	354	2800	17,9	5,5	6,7	7,1	7,6	3,3
32	Costa Rica	339	2430	7,1	3,4	8,1	13,1	5,4	3,4
33	Lebanon	314	2360	12,2	3,7	4,9	10,4	8,3	2,7
34	Surinam	310	1980	11,8	2,9	5,9	12,1	5,9	3,1
35	Portugal	285	2550	15,0	4,0	4,6	8,1	7,1	4,3
36	Iraq	273	2140	4,3	2,6	7,7	14,6	8,3	4,3
37	Colombia	264	2210	5,9	4,2	11,7	7,8	5,0	4,6
38	Guatemala	256	2080	3,5	7,4	4,3	9,7	9,2	11,7
39	Yugoslavia	254	3030	9,4	3,8	9,1	5,7	9,4	3,0
40	Peru	246	2268	8,8	3,5	6,5	6,5	7,3	3,3
41	Ivory Coast	225	2294	4,4	6,0	1,8	3,5	7,3	1,8
42	El Salvador	222	2030	6,7	6,0	6,8	8,3	8,7	3,0

APPENDIX (Cont'd.)

		GDP per caput/ year	Calories	Separated edible fats	Unsepar. vegetable fats	Unsepar. animal fats	Sugar	Vegetable proteins	Animal proteins
43	Ghana	218	2157	4,7	8,0	1,8	3,9	7,0	2,0
44	Turkey	212	3110	6,3	5,0	4,3	6,2	10,5	2,0
45	Honduras	201	2080	3,5	6,1	4,1	6,7	7,9	2,4
46	Senegal	198	2279	9,9	7,2	3,8	5,5	8,1	3,2
47	Iran	193	2050	8,0	3,3	5,0	9,9	9,0	2,6
48	Malaysia	192	2336	10,0	2,4	4,5	10,6	6,4	2,6
49	Syria	182	2340	9,8	3,7	5,0	5,7	9,6	2,1
50	Jordan	178	2230	10,9	4,6	2,9	11,0	9,3	1,9
51	Paraguay	176	2733	6,8	3,3	13,7	12,8	5,5	4,9
52	Equator	174	1846	6,7	3,2	8,3	12,8	6,1	3,0
53	Zambia	173	2277	3,2	7,5	1,1	1,5	10,9	1,7
54	China Taiwan	170	2400	4,9	3,3	7,1	7,4	7,4	2,3
55	Congo B.	168	2125	11,1	7,0	2,6	1,0	4,5	2,8
56	Libya	156	1850	9,5	3,6	3,7	10,2	8,3	2,2
57	Philippines	152	1875	4,6	4,3	5,6	6,7	6,4	3,0
58	Brazil	146	2830	4,5	4,4	7,9	13,8	8,7	3,1
59	Ceylon	138	2049	4,8	12,3	1,7	9,9	7,1	1,7
60	U.A.R.	135	2690	5,0	5,1	4,0	5,6	9,9	1,8
61	Cameroon	121	2133	6,4	10,8	2,6	0,8	8,4	1,9
62	Mauritania	115	1954	1,9	19,5	16,7	13,5	6,5	7,9
63	Thailand	112	2127	1,7	8,3	4,1	1,9	6,8	2,0
64	C.A.R.	108	2122	2,4	11,3	2,4	0,9	6,5	1,7
65	Bolivia	108	1785	6,3	4,6	5,7	10,2	7,4	2,7
66	Madagascar	105	2333	3,5	3,3	1,3	3,0	7,3	1,6
67	Congo K.	103	1914	7,7	6,5	1,5	1,4	4,4	1,6
68	Sudan	93	1940	9,0	6,6	7,8	5,6	8,9	4,7
69	Kenya	86	2118	4,7	6,8	1,5	5,3	9,9	2,3
70	India	86	1977	6,3	4,8	1,7	2,9	9,5	1,1
71	Togo	85	2214	3,9	9,3	1,8	1,4	7,9	1,0
72	Pakistan	80	1940	5,7	2,5	3,8	1,3	7,7	1,8
73	Niger	80	2161	1,3	11,0	4,8	0,9	11,9	2,6
74	Gambia	72	2301	8,1	6,9	1,9	5,3	8,4	2,1
75	Nigeria	71	2182	7,8	7,8	1,3	0,6	9,9	1,0
76	Dahomey	71	2124	6,1	5,0	1,2	1,5	8,7	1,1
77	Uganda	70	2068	2,7	7,2	3,1	5,6	7,7	1,9
78	Mali	68	2120	3,3	9,7	3,4	2,8	10,0	2,1
79	S. Korea	65	2209	0,6	4,7	1,5	0,9	10,7	1,1
80	Tanzania	64	2102	2,3	6,6	2,7	3,0	9,4	1,7
81	Chad	63	2184	1,1	12,3	3,3	2,1	11,7	2,2
82	Afghanistan	60	2050	1,0	4,7	7,4	1,7	10,3	3,1
83	Upper Volta	50	2016	2,5	11,5	1,5	1,0	12,8	1,0
84	Ethiopia	46	2039	6,0	6,3	2,5	1,1	10,5	2,9
85	Malawi	36	2113	1,0	10,8	1,5	1,3	11,4	0,6

NOTES AND ARTICLES

STUDY OF THE CORRELATIONS BETWEEN BIOLOGICAL AND CHEMICAL MEASUREMENTS OF FOOD PROTEIN QUALITY

(Original text in French - contract translation)

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1. INTRODUCTION

In a previous paper we dealt with the different protein values of various types of human diet (1). A very careful determination of a protein quality index based on the amino acid content is particularly important when it is not possible to apply methods of biological measurement systematically. This quality factor should be taken into account both in assessing protein requirements and in shaping food policy.

The table "Amino Acids Content of Foods and Biological Data on Proteins" (2), compiled by the Nutrition Division of FAO, gives a number of biological data derived from tests carried out on rats fed with experimental diets, from which the amino acids content of foods can be calculated a posteriori. We came to the conclusion that a study of the correlation of the biological with the chemical measurements, as well as an attempt to assess the role of the various reference proteins which have been used up to now, would prove of value in establishing a protein quality index. An IBM 1130 computer was used for all statistical caloulations.

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(1) *Autret, M., Périssé, J., Sizaret, F. and Cresta, M. Protein Value of Different Types of Diet in the World: Their Appropriate Supplementation. Nutrition Newsletter, FAO, Vol. 6, No. 4, 1 - 29 (1968).*

(2) *FAO. Amino Acids Content of Foods and Biological Data on Proteins (1969, in press).*

2. HISTORICAL BACKGROUND

In 1946 Mitchell and Block proposed a method for assessing the quality of nutritional proteins by means of an index (3). This method, which is still widely adopted, consists in calculating by the use of tables the quantity of each essential amino acid contained in the protein mixture. The values so deduced are then expressed individually as percentages of the corresponding amino acid content of egg protein. The amino acid which shows the lowest percentage is called a limiting factor, and the percentage so obtained is the protein score 1/. To justify the merits of this method, the authors showed the results of a correlation study between the chemical score (CS) established for 23 different foods and their biological value (BV) obtained from nitrogen balances.

The composition of the amino acids contained in the foods examined and in the egg protein used as reference, had been determined previously by various investigators using chemical and microbiological methods. The data referring to biological value were extracted mainly from the findings of the University of Illinois on young growing rats. By comparing these two sets of data, Mitchell and Block ascertained that the representative values of the chemical score and of the biological value showed an extremely satisfactory coefficient of correlation ($r = -0.86$) 1/, which (in their opinion) confirmed both the validity of adopting the chemical score for grading the quality of proteins and the hypothesis whereby the protein synthesis is limited, in relation to the requirements of the organism, by those amino acids which are present to a minor degree.

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(3) Mitchell, H.H., Block, R.J. Some Relationships between the Amino Acid Contents of Proteins and their Nutritive Value for the Rat. J. Biol. Chem. 163, 599 - 620 (1946).

1/ In fact, from the first stages of their research, the authors adopted as representative measurement of protein quality not a percentage but the difference between its value and 100. This does not in any way alter the order of classification, but it does cause the coefficients of correlation to assume a negative value.

On the other hand, in the scatter diagram, the regression line representing the set of points cuts the coordinates at such a value that many proteins, although showing a zero chemical score (through the absence of one or more essential amino acids), could nevertheless have a definite biological value. The authors then put forward the hypothesis that "proteins inadequate for growth, but possibly adequate for maintenance, would possess a biological value of 39".

Mitchell and Block followed up this line of research and, in 1946-47, published a further study on the correlation of the chemical score with the protein efficiency ratio (PER), based on 23 different foods (4). The PER values were obtained by various investigators who fed rats for periods of four to eight weeks on diets containing from eight to twelve percent of proteins. The coefficient of correlation established between the two series of data was again high ($r = -0.89$), and was comparable to the coefficient obtained previously by correlating chemical score with biological values; in this latter case, however, results showed a degree of dispersion (eight percent of standard error in the regression equation) which was less than that obtained with the protein efficiency ratio (16 percent).

The interrelationship existing between chemical and biological measurements of protein quality also attracted the attention of the FAO Committee set up to define protein requirements (5). This Committee examined the concordance between the two sets of variables on 30 different foods. The biological values were established on adult men and young growing rats, while the chemical score was calculated with reference to the "provisional amino acid pattern" proposed by the Committee itself (FAO reference protein). A proper mathematical correlation study was not carried out, but nevertheless the scatter diagram showed a high degree of dispersion among the results. The Committee came to the conclusion that complete concordance between protein scores and biological values is not to be expected in view of the incompleteness of present knowledge of amino acid requirements of man and of amino acid values of foods.

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(4) Block, R.J., Mitchell, H.H. The Correlation of the Amino Acid Composition of Proteins with their Nutritive Value. Nutr. Abst. Rev. 16, 249 - 278 (1946-47).

(5) FAO. Protein Requirements. FAO Nutritional Studies No. 16 (1957).

The problem was re-examined in 1963 by a Joint FAO/WHO Expert Group who were entrusted with the revision of protein requirements. The group investigated 26 foods, comparing the chemical scores with the net protein utilization (NPU) as determined on rats (6). The results showed numerous discrepancies, which the Committee ascribed to the fact that biological tests and chemical analyses had been carried out on different samples and that, as a result, the measurements were liable to error. The chemical score does not, in facts, show any possible imbalance between amino acids, and there is the risk of overestimating the values of certain amino acids which are not available.

As we shall see, another (and not unimportant) reason for these inconsistencies lay in the choice of reference protein (FAO pattern, egg, milk) used to calculate the chemical score.

3. REGRESSION STUDIES WITH TWO VARIABLES

From the data contained in the table "Amino Acids Content of Foods and Biological Data on Proteins", 274 diets were selected. These diets were used by various investigators to determine protein quality in rats. Eighty-seven of these diets were used in connection with the biological value (BV), and 187 with the protein efficiency ratio (PER). The amino acids content of each diet was determine using the above-mentioned table, taking into account the composition of the foods contained in the various diets. The source of nitrogen for the diets was either one food only, or several foods (in both cases with or without the addition of amino acids).

Diets supplemented with high amounts of amino acids (more than 0.4 percent of lysine or more than 0.1 percent of methionine) were discarded, since at these levels certain side effects (linked to amino acid imbalance and to possible toxic effects) can possibly interfere and become a cause of heterogeneity. The number of experiments considered in the two series of results is markedly greater than those considered in previous studies, thus allowing a significant statistical analysis.

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(6) FAO. Protein Requirements. FAO Nutrition Meetings Report Series No. 37 (1965)

a) VARIATION OF THE CHEMICAL SCORE ACCORDING TO THE NATURE OF THE REFERENCE PROTEIN

The chemical score of each diet was calculated by the Mitchell and Block method, using various reference proteins whose composition is given in table 1.

The chemical score was also calculated in terms of egg protein (1963), using however the method of calculation recommended by the Joint FAO/WHO Expert Group in their report (Appendix 2): this method takes into consideration the total content of essential amino acids (A/E method).

Table 1 calls for some comments. Compared to the 1963 data, the egg protein (1946) proposed by Mitchell gives 10 or 15 percent higher values for isoleucine, lysine and sulphur amino acids. The levels of isoleucine and sulphur amino acids are, instead, perceptibly lower in cow milk and in human milk proteins than they are in egg. Finally, the level of sulphur amino acids in the FAO provisional pattern is, generally speaking, lower than in either milk or egg. In view of these variations, it might be expected that both the type of the limiting amino acid and the value of the chemical score would vary according to the choice of reference protein. In other words, if egg protein were adopted as reference, its high content of sulphur amino acids would tend to show methionine-cystine as the limiting factor in diets, and the chemical score would be lower than when milk is used as reference protein. Conversely, if cow milk protein were adopted as reference, its high content of lysine would increase the number of diets for which this amino acid is the limiting factor and the deficit would be more pronounced than if egg or human milk were used.

The FAO reference protein pattern was devised with intent to minimize these disadvantages. The low level fixed for most of the amino acids forming this reference protein does in fact diminish the deficits and penalizes diets to a lesser extent. We shall have the opportunity later on to consider whether this reference protein does in fact reflect actual biological reality more closely or not.

Table 1

ESSENTIAL AMINO ACIDS CONTENT OF THE VARIOUS REFERENCE PROTEINS EXPRESSED IN MG OF AMINO ACID PER G OF NITROGEN

	Egg 1946 1/	Egg 1963 2/	Egg 1969 3/	Human Milk 4/	Cow Milk 5/	FAO Pattern 6/
Isoleucine	500	415	393	254	295	270
Leucine	575	553	551	548	596	306
Lysine	450	403	436	428	487	270
Sulphur A/A *	406	346	362	185	208	270
Aromatic A/A **	675	627	618	421	633	360
Threonine	306	317	320	280	278	180
Tryptophan	94	100	93	105	88	90
Valine	456	454	428	284	362	270

* Methionine + Cystine ** Phenylalanine + Tyrosine

1/ Mitchell, see reference (3), page 1.

2/ Report of Joint FAO/WHO Expert Group (1963), table 6B.

3/ Amino Acids Content of Foods and Biological Data on Proteins. Average data by column chromatography.

4/ Report of Joint FAO/WHO Expert Group (1963), table 6B.

5/ Report of Joint FAO/WHO Expert Group (1963), table 6B.

6/ FAO Committee Report on Protein Requirements (1955).

Table 2 shows the frequency with which a given amino acid assumes a limiting role for the 87 diets under consideration in the first regression study, according to different reference proteins.

As might have been expected, 40 to 50 of these 87 diets are limited by methionine-cystine when the various egg proteins are used as references, while the same amino acids are limiting, for two and ten diets respectively, when cow milk and human milk are adopted as references. Conversely, lysine and threonine are limiting factors 60 times out of 87 when milk is adopted as a reference, but only 25 times in the case of egg. The type and frequency of occurrence of the limiting amino acids with the FAO pattern are rather similar to the results obtained with egg protein, but the chemical scores are higher than when the other reference proteins are used.

Table 2

COEFFICIENTS OF CORRELATION BETWEEN CHEMICAL SCORE AND BIOLOGICAL VALUE AND FREQUENCY OF OOCURRENCE OF LIMITING AMINO ACIDS ACCORDING TO VARIOUS REFERENCE PROTEINS

	Egg 1946	Egg 1963	Egg 1969	Human Milk	Cow Milk	FAO Pattern
Isoleucine	3	15	5	-	-	2
Leucine	-	-	-	3	10	1
Lysine	24	21	25	44	51	18
Sulphur A/A	53	41	50	2	10	40
Threonine	1	4	2	22	12	21
Tryptophan	3	6	5	16	3	3
Valine	3	-	-	-	-	-
Diets with CS 100	-	-	-	-	1	2
Total	87	87	87	87	87	87
Coefficient of Correlation	0.383	0.501	0.524	0.619	0.673	0.378

Table 3

COEFFICIENTS OF CORRELATION BETWEEN CHEMICAL SCORE AND PROTEIN EFFICIENCY RATIO AND FREQUENCY OF OCCURRENCE OF LIMITING AMINO ACIDS ACCORDING TO VARIOUS REFERENCE PROTEINS

	Egg 1946	Egg 1963	Egg 1969	Human Milk	Cow Milk
Isoleucine	73	44	20	-	-
Leucine	-	-	-	2	9
Lysine	35	44	52	93	149
Sulphur A/A	79	86	106	3	7
Aromatic A/A	-	-	-	-	3
Threonine	-	4	4	14	4
Tryptophan	-	3	2	75	15
Valine	-	6	3	-	-
Total	187	187	187	187	187
Coefficient of Correlation	0.710	0.726	0.678	0.647	0.656

b) CORRELATION BETWEEN THE BIOLOGICAL VALUE (BV) AND THE CHEMICAL SCORE (CS)

Table 2 also shows the coefficient of correlation of the protein score with the biological value. The chemical scores obtained on the basis of the FAO pattern show a very poor correlation with the biological value (r = 0.38). In the same way, the A/E method of calculating (in terms of egg protein) the chemical score, recommended by the Joint FAO/WHO Expert Group, gives a very low coefficient of correlation (r = 0.29). The best coefficients of correlation are obtained with human milk protein and, above all, with cow milk protein (r = 0.67).

The data contained in this table do not, however, confirm the good coefficient of correlation established by Mitchell and Block on 23 diets with egg as reference protein; but, as we have seen, these investigators carried out far fewer experiments and moreover used an amino acid pattern which was either incomplete

(the value of cystine not having been taken into consideration) or based on methods some of which are technically obsolete (chemical methods).

Figure 1 shows the regression lines obtained by correlating the biological values with the chemical score; these last are calculated on the basis of the three reference proteins (namely, egg (1963), human milk, cow milk). The regression lines have been extended so as to include the values of the chemical score between two standard deviations which comprises 97.5 percent of the observations. The standard deviation is represented by two curves, one above and one below the regression line; these curves delimit a confidence interval which includes 68 percent of the observations.

c) CORRELATION BETWEEN THE PROTEIN EFFICIENCY RATIO (PER) AND THE CHEMICAL SCORE (CS)

This study is based on 187 experimental diets. The values of the chemical score have been established using as reference protein the three egg proteins (1946, 1963, 1969), human milk and cow milk. Table 3 shows that the coefficients of correlation of the chemical score with the PER are higher than those given in table 2 for the biological value. In this case the coefficient is more than 0.60, whichever protein is adopted, but the highest value is obtained when egg protein is used as reference protein.

Among the various reference proteins used, MILK PROTEIN - AND ESPECIALLY COW MILK PROTEIN - GIVES THE BEST CORRELATIONS WITH THE BIOLOGICAL VALUE, AND EGG (1963) GIVES THE BEST CORRELATION WITH THE PROTEIN EFFICIENCY RATIO. These results are plotted on the diagram in figure 1.

These first findings confirm the classical assumption that some amino acids play a role, the importance of which varies according to whether maintenance requirements (BV) or growth requirements (PER) are considered.

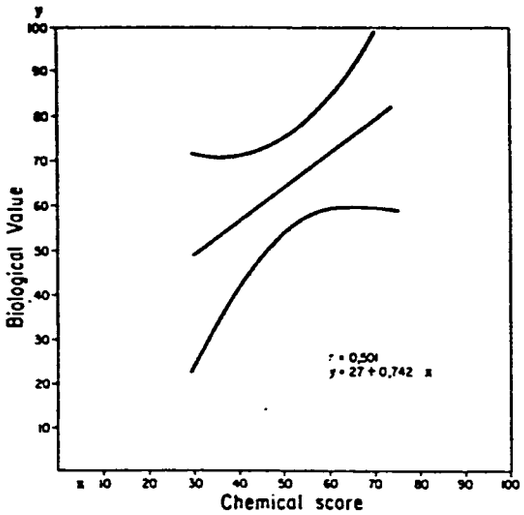
4. MULTIPLE CORRELATION STUDY

This study is an attempt to ascertain whether a mathematical formula instead of the chemical score would not give a protein quality index more respondent to biological reality, and whether the respective importance of each essential amino

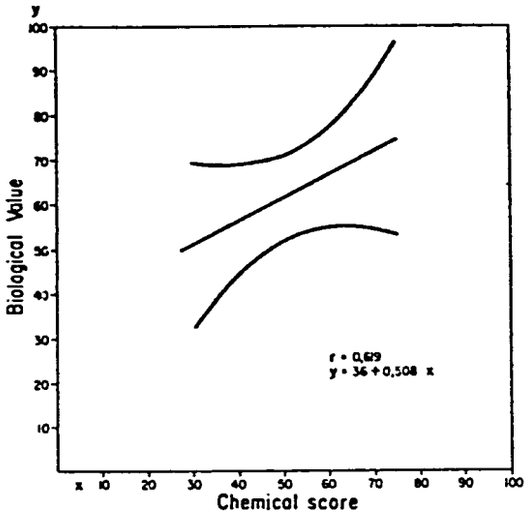
LINES OF REGRESSION AND CONFIDENCE LIMITS (±DS) AS RESULTS OF CORRELATION BETWEEN.

1. BIOLOGICAL VALUE (BV) AND CHIMICAL SCORE (CS)

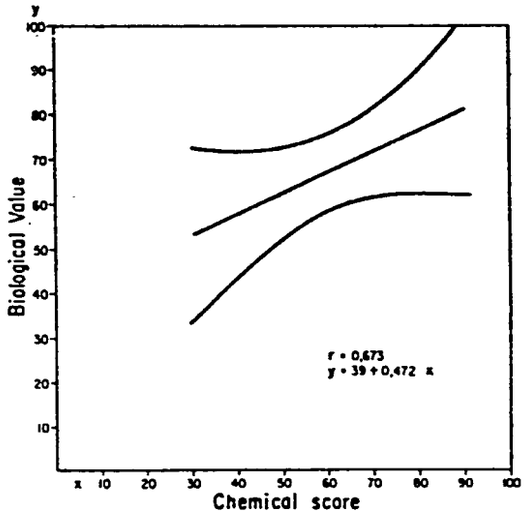
ref. prot.: egg



ref. prot.: human milk

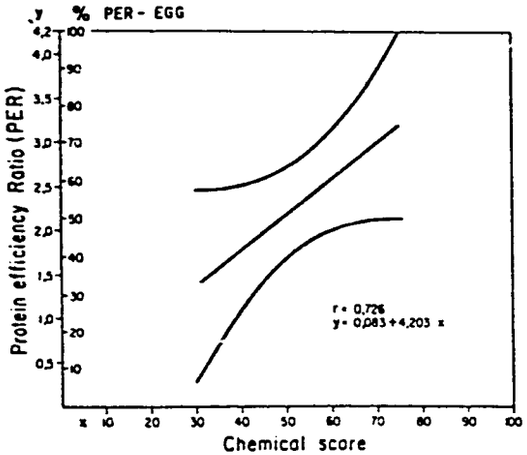


ref. prot.: cow's milk

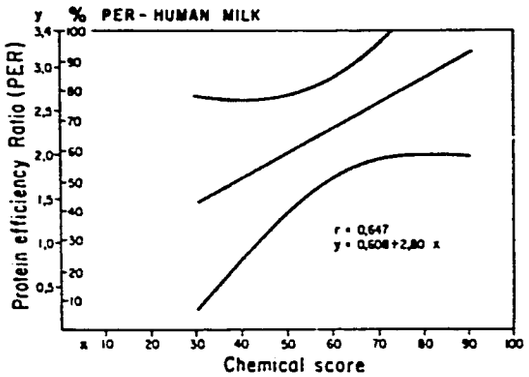


2. PROTEIN EFFICIENCY RATIO (PER) AND CHEMICAL SCORE (CS)

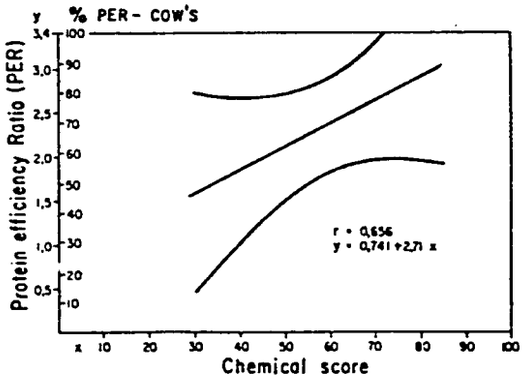
ref. prot.: egg



ref. prot.: human milk



ref. prot.: cow's milk



acid with regard to growth and maintenance requirements can be measured by a suitable test. The methodological aspects and the definition of the mathematical concepts used are given in the Appendix.

a) MULTIPLE CORRELATION OF BIOLOGICAL VALUE WITH ESSENTIAL AMINO ACIDS.

This analysis relates to the 87 diets previously investigated. Table 4 specifies the different parameters of the multiple regression correlation and gives two formulae. The first takes into consideration each individual essential amino acid and the total of the non-essential amino acids. The second is a simplified formula and considers only those amino acids which, following the Student test, appear to be the most representative. In both cases, the coefficients of correlation ($r = 0.707$, $r = 0.688$) are higher than those obtained previously by the simple correlation of chemical score with biological value (see table 2). It would seem, therefore, that the application of a multiple regression equation to the amino acids content of a diet gives a higher degree of approximation in assessing the biological value than the use of the classical method of chemical score calculation.

The relative importance of each essential amino acid and of the totality of non-essential amino acids in determining the biological value can be evaluated by calculating Student's variable t (table 4, col. 8). Lysine ($t = 3.5$) appears to play a fundamental role, followed by tryptophan ($t = 2.3$) and leucine ($t = 2.2$), and then later by isoleucine on account of its high negative index ($t = -1.6$). On the other hand, sulphur amino acids are of lesser account. Threonine, valine and the non-essential amino acids appear to have a negligible influence.

b) MULTIPLE CORRELATION OF PER AND ESSENTIAL AMINO ACIDS

Table 5 lists the values of the various multiple correlation parameters resulting from the 187 experimental diets. The table gives two multiple regression equations (as in the case of biological value), one of which is simplified to five variables. High coefficients of correlation are obtained in both cases ($r = 0.72$, $r = 0.72$), but these are no better than the coefficient obtained by correlating the PER with the chemical score calculated by reference to egg protein (1963) ($r = 0.73$). As far as the PER is concerned, therefore, the Mitchell and Block method gives as good results as the formula of multiple regression.

Table 4

MULTIPLE REGRESSION BETWEEN BIOLOGICAL VALUE, ESSENTIAL AMINO ACIDS AND THE TOTAL OF NON-ESSENTIAL AMINO ACIDS

	Mean	Standard Deviation	Coefficient of Variation	Correlation Coefficient for each A/A with BV	Coefficient of Regression	Standard Deviation of Regression Coefficient	Student's Variable t for each Amino Acid
Isoleucine	256.50574	33.67901	0.131	0.45352	-0.07897	0.05086	-1.55257
Leucine	462.14942	75.38020	0.163	0.28688	0.03628	0.01680	2.15943
Lysine	318.86206	123.91906	0.389	0.62374	0.06267	0.01780	3.52109
Sulphur A/A	211.36781	53.97439	0.255	0.10462	0.02171	0.02393	0.90708
Arom. A/A	491.31034	61.84626	0.126	0.15902	-0.01694	0.02312	-0.73268
Threonine	223.39080	40.22967	0.180	0.62105	0.02649	0.05506	0.48118
Tryptophan	70.68965	14.27170	0.202	0.17842	0.20699	0.08984	2.30395
Valine	301.27586	44.86923	0.149	0.40615	0.01048	0.02891	0.36282
Non-Ess.A/A	3663.55172	311.95187	0.085	-0.39687	-0.00079	0.00468	-0.17007

Multiple Regression Formulae:

1) with all amino acids (r = 0.707)

BV = 32.831 - Iso 0.07897 + Leu 0.03628 + Lys 0.06267 + Sulphur A/A 0.02171 - Arom. A/A 0.01694 + Threo 0.02649 + Tryp 0.20899 + Val 0.01048 - Non-Ess. A/A 0.00079

2) with the more representative amino acids only (t 1.5) (r = 0.688)

BV = 30.556 - Iso 0.06543 + Leu 0.03381 + Lys 0.06814 + Tryp 0.21581

Table 5

MULTIPLE REGRESSION BETWEEN PROTEIN EFFICIENCY RATIO AND ESSENTIAL AMINO ACIDS

	Mean	Standard Deviation	Coefficient of Variation	Correlation Coefficient for each A/A with PER	Coefficient of Regression	Standard Deviation of Regression Coefficient	Student's Variable t for each Amino Acid
Isoleucine	256.43850	37.93826	0.147	0.48144	0.00237	0.00126	1.88383
Leucine	495.83422	89.12772	0.180	0.08852	-0.00046	0.00048	-0.96459
Lysine	304.60962	101.45295	0.333	0.50204	0.00214	0.00041	5.19566
Sulphur A/A	217.22459	59.22658	0.273	0.39206	0.00249	0.00071	3.48082
Arom. A/A	515.64705	40.16743	0.078	0.32615	0.00018	0.00102	0.18024
Threonine	224.15508	57.33426	0.256	0.27132	0.00033	0.00065	0.51645
Tryptophan	74.00000	13.65315	0.184	0.49798	0.00587	0.00379	1.54838
Valine	303.26737	34.29886	0.113	0.58927	0.00462	0.00168	2.74326

Multiple Regression Formulae:

1) with all essential amino acids (r = 0.724)

PER = -1.2689 + Iso 0.00237 - Leu 0.00046 + Lys 0.00214 + Sulphur A/A 0.00249 + Arom. A/A 0.00018 + Threo 0.00033 + Tryp 0.00587 + Val 0.00462

2) with the more representative amino acids only (t 1.5) (r = 0.722)

PER = -1.25482 + Iso 0.00210 + Lys 0.00229 + Sulphur A/A 0.00256 + Tryp 0.00706 + Val 0.00412

Student's test (table 5, col. 8) shows that lysine has an extremely high relative importance and plays a leading role (t = 5.2), a role which is even more decisive than in the case of biological value. Sulphur amino acids follow in order of importance (t = 3.5), then valine, isoleucine and tryptophan.

c) COMMENTS ON RESULTS RELATED TO BIOLOGICAL VALUE AND PROTEIN EFFICIENCY RATIO

According to the results of Student's test, the importance of the most representative amino acids in relation to BV and PER can be summed up as follows:

	Biological Value	Protein Efficiency Ratio
Lysine	++++	++++
Tryptophan	++	++
Isoleucine	-	++
Leucine	++	-
Sulphur amino acids	+	+++
Valine		+++

The signs + and - represent one unit of Student's variable t.

Essential amino acids appear to vary in importance (at least on rats) according to whether they are considered in relation to the requirements of growth or of maintenance. There would not, therefore, seem to be one ideal protein and one only, which should be adopted as a reference, but at least two: one suitable for obtaining a chemical score more consistent with the biological value (this is the case of milk protein which has a higher coefficient of correlation than egg); and the other for supplying a chemical score more closely correlated with the values of the protein efficiency ratio (in this case egg protein is superior to milk protein).

The role ascribed to certain amino acids by Student's variable t would appear to explain why some reference proteins give chemical score values which are better correlated than others with, at times, the biological value and, at times, the protein efficiency ratio.

In a given series of observations, some amino acids can show, insofar as they are limiting factors, a high frequency of occurrence even though they have a merely relative importance in the study of multiple regression. The role of these amino acids can thus be erroneously overestimated, and the diet under examination is consequently penalized. These limiting amino acids (or rather, amino acids which are identified as such) can thus become misleading factors in the establishing of biological quality of protein from chemical score.

For this reason, only a poor correlation can be obtained between the two measurements. For example, when simple correlation is attempted between biological value and the chemical score calculated from egg, sulphur amino acids are frequently limiting (see table 2) since egg is rich in methionine-cystine. Now, Student's variable t shows that sulphur amino acids play a secondary role with regard to biological value (see table 4). The chemical score of these amino acids will thus interfere in the correlation calculations, with the result that the coefficient of correlation will drop.

On the other hand, sulphur amino acids show a reduced frequency of occurrence as limiting factors when milk is used as a reference protein, since milk is less rich in sulphur amino acids. The role of the sulphur amino acids, therefore, diminishes in importance and falls more into line with the results of Student's test t. As a consequence, it is not surprising that milk as a reference protein should give a better correlation with biological value than egg.

The same line of reasoning can be used to explain the different intensity of simple correlations between chemical score and PER. The use of egg as a reference protein in preference to milk will give rise to a high frequency of occurrence of sulphur amino acids as limiting factor. The choice of this protein will give to sulphur-containing amino acids an importance which is more in line with the data obtained from Student's test t. As a result, the coefficient of correlation between the chemical score and the PER will be higher with egg than with milk. The same general argument holds good for all other amino acids. The effect that they may have on the correlation will depend on their respective levels in the reference protein which determine the frequency of occurrence of the limiting factor. At the same time, however, the effective role of these amino acids depends on their relative importance as indicated by Student's variable t.

Calculations support this line of reasoning. We have seen that the coefficient of correlation between the biological value and the chemical score is low ($r = 0.50$) when egg (1963) is used as reference. Let us now take it that the sulphur amino acids are by-passed as limiting factor and that the biological value is correlated with the chemical score of the second limiting amino acid; in this way the influence of the sulphur amino acids is minimized, in full accordance with the minor role indicated for them by Student's variable t in relation to biological value. The relevant calculations show that, in this case, the coefficient of correlation does in actual fact improve and its value increases from 0.50 to 0.60.

In the case of the PER, on the contrary, Student's test t shows that sulphur amino acids are of considerable importance. If we by-pass them as before and only take into account the chemical score of the second limiting amino acid, it follows logically that the correlation between the two variables will deteriorate. In fact, calculation demonstrates that the coefficient of correlation does indeed drop from 0.73 to 0.62.

Here, therefore, is the proof that some amino acids play different parts according to whether one refers to biological value or to PER. Their respective importance can be measured by means of a multiple regression analysis using Student's test t.

5. PRACTICAL CONCLUSIONS

Whenever the chemical score is used to estimate the ability of a food protein to maintain the nitrogen balance (BV), the reference proteins should be chosen among those which have high levels of lysine, tryptophan and leucine and with low levels of isoleucine. These optimum levels should be comprised between the average values indicated on table 4 (col. 2) and the two positive standard deviations for the first three amino acids and two negative standard deviations for isoleucine (col. 3).

According to these data, the pattern of milk protein appears to be more suitable than egg protein. However, neither cow milk nor human milk seem to have an optimum amino acid composition with regard to biological value. Cow milk is richer than human milk in leucine and lysine (positive aspect), but it is poorer in tryptophan (negative aspect). Neither completely meets the optimum levels

indicated by the multiple correlation. In fact, the regression equations (table 4) appear to give an estimate of the BV which comes much closer to biological reality.

When the chemical score is used for estimating the capacity of proteins to meet growth requirements (PER), the reference protein should be selected from among those with high levels of lysine, sulphur amino acids, valine and isoleucine. These levels should be comprised between the average values indicated in table 5 (col. 2) and two positive standard deviations (col. 3). The pattern of egg protein appears to be in this case more suitable than that of milk protein. Among the three egg proteins used as reference, the egg protein pattern recommended in 1963 by the Joint FAO/WHO Expert Group on Protein Requirements appears to give the best coefficient of correlation in relation to the PER when the calculation of the chemical score is carried out according to the classical Mitchell and Block method and not by the A/E method. In this case, the multiple regression equation (table 5) does not give a better approximation than calculating the chemical score.

Not one of the reference proteins at present in use seems to give a good correlation of the chemical score simultaneously with both biological value and PER. The multiple regression analysis moreover shows that the amino acids vary in importance according as to whether they are to meet maintenance or growth requirements.

As young children and expectant and nursing mothers are usually the first to suffer from protein deficiencies, in practice the quality of proteins contained in the various diets should logically be assessed in terms of growth requirements. Under these conditions - and for want of something better - the Mitchell and Block method would seem to be the most suitable, provided that egg (1963) is adopted as reference protein. These results would seem to justify a posteriori our choice of this method in a previous paper (see ref. (1)).

This does not, however, mean that we should stop short here: the coefficient of correlation is only 0.73 and the standard error of regression reaches 12 percent. The approach we have used might well give useful results, but the input information of the mathematical model was vitiated by errors inherent to the nature of the data available.

These errors concerned the composition of diets, biological methods, and the nature of the reference protein. The amino acids content of the diets had also been calculated from the average values shown in composition tables; but it is a well-known fact that the composition of foods can present varietal differences and that it can also be modified by production factors.

The representative values of the biological value and the protein efficiency ratio supplied by different investigators are also a source of heterogeneity. This was the main reason why there was a great variance in the PER results, both between individual cases of identical experimental lots and between different sets of experiments. The use of a more precise biological method, such as net protein utilization (NPU), would perhaps allow a better correlation with the chemical score. We were, however, unable to do this owing to the limited number of data available to us at that moment. According to the classical Thomas method (7), biological value (BV) should be calculated on adult animals only, but some investigators have used young animals with the result that maintenance and growth requirements have interfered in the nitrogen balances studies.

Finally, the reference protein is not perforce an optimum pattern. If, for example, we consider the results of the multiple regression in table 5, we will see that the quantities of isoleucine, sulphur amino acids and valine contained in egg reference protein (1963) are either equal or greater than the maximum values plus two standard deviations. At the same time, the quantity of lysine is inferior by 20 percent to the maximum value obtained in the multiple regression analysis. These differing levels of amino acids may be due to chance and have no biological significance, but it it cannot be exluded that a reference protein, which is rich in lysine and low in the other four amino acids, might have a higher PER value than egg.

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To be decisive, any contribution towards the solution of this problem of assessing protein quality should originate in a series of biological experiments (BV, PER, NPU) carried out on a sufficiently extensive number of foods and diets; it is also essential that the amino acid composition of these foods and diets should be ascertained by column chromatography. Results could then be subjected to the same kind of mathematical processing as we have used.

A comprehensive programme along these lines would certainly call for considerable financial backing and technical means. Some laboratories are already said to be implementing programmes of this kind (8). Such enterprises can never be given too much encouragement; clearly any revision of the report on protein requirements will only lead to a real improvement in current knowledge when more precise data are available on the existing interrelationship between the amino acid composition of foods and their protein quality.

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APPENDIX

GLOSSARY

PROTEIN EFFICIENCY RATIO (PER)

Increase of body weight during four weeks, divided by the weight of protein intake.

BIOLOGICAL VALUE (BV)

Proportion of nitrogen intake retained by the body for growth and for maintenance requirements.

LINEAR REGRESSION WITH TWO VARIABLES

A stochastic linear relationship between two random variables. This can be obtained by determining the linear function $y = f(x)$ which considers all points-observations. The parameters a and b of the equation are obtained with the method of least squares.

COEFFICIENT OF CORRELATION WITH TWO VARIABLES

This quantity measures the linear relationship of two variables. It can be calculated with the following formula:

$$r = \frac{\frac{1}{n}\sum\sum(x-\bar{x})\ (y-\bar{y})}{\sqrt{\frac{1}{n}\sum\sum(x-\bar{x})^2}\sqrt{\frac{1}{n}\sum\sum(y-\bar{y})^2}} = \frac{\sum\sum(x-\bar{x})\ (y-\bar{y})}{n\sigma_x\ \sigma_y} = \frac{\sum\sum xy-n\overline{xy}}{n\sigma_x\ \sigma_y}$$

STANDARD DEVIATION OF LINEAR REGRESSION

This indicates the confidence interval around the regression line. The deviation is small for values near to the mean and becomes progressively larger as the distance from the mean increases. The confidence limits shown in figure 1 have been calculated for $\pm$ 1 standard deviation.

When the regression curve between y and x is considered, then the standard deviation can be decomposed into two terms: a) the standard deviation around the regression curve $\sigma_2 = \sqrt{(1-r^2)}\ \sigma_y$ and b) the standard deviation of the regression line $\sigma_1 = \sqrt{r^2}\ \sigma_y$ In the case of a multiple regression σ_2 is calculated with (n- k- 1) degrees of freedom as the determination of the adjusted y requires k + 1 relationships between the y observations (k + 1 normal equations). The value of σ_1 is instead calculated with only k degrees of freedom as the mean $\bar{y}$ is given; only a k number of values are therefore sufficient to determine the regression plane.

STANDARD ERROR OF REGRESSION EQUATION

This is the standard deviation around the regression line:

$$\sigma_2 = \sqrt{(1-r^2)}\ \sigma_y = \sqrt{\frac{(1-r^2)}{n-k-1} \sum (y-\bar{y})^2}$$

In this paper, this measure is given as a percentage, in the form $(1 - \frac{\sigma_2^2}{\sigma_y^2}) \times 100$.

MULTIPLE LINEAR REGRESSION

This stochastic linear relationship can exist between a dependent variable y (i.e. biological value or protein efficiency ratio) and several independent variables x_1, x_2 ..... x_n (amino acids). The linear relationship can be expressed as follows (when a, b_1, b_2 ..... b_n are constants):

$$y = a + b_1 x_1 + b_2 x_2 + \ldots\ldots + b_n x_n$$

COEFFICIENT OF MULTIPLE CORRELATION

This quantity measures the relationship of the dependent variable y and the several independent variables included in the model. In the case of a linear relationship, this coefficient is calculated with the following formula:

$$r = \frac{\sqrt{1-s^2}}{\sqrt{\sigma_y^2}}$$

Where s^2 is based on the sum of the squares of the distances of each point from the adjusted hyperplane of estimation.

APPLICATION OF STUDENT'S T TEST TO MULTIPLE REGRESSION

In terms of probability, this test measures the importance assumed by each independent variable in a multiple regression:

$$t = \frac{b_i}{\sigma_{b_i}} \qquad (i = 1, \ldots. n)$$

with n - k degrees of freedom.

EDIBLE GROUNDNUT MEAL AS A PROTEIN SOURCE IN THE NUTRITIONAL PROGRAMMES*

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Most of the technologically less developed countries of the world are short of calories and proteins. The worst affected population in these countries are the vulnerable groups such as children below 5 years, who constitute about 75 million in India and the pregnant women and nursing mothers who number about 20 million[1]. Malnutrition during pregnancy can seriously affect the post-natal health of the mothers and their infants[2]. It can also reduce their resistance to diseases. Inadequate intake of protein by children during the first three years can retard physical growth and even affect mental development under certain conditions[3].

The current levels of consumption of the main categories of food in India show that the diets of the people are based predominantly on cereals and legumes. The percapita consumption of animal protein is as low as 6.0 g per day out of a total intake of 51 g of dietary protein. This is far short of the recommended requirements[4] (Table 1). Though attempts to increase the production of milk and animal proteins are in progress, it is realised that the present resources of land,

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water and animal feeds are inadequate to accomplish significant results. In addition, the high cost of animal protein foods limit their extended use by the low income groups who suffer most from malnutrition and dietary deficiencies.

Abundant supplies of oilseeds in the developing countries at low cost have led to an increasing realisation of their importance as sources of supplementary protein for human feeding. India is one of the major oilseed producing countries of the world and has the largest production of groundnut (Table 2). Though groundnut kernels are used traditionally in various forms after roasting in candies and food preparations, bulk of the production (more than 80 percent) is used for the recovery of edible oil. The oil milling industry makes available approximately 1.6 million tons annually of groundnut pressed meal with about 45 per cent protein. The commercial meal is, however, unfit for human consumption because of unhygienic handling and processing conditions. Efforts to process groundnut into an acceptable edible protein concentrate began in India in 1950. The present paper deals with the technological improvements in groundnut processing and in the utilisation of this valuable source of protein for human consumption.

Choice of raw materials and its quality factors.

Groundnuts are generally marketed as pods (nuts in shells) in India; the problem of drying arises in areas where humidity is high or rainfall occurs during the time of harvest. The

shelling of dried pods is done mechanically in decorticators. In commercial practice the quality of groundnut is judged by: (a) moisture content, (b) shelling percentage (proportion of kernels to pods), (c) natural test weight (weight to volume ratio), (d) size of kernels, (e) colour of pods and kernels, (f) oil content of kernels, and (g) free fatty acid content.

The presence of mould (A.flavus) infected kernels presents a special problem in groundnut. Surveys carried out on several commercial samples of seed and meal have revealed the presence of low to high levels of aflatoxin (unpublished data). One of the important requirements in the choice of kernels for processing is freedom from mycotoxins. The major approaches for eliminating aflatoxin are: (1) prevention of mold infestation during harvesting and storage, (2) removal of infected nuts by manual or electronic means, (3) extracting the toxin by selective solvents, and (4) inactivation of the toxin by chemical treatment without impairing meal quality. It has been found that considerable reduction in aflatoxin levels could be achieved by adopting the first two alternatives and in case the aflatoxin content is high in the meal, the third and fourth alternatives could be adopted.

Production of edible groundnut flour.

The process for the production of edible groundnut flour consist of: (1) grading and precleaning of kernels (2) heat treatment for removal of testa, (3) mechanical sorting, (4) screw-pressing and solvent extraction using food grade solvent, (5) storage and (6) grinding. A flow-sheet of the process is given in Fig. 1.

Shelf-life of edible groundnut meal and flour.

Edible groundnut flour can be stored in polyethylene lined jute bags without any significant deterioration in quality for a period of 5-6 months under moderate conditions of temperature and humidity[5]. In areas where the temperature exceeds 37°C and humidity is in the range of 80-90 per cent for long periods, the shelf-life of the flour may be restricted to 3-4 months. Storing in tin containers, though a costly process, affords better stability[6].

Standards for edible groundnut flour.

Specifications for screw-pressed edible groundnut flour have been laid down by the Indian Standards Institution (IS4684-1968) and by the Protein Advisory Group of the FAO/UNICEF/WHO. Stress is laid on the collection, handling and cleaning of raw materials, processing conditions, particularly time/temperature relationships, hygienic conditions of plant and quality controls, nutritional value and sanitary quality. The Protein Advisory Group tentatively recommended that the aflatoxin limit in foods containing groundnut should not exceed 30 ppb (0.03 mcg/kg). However, the Indian Standards Institution has prescribed a limit of 120 ppb for flour used in compositions, but the overall aflatoxin content in the food not to exceed 50 ppb (0.05 mcg/kg).

As a consequence of heat during expelling, it has been observed that part of the lysine in groundnut is rendered biologically unavilable. To avoid this milder conditions in expelling are recommended. Specification for available lysine content in groundnut flour has been fixed as 2.5 g/16 g of nitrogen. The standards laid down for edible flour (both screw-pressed and solvent extracted) are given in Table 3.

Utilisation of edible groundnut flour.

Fortification of wheat flour. Attempts to use groundnut flour on a large scale with cereal and tuber flours in the preparation of several nutritious, bulk foods which could stretch the available food supplies were made earlier. A blend of cassava flour, wheat flour and groundnut flour (75:17:8) proved as acceptable and as nutritive as wheat flour to consumers and could be used in Chapathi (unleavened bread). These attempts have not been very successful. But recently the Government of India has adopted a programme of enrichment of wheat flour with 5 percent edible groundnut flour. This is now being produced and marketed in Bombay and it will be extended to Calcutta, Delhi and other places. Thir enrichment increases the protein content of wheat flour by 2.5 percent.

Feeding trials in India[7] on school children have shown that supplementation of cereal based Indian diets with 50g/day/child of groundnut flour fortified with vitamins and minerals significantly increased height, weight and haemoglobin content (Table 4). These objectives can be further achieved by a judicious mixture of groundnut flour with other traditional food items such as grain legumes[8,9]. Two plants for the production of edible groundnut flour of 5 tonnes capacity per day have been set up in Coimbatore and the other in Bombay under UNICEF aid. Efforts have also been made in several African countries to use groundnut and groundnut flour as protein supplements to human diets. In Nigeria,

groundnut flour has been tested as a supplement to cassava on boys and adults[10]. In long term feeding trials carried out at Senegal[11], good nitrogen retention and minimal digestive disturbances were noticed in infants and young children receiving 75-150 g. groundnut flour per day for long periods.

High protein supplements.

One of the earliest products based on groundnut flour is the Indian Multipurpose Food (IMPF) which is a (3:1) blend of edible groundnut flour and chick pea (*Cicer arietinum*). The blend is fortified with minerals and vitamins and vitamins (A&D, thiamine and riboflavin). The product is being prepared in three forms to serve the Indian preferences and needs: (a) seasoned (b) unseasoned and (c) unseasoned product with 20 percent milk solids.

Feeding experiments with children[12] have shown that supplementation of diet with 56 g. of MPF daily significantly improved height, weight, RBC count, haemoglobin and nutritional status. MPF containing 20 percent milk solids also proved effective as a dietary supplement for weaned children[13] and in the treatment of kwashiorkor[14].

The Indian MPF has been tested widely for its acceptability in educational, social, industrial and catering institutions. During the years 1958-1959, the Government of India took keen interest in the popularisation of this product. Subsequently a plant with a capacity of 2 tons per day was set up in the private sector in Coimbatore with the help of the CFTRI. The entire production of MPF from the plant was being utilised by the Government of Madras in School feeding programmes over a number of years. In Mysore, the CFTRI has been producing MPF in a

small plant with a capacity of ½ tonne per day since 1956. Recently three additional units have been set up by the private industry in Uttar Pradesh for the production of MPF.

Infant foods.

Infant foods based on vegetable proteins for feeding infants and preschool children have been developed at the CFTRI, Mysore[15,16]. More recently the preparation of a spray dried infant food based on groundnut flour has been standardised[17]. In composition, it has 26 percent protein out of which 15.6 percent is from groundnut, 7.8 percent from milk solids and 2.6 percent from cereals. Feeding trials conducted on children aged 6-18 months have shown that this food has nutritional qualities comparable to those of infant foods based on animal milk[18] Nitrogen balance experiments carried out on nine new born babies fed on this food at various levels of protein have shown that the net protein utilisation (NPU) was similar to that of a control food based on skim milk solids; no adverse reactions were noticeable[19] (Table 5).

Precooked Weaning Foods.

More sophisticated than the above, precooked weaning foods, which are ready to serve are also now being produced in the country. These are made by roller drying, blends of groundnut flour, pulse flours and cereal flours. One such blend based on soya flour in place of groundnut flour is now being marketed in India under the name of Bal-Amul. A second product containing groundnut protein isolate is in the final stages of development.

Foods for the weaned child.

In India as in many other developing countries protein malnutrition develops in children when they are weaned from mothers milk and put on solid foods, at the age of 6 months and above. Due to economic privations these children are given only starchy foods, which lack the required quantity and quality of protein and in addition lack the vitamins and minerals.

To overcome this the Government of India has undertaken with the help of foreign agencies the manufacture and distribution of a type of weaning food under the name of "Bal-Ahar". The developmental work of this food was carried out at CFTRI, Mysore. The food is based on a blend of 75 parts of wheat flour, 20 parts of edible solvent extracted groundnut flour and 5 parts of milk powder fortified with vitamins A, D, C & B group with calcium and iron. The protein content is about 22 percent. The production during 1970 is estimated to be 50,000 tonnes.

Protein isolates and their products:

A process for the manufacture of protein isolate from groundnut flour (92-94 percent protein) has been developed at CFTRI, Mysore[20,21] and a plant set up by private industry at Bombay is producing 2.5 tons of this product per day since 1968. The capacity of the plant is now being further increased to 5 tonnes per day. It is being used in the preparation of high protein biscuits, beverage foods, etc.

Use of protein isolates in stretching the milk resources of the country. Recently successful attempts have been made in using groundnut protein isolate, with sugar or hydrolysed starch

for toning of buffalo or cow's milk. In the process an emulsion of the protein isolate, carbohydrates, vitamins and minerals are made, homogenized with an equal part of milk, pasteurized and bottled. The resulting vegetable protein toned milk (Miltone) has all the characteristics of milk and could be used in its place for feeding children for making lactic culture milk (Yoghurt), and as a beverage food after flavouring or as sterilized milk. The protein isolate could be prepared insitu as wet protein or the spray dried proteinisolate could be used. One unit at present in Bangalore is producing about 1,000 litres of Miltone per day which is being used in a slum feeding programme now been operated by the Government there. The UNICEF is supporting this project by partly subsidizing the production.

Cost of production, protein content and protein value cost index.

Market price of groundnut kernel has steadily increased during the past five years and has been reflected in the price of oil and meal. At present, commercial groundnut meal costs about Rs.700/- and the oil Rs.4,500/- per tonne. The cost of edible groundnut flour would be necessarily higher than that of the commercial meal and actual cost data, indicates its price in the range of Rs.1,000-1,100 per tonne.

There is a considerable variation in the protein content, protein efficiency ratio and relative cost of the different oilseeds. Campbell[22] suggested a protein rating system based on the protein content, protein efficiency ratio and the quantity of protein likely to be consumed. A modified index (protein value cost index) as designed by Parpia which relates the cost of the protein to its nutritive value (PER) is given in Table 6. (The data indicates

that the PVCI of the vegetable protein based foods is significantly higher than the currently used milk based foods and hence their advantage in meeting the protein needs of low income groups).

Marketing of protein foods based on edible groundnut flour.

Commercial groundnut meal has been used hitherto as livestock feed and manure. Hence, considerable consumer resistance is encountered owing to prejudices predominant in the minds of the user that it is unfit for human consumption. Due attention has therefore to be given in developing processed foods containing edible groundnut flour so that they would fit into the existing dietary patterns as substitutes and supplements. The sociological and economic factors of the population should also be taken into consideration. In the marketing of Indian Multipurpose Food supplement, for example, a detailed promotional programme was undertaken by the CFTRI, Mysore, before the Madras State Government could be induced to adopt a product in its mid-day feeding programme in schools. In addition, an aggressive and alert campaign for the popularisation of the protein foods is also essential. Market surveys and promotional techniques such as audio-visual aids, are of utmost value in this regard. In the development of products like Bal-Ahar, fortified wheat flour, vegetable toned milk, weaning foods, etc. the Food and Nutrition Board of the Government of India is actively collaborating with research institutions and other commercial agencies for the large scale production and promotion of these productions. The Protein Foods Association

of India established in 1968 is helping in these efforts. There is no doubt that the use of groundnut flour in processed foods would offer new possibilities of improving nutritional status of the vulnerable groups of the population.

Conclusion.

Groundnut occupies a prime place as a commercial oilseed crop. The entire world production of 11.2 million tonnes if processed into edible protein concentrates, would provide 3 million tonnes of additional protein for enrichment of deficient diets. At present, however, only a fraction of this is used as human food. The protein-calorie gap could be bridged if the quality of protein is improved by eliminating deleterious and toxic factors, better processing conditions and supplementing the protein with other vegetable proteins. Introduction and development of nutritional standards for oilseed meals and oilseed proteins become all the more essential in this regard. The most important aspect of the problem of utilising groundnut flour, however, is the marketing and promotion of the processed foods, for which concerted efforts are being made both by Government and private agencies.

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TABLE 1: Per Capita Consumption of Food and Protein in India*

	Food g	Protein g
Cereals	375	30
Starchy roots	30	-
Sugar	45	-
Pulses and nuts	65	14
Fruits and Vegetables	80	1
Meat, Poultry and eggs	12	1
Milk and Milk Products	140	5
Fats and Oils	11	-

Total Calories	1970
Animal Protein	6g
Total Protein	51g

* Source: Sukhatme, P.V., 'Feeding India's Growing Millions', Asia Publishing House, Bombay, 1965.

TABLE 2: Production and Yield of Groundnuts (in shell) in India and Other Major Producing Countries of the World* (1967)

Country	Production (1000 metric tons)	Yield (100 kg/ hectare)
1. India	5829	7.7
2. China	2450	12.4
3. Nigeria	1252	12.3
4. U.S.A.	1122	19.8
5. Senegal	1114	9.7
Others	5631	-
World Total	17398	12.4

* Source: Food and Agriculture Organisation of the United Nations, Rome Production Year Book, Vol. 22, 1968

TABLE 3: Specifications for Edible Groundnut Flour

Constituent	Draft standards laid for solvent extracted groundnut flour for human consumption	ISI Specifications for edible groundnut flour (expeller pressed)	UNICEF Specifications*		
			High speed expeller	Low speed expeller	Pre-pressed solvent extraction
Moisture % (max.)	8.0	9.0	5.0	5.0	5.0
Ether extractives % (max.)	1.5	8.0	5.5	5.5	1.0
Protein (N x 6.25) % (min.)	47.0	45.0	52.0	50.0	53.0
Fibre % (max.)	5.0	2.1	3.5	3.5	3.5
Total ash % (max.)	5.0	5.0	4.5	4.5	4.5
Acid insoluble ash % (max.)	0.35	0.10	-	-	-
Available lysine (g/16 g N) (min.)	-	2.5	-	-	-
FFA (% oleic acid) (max.)	-	3.0	-	-	-

* Free from E.coli., Salmonella and pathogenic anaerobes.

TABLE 4: Increase in Height, Weight, Haemoglobin and Red blood Cell Count of Children Receiving Supplements of Fortified Groundnut Flour

(Duration of Experiment 3 months)

Character	Control Group (Rice diet+ Wheat-tapioca blend)	Experimental Group (Rice diet + fortified groundnut flour)	Significance of difference
Height(cm)	1.04	1.88	Sig. at 0.1%
Weight (kg)	0.37	1.02	" "
Haemoglobin (g/100 ml)	0.51	1.20	" "
R.B.C.Count (10^6/cu.mm)	0.09	0.37	" "

Each group had 23 boys aged 5-11 years. The control group received a daily supplement of 50 g of 1:1 blend of wheat and tapioca flours, while the experimental group received a daily supplement of 50 g of fortified groundnut flour. 15 boys in the experimental group and 3 in the control group improved in their nutritional status.

TABLE 5: Mean Value of Intake and Retention of Nitrogen by Infants on Infant Food and Control Food (per kg body weight)

Type of food and level of protein fed(g/kg body wt.)	No. of infants	Total Nitrogen(mg)		Uncorrected NPU %	Corrected NPU %
		Intake (mg)	Retention (mg)		
1. Infant Food (Experimental)*					
1.9	1	298	178	59.7	78.9
2.7	3	444	306	68.9	81.8
3.5	2	563	345	61.4	71.4
5.3	1	851	600	70.5	77.1
7.2	3	1165	838	71.9	76.8
2. Control Food**					
1.9	1	304	163	53.6	72.3
2.6	6	417	277	66.3	80.1
3.4	5	538	381	70.8	81.4

* Average weight of infants : 2.57 kg

** Average weight of infants : 2.38 kg.

TABLE 6: Chemical Composition of Groundnut Flour and Processed Foods Based on it (per 100 g on fresh basis)

	Protein (Nx6.25) g	Ether extractives g	Carbohydrates g	Calcium g	Phosphorus g	Iron mg	Thiamine mg	Riboflavin mg	Nicotinic acid mg	Vitamin A	Vitamin D	Calories per 100 g
Groundnut flour	52.7	8.9	21.8	0.07	0.05	2.9	0.95	0.20	19.5	-	-	378
Soya flour (low fat)*	50.0	7.0	30.0	0.33	0.42	5.6	0.70	0.58	5.7	-	-	383
Sesame meal*	33.3	12.2	38.1	2.38	0.63	19.3	1.05	0.33	5.3	-	-	395
Supplementary Protein Food												
Multipurpose Food	41.9	8.5	35.3	0.67	0.32	5.1	1.03	3.00	14.0	3000	300	387
Bal-Ahar	25.1	3.1	56.0	0.40	0.63	20.1	0.30	0.40	5.0	-	-	351
Bulk Foods												
Groundnut flour +Tuber flour (1:3)	13.8	2.7	69.8	0.06	0.18	3.6	0.31	0.07	5.4	-	-	359
Groundnut flour +Tuber flour+ Wheat flour (8:17:75)	13.4	2.0	71.8	0.05	0.29	5.0	0.50	0.13	5.6	-	-	359
Wheat flour*	12.1	1.7	72.2	0.04	0.32	7.3	0.54	0.12	5.0	-	-	-
Skim milk powder*	35.6	1.0	52.0	1.30	1.03	0.6	0.35	1.96	1.1	-	-	359

* Included for comparison.

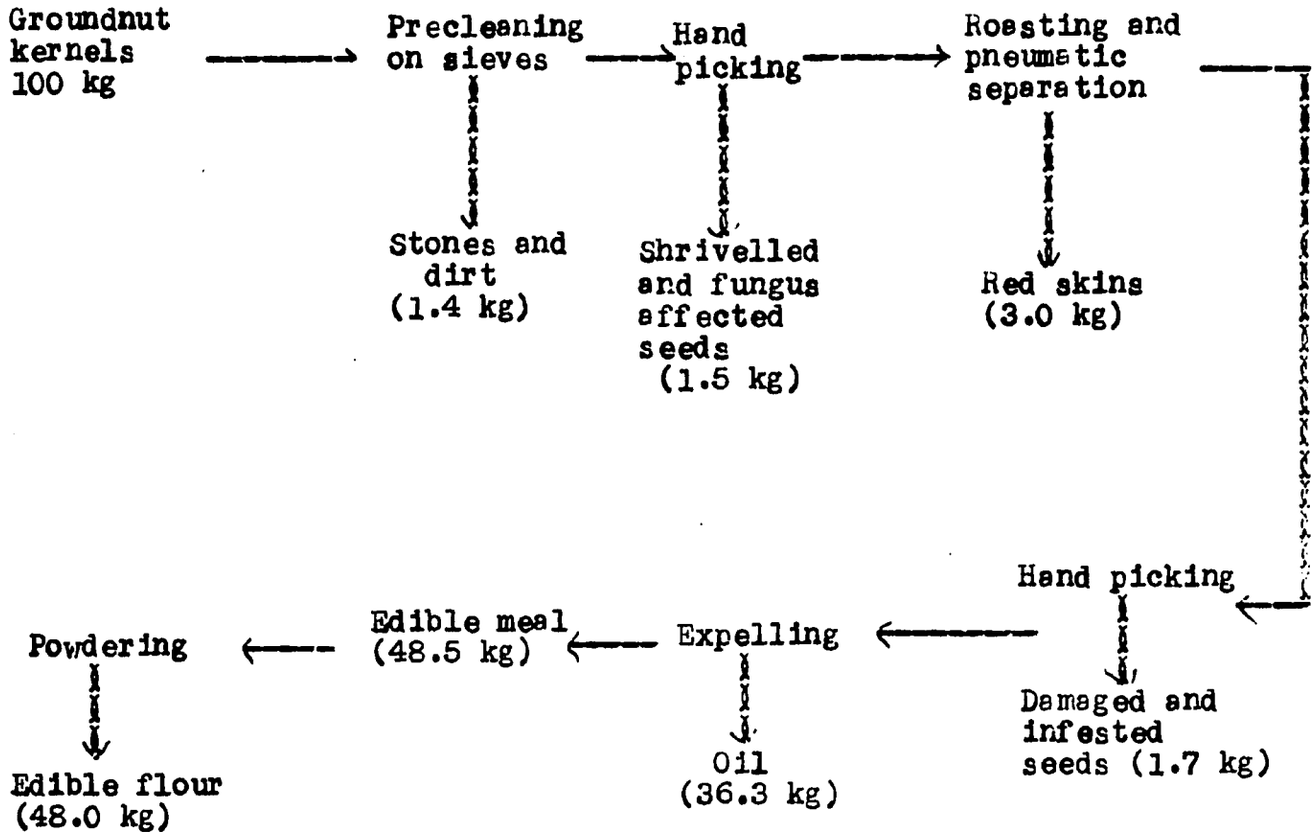
TABLE 7: Relative Cost and Protein Contents of Some Processed Protein Foods

Protein Food	Cost/kg		Protein g %	PER	PVCI*
	US $	Indian currency Rs.			
Groundnut four	0.14	1.00	50.0	1.6	57.0
Indian MPF	0.32	1.60	41.9	1.8	24.0
Milk	0.14	1.00	3.4	3.0	7.3
Skim Milk powder	1.10	8.25	35.0	2.8 to 3.2	10.0
Miltone	0.10	0.75	3.5	2.3	8.0
Infant Food	0.79	5.80	26.0	2.7	8.9
Weaning Food	0.41	3.00	17.0	2.3	8.0
Biscuits with MPF	0.41	3.00	17.0	2.1	8.0

$$* \quad PVCI = \frac{\text{Protein per 100 g}}{\text{Cost per 100 g in cents (US)}} \times PER$$

The higher the index, the higher would be the value of food as a source of protein per unit cost.

FIG. 1: Flow Sheet for the Production of Edible Groundnut Flour



AN EXPERIMENT ON THE ADMINISTRATION OF LYSINE TO SCHOOL CHILDREN

TADATAKA FUKUI

HISAKO FUKUI

TOSHIHIDE SASAKI

The authors reported sometimes in meetings of the Society and others that the development of children can be promoted by administration of an appropriate amount of lysine. But in these experiments previously reported the administration was continued for only 6 months at the longest. The authors after that had an opportunity to continue the administration over a period of one year, pbtaining interesting results which are dealt with in this paper.

1) Method

The experiment was carried out on the fifth-year boys and girls, 96 in total, of a primary school admitting mainly farmers' children in the vicinity of Tokushima City. Both sexes of children were divided into 4 groups, the control, Lysine-0.5, 1.0 and 1.5g, respectively. Attention was paid to the grouping in order to make these groups as equal as possible in the physique and family condition of the children.

The material used for administration was the L-Lysine in tablets donated by Ajinomoto Co., Inc. The Lysine (0.5g a dose) was administered one time a day, at the lunch time, in the group L-Lysine-0.5g, two times a day, at the beginning of class in the morning and at the lunch time, in L-Lysine-1.0g, and three times a day, at the beginning of class in the morning, at the lunch time and after the evening meal in L-Lysine-1.5g. The experiment was continued for one year from February in the fifth year to February in the 6 year. The development of children was examined on the height, body weight and grasping power of them every other month.

2) Results and Consideration

The development was more promoted in every Lysine group than in the control irrespective of sex as shown in Table 1 and Figs. 1 and 2.

In the boy, increases in body weight in both L-Lysine-1.0g and 1.5g, and in height in L-Lysine-1.5g were significantly larger, respectively, than in the control.

The increase in body weight and height of the boy was equal to or a little smaller than the mean throughout the country in the control, while it was larger than the control in every Lysine group.

In the girl, the difference in development between the Lysine and control groups was greater than in the boy. Especially, an increase in body weight in every Lysine group and that in height in L-Lysine-0.5g were significantly larger than in the control.

The development in the girl was also equal or a little inferior to the mean throughout the country in the control, but it was superior to the mean in every Lysine group.

The comparison between the Lysine group in total and the control showed that an increase in body weight of the boy and that in body weight and grasping power of the girl were significantly larger in the Lysine group than in the control.

The Lysine group is thus superior in development to the control irrespective of sex. However, the development in Lysine group was not always in proportion to the dose of Lysine administered. This discrepancy is considered as follows.

The amount of nutrients taken by the boy in Lysine groups is: nearly the same in all groups in calory, a little larger in the 1.0 and 1.5g groups in protein and nearly in proportion to the amount administered in Lysine. The ratio of Lysine to Tryptophan ingested is 6 or so in the Lysine groups which are superior in development.

And if the optimum L/T ratio is 6 in the development stage concerned, it is understood that shortage in the amount of Lysine is the inhibitory factor for development in the control and L-Lysine-0.5g groups, while shortage in Tryptophan in the inhibiting factor in L-Lysine-1.5g. The practical efficiency, calculated from the amount of Lysine and Tryptophan on the basis of the L/T ratio 6, is smaller in the control than in the others, and shows no difference between L-Lysine-1.0 and 1.5g groups. This result seems to indicate that the practical efficiency explains well the developmental condition in each group. In the girl, the inhibitory factor is Lysine in L-Lysine -0.5g, and Tryptophan in L-Lysine-1.5g. The comparatively good development in L-Lysine-0.5g, in which the administration was small in amount, appears to be due to a little larger practical efficiency of Lysine and Tryptophan than in the other groups resulting

from the intake of a comparatively larger amount of Tryptophan, protein and calory.

The fact that there was no difference in development between L-Lysine-1.0 and 1.5g may be explained by the nearly same practical efficiency in them. And the inferior development in the control, which took a comparatively larger amount of Tryptophan, is considered to be due to the smallest practical efficiency.

3) Conclusion

An experiment was carried out on the administration of L-Lysine to school children, mostly of farmers', of 11-12 years old over a period of one year, obtaining the result that the development in the administration group was superior not only in body weight but also in height of children to that in the control. In the control the intake of Lysine was small in amount and it was the inhibiting factor for development. It is considered that, in such a case, the administration of Lysine can increase the practical efficiency of Tryptophan and in the same way those of the other amino anid which have excesses in the balance of amino acids as Tryptophan, inducing increased synthesis of protein, accompanied by promotion of development.

Albanese reported that the optimum ratio of Lysine to Tryptophan is 6. This result was confirmed by the authors who carried out an experiment in the dietary life of our country, obtaining results which can be understood by supposing that the optimum L/T ration is 6.

We should like to thank President Dr. K. Kodama for his guidance and Ajinomoto Co., Inc. for their donation of material.

(Table 1)

Growth gain of children on Lysine supplemented diet

Group			Height			Weight			Grasping Power	
sex	personnel		initial	gain	rate of gain	initial	gain	rate of gain	initial	gain
			cm	cm	%	kg	kg	%	kg	kg
Girls	control	17	133.72	5.85	4.49	30.05	3.78	12.63	18.14	3.14
	L-Lysine 0.5g	9	133.01	*7.23	⊕5.45	28.54	**5.48	**19.33	17.50	*6.02
	L-Lysine 1.0g	7	140.57	6.34	4.53	34.93	*5.81	*16.58	19.86	4.75
	L-Lysine 1.5g	8	134.20	6.04	4.51	29.98	*5.02	*16.56	18.50	3.74
	L-Lysine total	24	135 61	6.58	4.87	30.88	**5.43	**17 60	18.52	*4.72
	average in primary in Japan (1956)		134.9	5.7	4.23	30.5	4.4	14.43		
Boys	control	24	132.72	4.74	3.57	28.50	2.88	10.07	20.48	3.45
	L-Lysine 0.5g	10	133.26	4.77	3.58	29.69	3.34	11.04	20.38	3.41
	L-Lysine 1.0g	11	134.32	5.17	3.83	29.55	*3.78	*12.78	19.50	4.63
	L-Lysine 1.5g	10	133.76	**5.94	**4.43	29.84	*3.56	⊕12.11	19.87	3.77
	L-Lysine total	31	133.80	*5.29	3.94	29.69	*3.57	*12.00	19.90	3.96
	average in primary in Japan (1956)		133.8	4.8	3.59	29.6	3.2	10.81		

remarks : ⊕ Significance as 10% level * as 5 % ** as 1 %

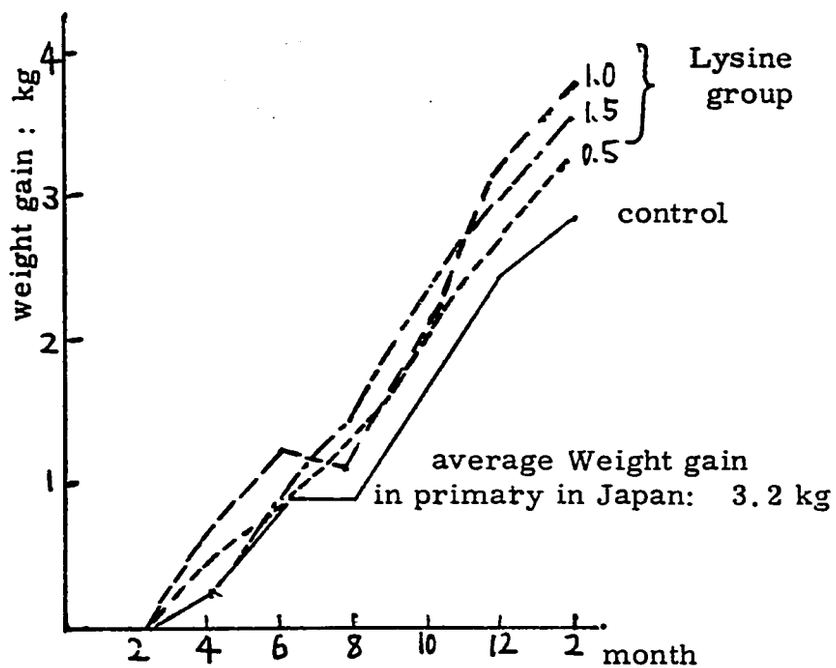
(Table 2)

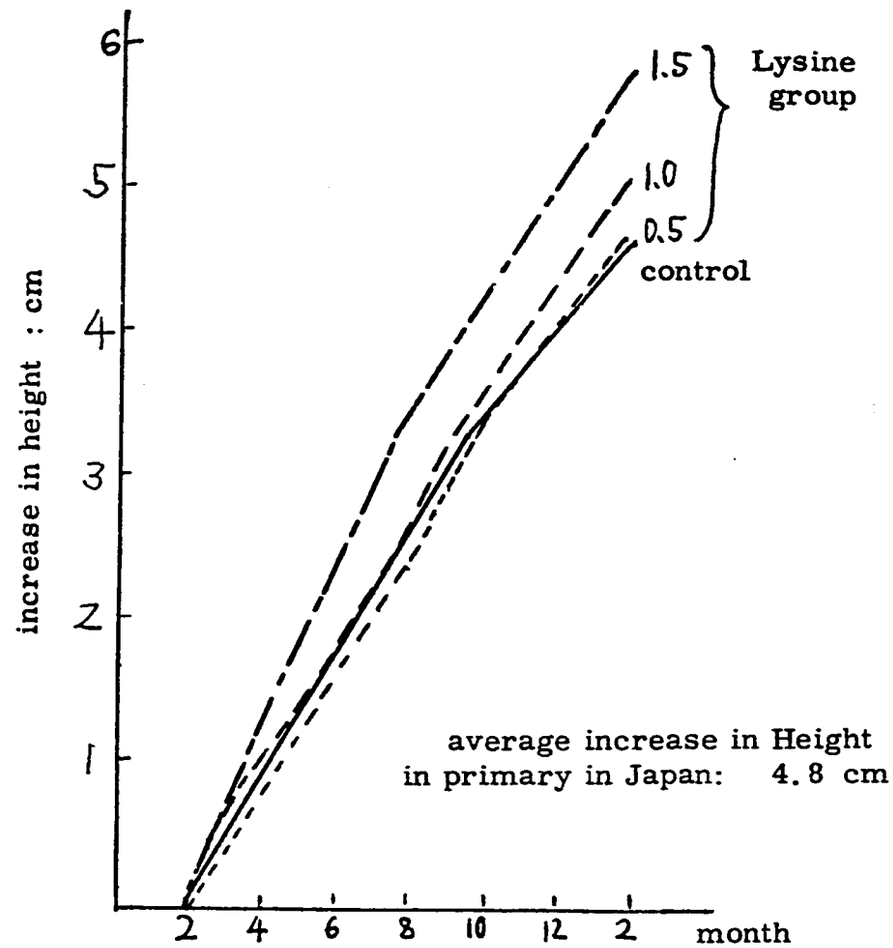
The amount of nutrients intake

		Boys					Girls				
		control	Lysine group				control	Lysine group			
the amount of L-Lysine supplement		0	0.5	1.0	1.5	0.5-1.5	0	0.5	1.0	1.5	0.5-1.5
Nutrients	Calorie Gal	2146	2013	2193	1947	2056	1979	2222	1950	1813	2006
	Protein g	69.4	66.6	73.6	74.6	71.7	65.4	75.5	61.2	62.4	67.0
	animal protein "	26.0	24.4	28.4	34.0	28.9	24.5	26.9	24.0	23.0	24.8
	L-Lysine "	4.03	4.49	5.27	5.76	5.17	3.79	4.79	4.58	5.05	4.82
	Tryptophan "	0.87	0.82	0.88	0.88	0.86	0.81	0.88	0.76	0.76	0.81
	L/T	4.63	5.48	5.99	6.55	6.01	4.68	5.44	6.03	6.64	5.95
Effective Value on L/T = 6											
L-Lysine g		4.03	4.49	5.27	5.28	5.16	3.79	4.79	4.56	4.56	4.82
Tryptophan g		0.67	0.75	0.88	0.88	0.86	0.63	0.80	0.76	0.76	0.80

(Fig 1)

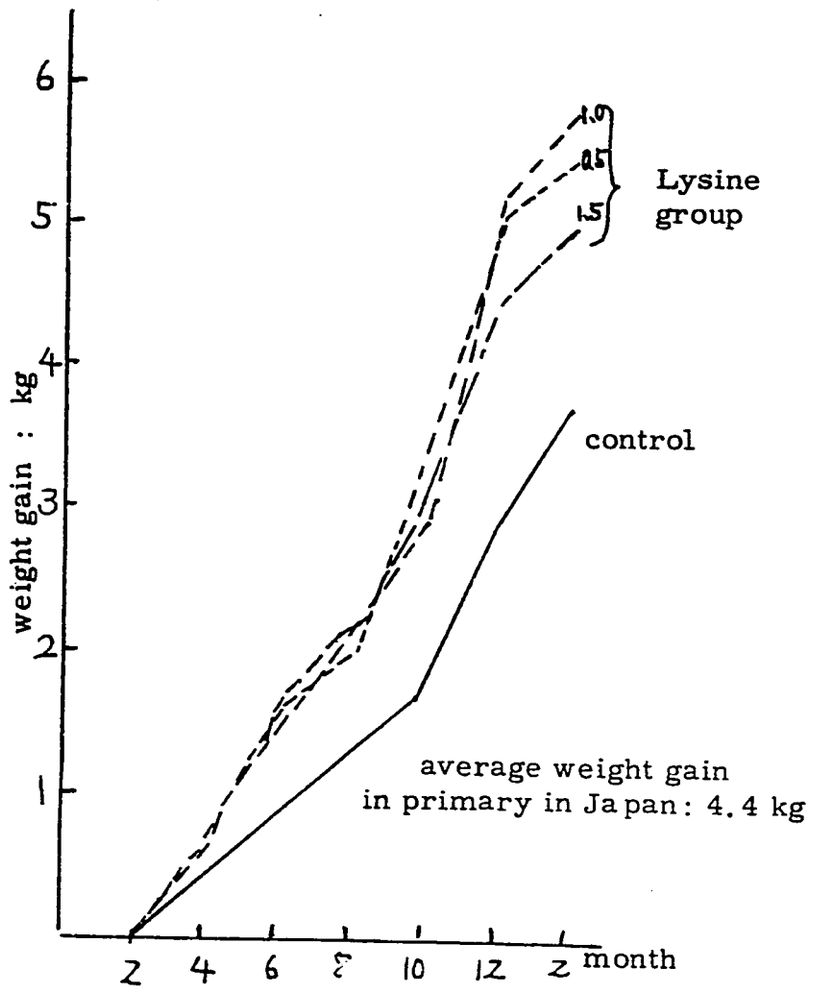
Weight gain and increase in Height of School boys aged 10 years old

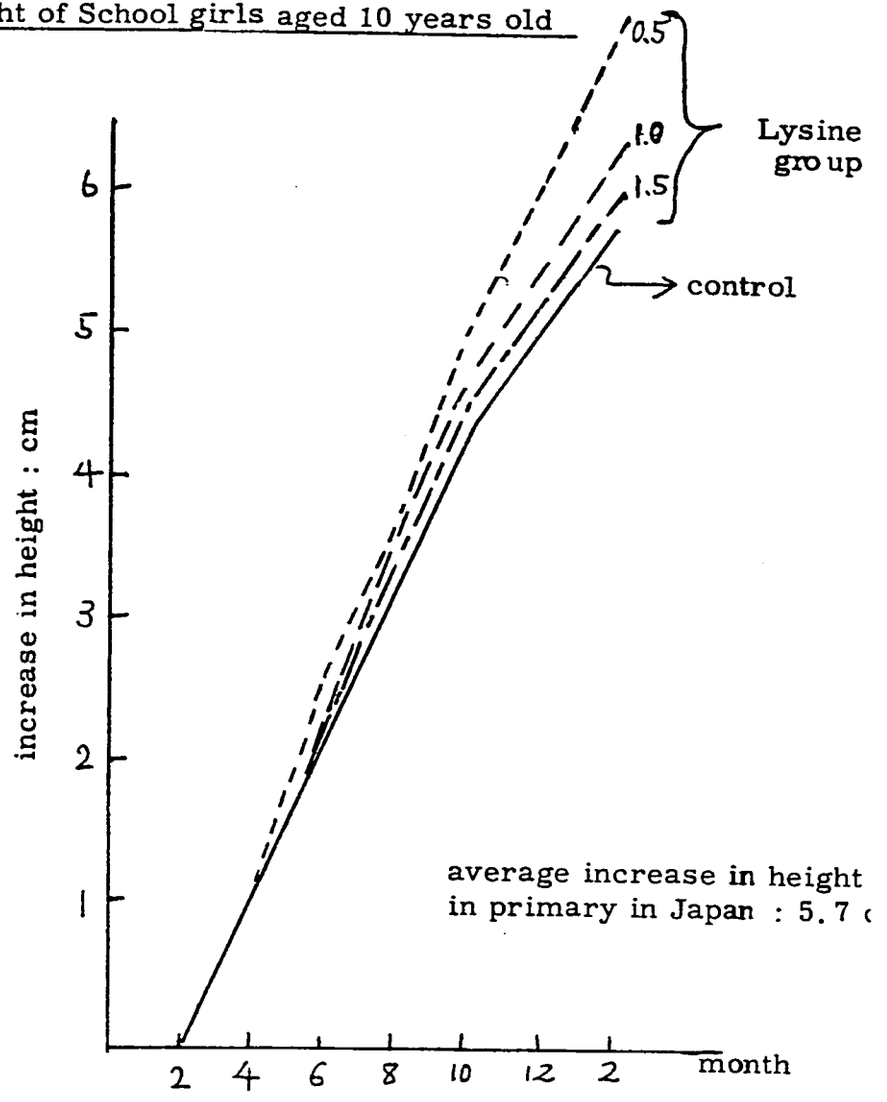




(Fig 2)

Weight gain and increase in Height of School girls aged 10 years old





Lysine Fortification of Intact Rice Grain

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The major source of calories and protein in the world for human nutrition is the cereals, and so it is in Asian countries. Rice constitutes the primary cereal in these countries. A national nutrition survey conducted in 1967 by the Japanese government revealed that rice provided about half of total caloric and about one-third of protein and vitamin B_1 intakes. One can imagine from these figures how rice grain plays an important role for the nutrition of Japanese peoples. Dependence on rice grain as major nutrient source would be much more in other Asian countries. Among the nutrients which are often found deficient in the diets of rice-eating peoples, vitamin B_1 and lysine are two of the most significant. This is a reflection of a nutritional inadequacy of their staple food, rice; vitamin B_1 and lysine content of rice grain as consumed by these peoples are too low to satisfy the nutritional requirements. There are two persistent opinions for the nutritional improvement of rice-eating peoples. One is to persuade the peoples to select subsidary dishes of high vitamin B_1 and lysine contents. Another is to dose peoples with the pills of vitamin B_1 and lysine. Peoples however can not comply with these impractical and atroucious opinions. In this paper, the author wishes to describe about the method of lysine fortification of intact rice grain, which is based on the acid-soaking method, and the nutritional impact brought about by lysine fortification.

Acid-Soaking Method

The acid-soaking method, which principle is based on the phenomenon of solute inclusion of or penetration into the rice grain, was developed by the author as an extention of acid-parboiling process employed for vitamin B_1 fortification. It would be thus worthwhile to make note on vitamin B_1 enrichment in Japan. Since 1885 when Takaki provide the first experimental evidence for the beriberi, a serious condition of athiaminosis, as a rice-originated malnutrition, there had been many approaches to improve the nutritional quality of rice grain; discovery of antiberiberi factor in rice bran leading to the discovery of vitamin B_1 and the invention of vitamin B_1 enriched rice. Nutritional improvement of rice kernel was started with practicing under-polished or germ-retaining rice, since it was well known that polishing causes a significant decrease in rice kernel. Under- or half-polished rice had actually been rationed in Japan as staple food, although it was discontinued soon due to a low palatability and a short storage life. Before the cost of synthetic vitamin B_1 declined to food additive levels, major efforts were made to increase the vitamin content of white rice by processing rough or brown rice prior to milling in a manner so as to cause transfer of the vitamins from germ and bran to the edible endosperm portion.

Acid-parboiling of brown rice is known as a unique process for increasing vitamin B_1 content in the endosperm. One of the serious limitations to this method is however that a limited amount of the vitamin is availabled even from whole grain. In order to employ synthetic vitamin B_1 as vitamin source, the acid-soaking method was developed by the author as an extention of the acid-parboiling process. The acid-soaking method consists relatively simple steps; either brown or polished rice is soaked in a 1% acetic acid solution containing enrichment ingredients such as synthetic vitamins, minerals,

and amino acids for a period of 12 to 24 hr, after draining off the solution, the wet kernels are steamed briefly to convert the surface starch into α-form, and the steamed grain is then dried to a moisture content of 12 to 13%, by adjusting the concentration of enrichment ingredients in the soaking medium and the duration of the soaking period, one can produce enriched rice of varied enrichment content as desired.

"Enriched rice" containing vitamin B_1 concentrations of 120 to 150 mg.%, produced by the acid-soaking method, has been on the Japanese market since the beginning of 1951. The acid-soaking method is different in principle from the coating method developed by Kik and Williams. The "enriched rice" kernel contains the ingredients within the kernel and has a rinse-resistant layer made of α-starch at the surface of the kernel, whereas "premix rice" is produced by spraying the ingredients on the surface of the kernel and then forming a rinse-resistant coat made of zein, a maize protein. The enriched rice available in today's Japanese market is almost exclusively the product of the acid-soaking method. Figure 1 shows a flow sheet for the manufacture of enriched rice.
The enriched kernel does not reduce the palatability of white rice, but rather, in a sense, improves it. Storage life of the enriched rice is adequately long; it is resistant to rice weevil spoilage which develops extremely easily during the storage of half-polished rice.

Rice is invariably washed with water before cooking to remove fine bran fractions which adhere to the surface of the kernel, and other contaminations which occur in storage handling and transit. The α-starch layer formed by the steaming process seals the enrichment ingredients within the kernel and thus prevents their loss in washing. Loss in vitamin B_1 content of the enriched kernel in cooking and in

washing/cooking is found to be around 7 and 12% respectively.

Enrichment with Lysine

Rice is generally acknowledged to be among the best of the cereals in terms of nutritive quality of its protein. It is theoretically and experimentally well known, however, that the protein quality of rice can be further improved by supplementation with lysine. Rice kernel enriched with lysine by means of a premix formula has been commercialized quite recently. This is due to the technical difficulty of applying relatively large amounts of this ingredient of the grain.

The soaking method developed for the production of vitamin-enriched rice can be effectively employed for this purpose. By employing a 1% acetic acid solution saturated with lysine as soaking medium, one can produce kernels enriched with lysine up to 66 mg. per g. of kernel. The steaming process is also effective in preventing loss of lysine in washing. Threonine, a second limiting amino acid in rice for human nutrition, can be introduced together with lysine by the soaking method. The product obtained after processing the kernel first in lysine solution and then in a solution of water-insoluble vitamin B_1 derivatives is found significantly resistant to washing. The technique for enrichment by this double-soaking method, which is outlined in Fig. 2, is quite feasible for fortifying staple food with both vitamin B_1 and lysine. Its appearance is close to that of ordinary white rice; neither cracking nor discoloration is detectable. Besides improving the nutritional quality of rice protein, lysine fortification produces a positive effect on the palatability of boiled rice; lysine added before cooking subdues, possibly by

trapping the volatile carbonyls, the strength of stale flavor which becomes distinct with the storage of rice grain for longer period.

It is figured out that a blending ratio of 1 to 100 of the enriched kernels containing 60 mg. per g. of lysine with ordinary white rice provides an optimum nutritional effect for Japanese people.

Some approaches have been made to provide premix granules which simulate rice kernels. To make such granules, a dough consisting of wheat flour as binder, rice flour, and the enrichment ingredients are either extruded through a macaroni press of passed through a noodle-making machine. Loss of the ingredients in washing/cooking are unfortunately too high to put them to practical use and, to make the matter worse, they spoil the palatability of boiled rice.

Nutritional Improvement Brought by Lysine-Enriched Rice

Benefits from use of lysine as a means of improving protein quality of Japanese diets have been demonstrated in various experiments. Data obtained by providing lysine tablets together with bread at the time of the school lunch indicated that Growth rate of children is significantly improved by administering even 0.5 g. of L-lysine per day. On the basis of these and other results, the Essential Amino Acid Research Committee of Japan initiated a lysine survey of feasible ways for enrichment of foods and to assess their practical nutritional effects. Feeding tests were continued from 1964 to 1966 with a total of 3,000 pupils in elementary schools by providing bread enriched with

lysine in the school lunch. Physical conditions of test groups, become, in general, better than those of control groups; increases in body height and weight were significant with test groups in rural areas.

In last april, the author had a chance to survey the actual nutritional conditions of the children in a village that locates in the mountain district further north-west from Chain Mai near to the Burmese border of Thailand. To say nothing of a specific rural area in so-called developing countries, there are many who suffer from malnutrition even on the corners of the street, in so-called developed countries. Shortage of food is bringing about, in a sence, food originated malnutrition in the world. One of the most feasible strategies for supplying protein for human nutrition, is to increase the amount of protein in the conventional foods by improving its nutritional quality. And the lysine "enriched rice" of premix formula, of high palatability, and in the form of conventional intact grain, is highly acceptable for rice-eating peoples as a means of improving their protein nutrition.

There are many developments in techniques for preparing enriched foods and processing them with minimum loss of enrichment ingredients. There are also several approaches to increasing the protein quantity and quality of cereal foods by means of protein isolated from single-cell materials. Recently some success was achieved in breeding of a high-protein mutant originating from domestic varieties of rice. If the palatability of the polished grain is high enough to be accepted by the majority of people, protein nutrition of rice-eating people may thus be improved to a certain extent.

Morphological evidence has been obtained indicating a particulate nature of protein in rice grains. This may provide a sound basis for developing new techniques in rice polishing and in by-product utilization.

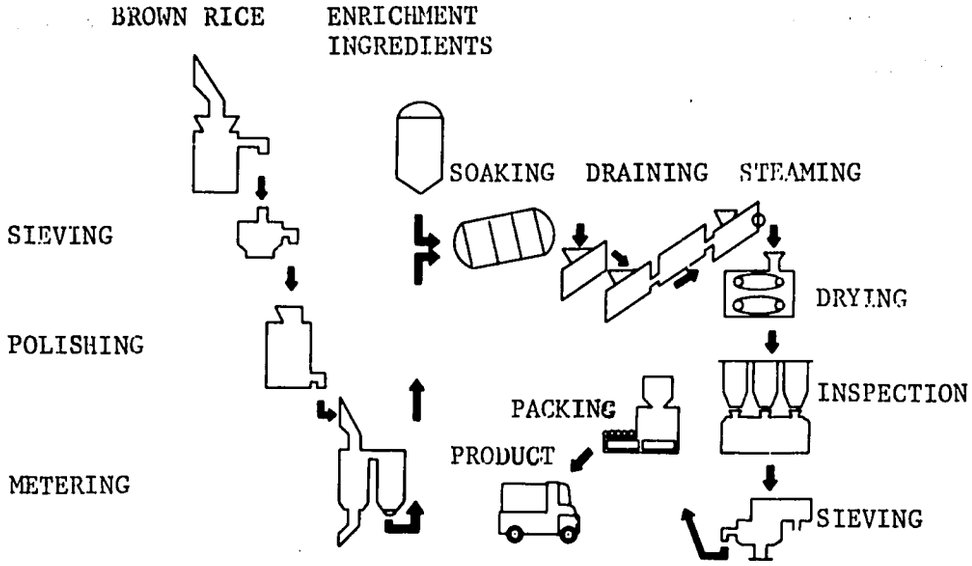


Fig. 1. Flow sheet for the manufacture of "enriched rice."

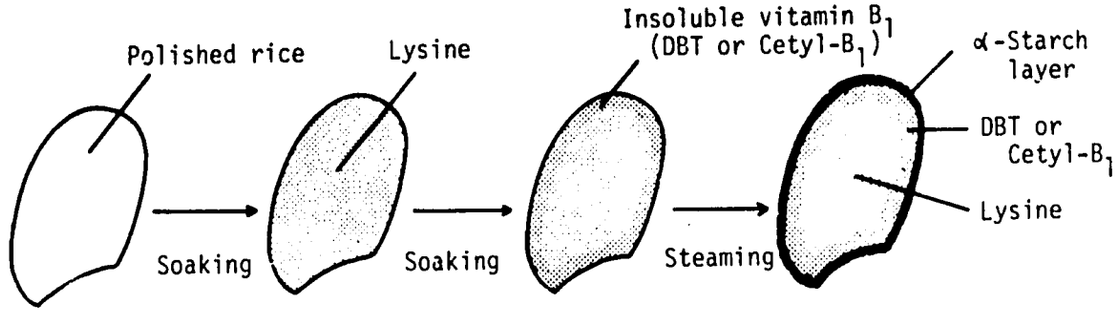


Fig. 2. Production of lysine- and vitamin B_1-enriched rice by double-soaking method.

Rice Fortification Granule (RFG)

RFG is an agent which has been developed to be used mixed with natural rice for the purpose of increasing the protein efficiency ratio in the latter. The natural rice is about 8 - 10 % in protein content. But its protein is low in the efficiency ratio, because the protein has a wrong pattern of constituting amino acids, and is especially low in the L-Lysine and L-Threonine contents. These are the '' Essential Amino Acids '' which can not be synthesized in the human body. There are several methods to evaluate the quality of protein and a popular criterion for it is the Protein Efficiency Ratio (PER) obtained by the experiment in the rat. This is a value expressed by the ratio of an increase in body weight during 28 days after weanling of the animal to an amount of the protein taken by it during the same period. The PER value in casein, which is the protein contained in cow's milk and considered to be one of the best protein, is 2.5. Consequently, it may safely be said that a target of the improvement in to increase PER to the level of 2.5 .

The value of PER in rice is 1.5 or so, though it is somewhat variable according to the variety of rice. The protein efficiency ratio in rice, thus, represents only about 60 % of the ratio in casein, But it has been proved that the protein of rice can be improved in quality to the level of casein if amino acids in want are added to it (0.27 % of L-Lysine and 0.17 % of L-Threonine).

This means that the protein of rice can be utilized most effectively if 1g of RFG is added to 100g of rice, a supposed amount, taken at one meal (RFG contains 20 % L-Lysine and 10 % L-Threonine, and 1g of it provides an appropriate amount of these amino acids for fortification). Supposing that rice contains 80 % protein, the amount of protein changed into the blood or muscle is only $8(g) \times \frac{1.5}{2.5} \times 0.7 = 3.36(g)$ (where, the amount was multiplied by 0.7 on the assumption that the digestibility of rice protein is the same as that of casein). If the rice is enriched with

1g of RFG, the amount of effective protein is increased to $8(g) \times 0.7 = 5.6(g)$, that is, $5.6 - 3.36 = 2.24(g)$ of effective protein is additionally produced in the body. And to take the same amount of protein from meat, it is necessary to eat $2.24(g) \times \frac{100}{20} \times \frac{1}{0.7} = 16(g)$ of meat with bread.

Therefore, 1g of RFG is equivalent to 16g of meat, and addition of RFG to rice will be understood to be very economic even if the price of RFG is $3.00 / kg. If ordinary rice is compared to less effective low-octane gasoline, addition of RFG to rice is supply of superior high-octane gasoline to an engine.

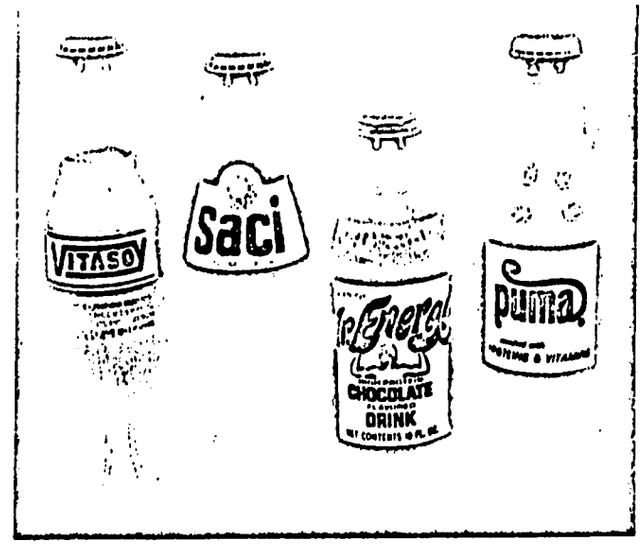
Mixing in advance of RFG with milled rice can save the trouble of weighing the additive at every cooking time, and will help effective use of RFG, because the rice fortified in advance with this product does not lose the amino acids added in washing with and soaking in water.

The rice fortified with RFG dose not show any change from natural one in smell, taste and resistance in the teeth after cooking.

Description

Name of product:	RFG (Rice Fortification Granule)
Component:	L-Lysine 0.2g L-Threonine 0.1g per 1g of RFG (Main component of the granulating agent is cornstarch).
Property:	This product mixed with ordinary (1 % in weight) increases markedly the protein efficiency ratio (as mentioned above). This product does not lose the components in washing with and soaking in water (the loss is less than 5 %), and can be finished mixed with natural rice into cooked rice without any change in acceptability of the rice.

by Daniel Rosenfield, Ph.D.,
and Fredrick J. Stare, M.D.



The short-term solution to protein malnutrition

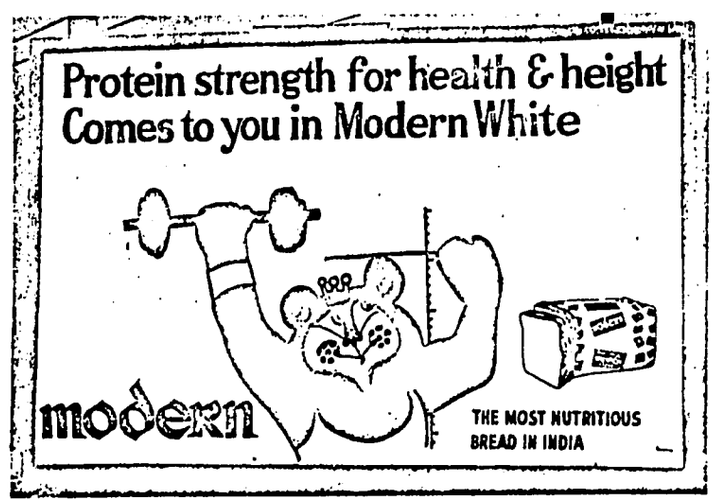
Agricultural development is the long-range goal. Today, however, attractive and inexpensive protein cereals, soft-drink beverages and textured foods are available or under research to alleviate nutritional shortages of the world.

THE POSSIBILITY OF WIDESPREAD FAMINE in the near future of some countries has been postponed, as evidenced by increases in agricultural production wherever science and technology have been applied to traditional agriculture. When adequate supplies of water, fertilizer, pesticides and modern equipment are coupled with the new high-yield varieties, agricultural production can be doubled and even tripled. But it is not realistic to expect that the potential increase in food supplies will be readily achieved.

Mankind has not yet solved his food problem.

For example, the lack of available irrigated land is a constraint

Dr. Rosenfield is Deputy Director, High Protein Foods and Agribusiness Group, U.S. Department of Agriculture, and Dr. Stare is professor of nutrition and chairman of the department of nutrition, Harvard School of Public Health.



Protein-rich beverages, top of page, are proving competitive to soft drinks in popularity. India's Modern Bread, immediately above, advertised on billboard, is fortified with lysine, vitamins and minerals. Left, Duryea, a baby food prepared from precooked high lysine corn, is fortified with soy flour and skim milk powder.

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to the spread of the high-yield varieties. As large financial outlays are needed to construct irrigation facilities, where are poor countries going to get the necessary capital? Financial resources are also needed for pesticides and fertilizer. A potential technological stumbling block is the change in texture, flavor and handling characteristics of the new varieties. The improved high-yielding rice varieties taste different; the high-lysine corn varieties crumble easily and this requires changes in milling and home preparation.

Agricultural progress will occur only at the speed at which the whole process of economic development takes place. There were limited economic advances by developing countries during the 1960's, the so-called Decade of Development; there is little reason to expect sudden dramatic economic progress during the next decade. Therefore, the rate of application of science and technology to pre-harvest agriculture, with subsequent improvement in the nutritional status of the majority of poor people in less-developed countries, will be slow. Hence pre-harvest agricultural solutions to malnutrition, which includes hunger, will be long term.

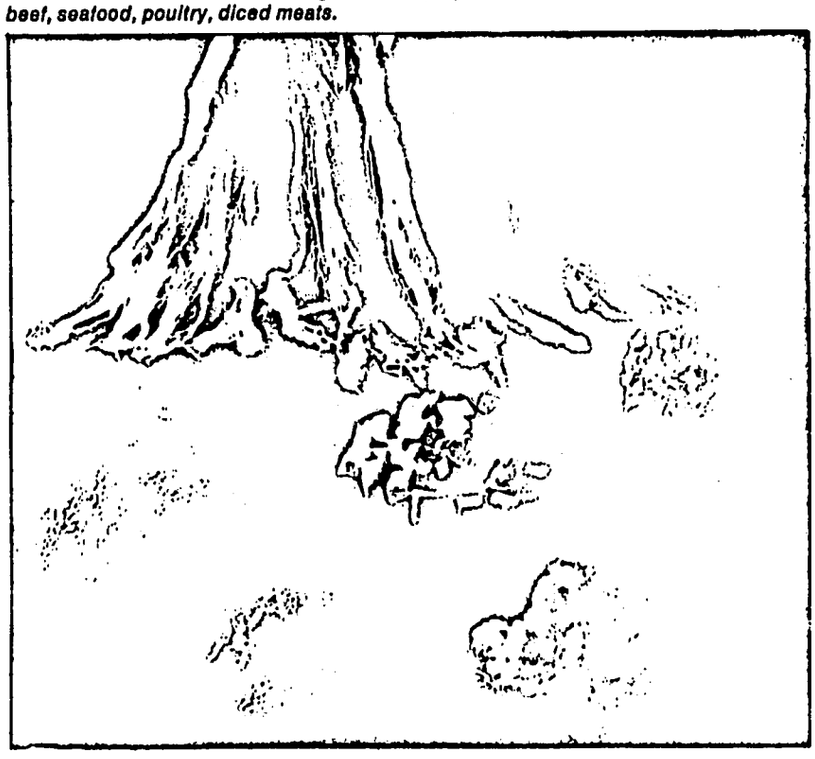
Fortunately, the use of modern science and technology in post-harvest agriculture (food processing, fortification, packaging and storage) is increasing. Here we believe are the short-term approaches and solutions to alleviating malnutrition.

Types of malnutrition

Before discussing some of the specific technical developments being used, we would like to discuss what is malnutrition and what is its prevalence today. The answers to these questions depend on the definition of malnutrition. With some 50 different nutrients in foods and water there can be very many different types of malnutrition.

Malnutrition is generally defined

Spun soy protein *fibers, top, form the base for new textured proteins of varying shapes and sizes. Products from Worthington Foods, a pioneer in the field, resemble ground beef, seafood, poultry, diced meats.*



as some measurable degree of ill health due to inadequate nutrition that can be prevented or cured by improved nutrition. With such a broad definition, malnutrition is widely prevalent in all areas of the world and includes starvation (marasmus) or severe lack of calories, protein deficiency, combinations of caloric-protein malnutrition, iodine-deficient goiter, tooth decay and osteoporosis from lack of adequate amounts of fluoride, obesity from an intake of too many calories in relation to those expended in physical activity, coronary and cerebral atherosclerosis when related in part to excessive quantities of saturated fats and cholesterol in the diet, hypertension when due in part to excessive intakes of sodium, anemias due to lack of iron, folic acid and vitamin B_{12}, and the classical vitamin deficiencies of scurvy, beriberi, pellagra, xerophthalmia and rickets which still exist, occasionally with high prevalence, in various parts of the world. Thus, malnutrition is a dominant factor in the health of mankind all over the world and among all social classes.

Research worker *adds flavoring to textured soy protein at Swift & Co. laboratory. Flavoring is one phase of company's development of new uses for its product, Texgran, which it makes in many varieties exclusively for the food-processing industry.*

Poverty-caused

The malnutrition to which we have devoted much professional attention is caused by poverty. In general, poor people have little choice but to consume a few food staples with monotonous regularity day after day.

One measurement of malnutrition due to poverty is the lack of variety of foods found on the kitchen table. A rough correlation can be obtained among income, lack of variety of foods, and malnutrition. As money available to a poor family anywhere in the world increases, variety of foods consumed increases and malnutrition decreases. Poverty-caused malnutrition may appear and disappear depending upon changing financial situations. It may also be seasonal due to changing prices of foods.

While there are many types of malnutrition caused by poverty, protein malnutrition, frequently accompanied by varying degrees of caloric malnutrition, is certainly one of the most prevalent and critical types of malnutrition.

Protein malnutrition

Protein deprivation can manifest itself in a variety of ways which frequently are not apparent in the early or mild (sub-clinical) stages. The situation is somewhat analogous to heart disease. Previously one had to have a heart attack to know one was suffering from heart deterioration. Now, blood analysis for cholesterol, measurements of blood pressure and various exercise tests serve as useful early indicators of potential heart trouble, particularly when in the presence of other findings such as cigarette smoking and overweight.

What is needed in the protein area are various indicators, including biochemical measurements for the early detection of protein malnutrition, that is, before it is visually recognized and the individual is suffering from associated illnesses. This is particularly important for adults. Were such a tool available, the endemic character of protein malnutrition would be more widely recognized.

The biochemical indicators such as total serum protein and albumin

levels in use today generally require rather marked changes in protein nutrition before they show measurable differences and thus they are of limited value.

In summary, protein deprivation has been obscured both by lack of an early warning system, and the presence of associated diseases at advanced stages of protein malnutrition. Within the past few years protein malnutrition is being recognized as a problem for people other than infants and special groups such as pregnant and lactating women.

Innovative approaches

The conventional approach to combating protein shortages is to increase the production of both cereal grains and animals. This conventional approach, while it should not be ignored, is closely tied to economic development and as such is long-term solution. What we will discuss are alternate innovative approaches which can have an immediate beneficial effect on the protein nutrition of large numbers of poor people. These approaches must of necessity not require large capital investments if they are to have a current impact. In short, they are inexpensive solutions which can and are being used now. Two of the most important solutions which will be discussed are development of new protein foods and fortification.

New protein foods

The processed food industry has begun to assume its logical role in the worldwide attack on protein malnutrition by designing and marketing inexpensive, esthetically attractive protein foods. They may be divided into the following classes:

- blended foods (usually cereal mixtures)
- beverages
- textured foods

Blended foods are designed primarily with nutritional needs in mind. The technology and degree of processing which goes into their preparation are usually less than that found in other protein foods. A major attribute is their low cost. Probably the best known of the blended foods is a cereal mixture known as Incaparina. This is a blend of corn and cotton seed protein fortified with 0.1% lysine to increase its biologically usable protein and to which a small amount of yeast and various vitamins and minerals are added. This was developed by the Institute of Nutrition of Central America and Panama.

Another representative of a blended food is CSM which is prepared from 70% gelatinized corn, 25% soybean and 5% non-fat dry milk. This is technically not a cereal mixture because of the 5% milk solids. Over one billion pounds of this product containing 20% protein has been distributed around the world under the U. S. Food For Peace Program.

Cereal mixtures in the United States have also been developed particularly in prepared breakfast cereals.

New protein beverages have great potential for popular acceptance as beverages appeal to all segments of a society. Protein beverages may be divided into two groups: milk-types or extended milks and those that resemble soft drinks. The technology for their preparation is similar. Method of marketing to the consumer is usually the major difference. There is special interest in extending milk supplies via addition of protein concentrates. For example, emphasis is being given in India to extending ("toning") high-fat buffalo milk with non-fat dry milk or other protein concentrates from sources such as peanuts, soy or cottonseed. The acceptance of milk-types and extended milks is dependent, in part, on the advances in developing the technology for preparing stable suspensions of protein and fat and the addition of appropriate flavors.

Soft-drink protein beverages vary in nutrition, appearance and flavor. To be commercially successful in the soft-drink market they must also give refreshment to the consumer. Their nutritional contributions may be secondary from standpoint of purchase.

Vitasoy which has been successfully marketed in Hong Kong for a few years is one example of this kind of beverage. It contains about 3% soybean protein, 20% of its calories are from protein and in Hong Kong it costs 3.5 U.S. cents per bottle. Another example is Puma which has exceeded all market expectations since its introduction by the Monsanto Co. in Guyana. Current plans call for the introduction of Puma, which is patterned after the Vitasoy model, into other countries.

The Coca-Cola Co. is testing a caramel flavored protein beverage in Brazil. It is called Saci. It also contains 3% protein.

Changes foreseen

We expect a number of carbonated protein beverages to be market-tested in the near future. P. Ballantine & Sons is currently testing a prototype product in the United States.

The protein beverages are currently selling at the same price as competitive soft drinks. When they replace regular soft drinks in the diet, the added nutrition is at no extra cost.

One way to increase the use of new protein foods is to build texture into food powders. For example, the wide use of wheat is due to its ability to be made into the textured products such as bread and noodles. Wheat flour as such is not consumed. Under development are new textured protein foods from low-cost sources such as oilseeds, fish and bacterial protein grown on petroleum or other hydrocarbon substrates. U.S. companies active in developing and marketing textured foods include General Mills, Swift, Archer-Daniels-Midland, H. B. Taylor, Worth-

ington Foods and Ralston-Purina.

The major texture technology lies in products prepared from soybeans. However, the technical principles are similar for proteins from other oilseeds such as peanuts or cottonseed, or protein from fish or bacteria. The availability and use of these materials will evolve to meet special economic and nutritional situations. For example, it can be expected that bacterial proteins will partially substitute for other materials such as soybeans in animal feeds; in turn, soybeans and fish protein concentrates will be used, in part, in human foods in addition to animal feeds. In general, there will be a gradual shifting in the use of oilseeds and fish from animal feed to human food as the needs for lower-cost protein in foods increase and as the technological problems are solved.

Fortification may be defined as the addition of nutrients to a food to nutritionally upgrade the product, generally at a level appreciably higher than found in the food in its natural state. The added nutrients may or may not have been present to any significant degree in the naturally occurring product. An example of the former is the addition of iodide to salt; addition of vitamin D to milk or vitamin A to margarine are examples of the latter. If originally present and lost during processing a nutrient may be added back to its approximate original level or to slightly higher levels. The former is usually referred to as restoration and the latter as enrichment. Thus we have "restored" cereals and "enriched" flour. "Fortified" products, as mentioned earlier, are those in which the nutrient supplements are added in an amount appreciably higher than in the natural food.

In the context of protein nutrition, fortification generally refers to the addition of amino acids and/or protein concentrates to food staples such as the cereals. Fortification with protein concentrates prepared from sources such as milk and oilseeds increases both total protein content as measured by chemical analysis and biologically usable protein. Fortification with amino acids such as lysine also increases the biologically usable protein but does not change the total protein content. From a nutritional viewpoint, the major consideration is the level of usable protein. The accompanying tables illustrate the effects of fortification with amino acids and some protein concentrates.

The percent usable protein from Hegsted's data, and net protein value from Jansen's table, are comparable ways to measure protein which is available for physiological purposes. Note that added lysine in both instances did not change the protein content, but did increase the biological value as shown by increases in NPV and PRE. While there is a divergence in the biologically usable protein for unfortified wheat (3.2% from Hegsted, 7.3% from Jansen), there is good agreement on the increment of usable

TABLE 1

Protein value of supplemented bread[1]

Supplement to Water Bread	PRE[2]	% Protein in Bread, Dryweight	Net Protein Value[3]
None	49	15	7.3
4% nonfat dry milk	53	16	8.5
4.1% toasted soy	53	17	9.0
10% nonfat dry milk	62	17	10.0
0.3% L-lysine monohydrochloride	62	15	10.0

1. Data from G. R. Jansen (1969) Amer. J. Clin. Nutr. 22, 38-43.
2. PRE—Protein Retention Efficiency which is a measure of biological value (so-called protein quality).
3. Net Protein value = PRE . % Protein/100.

TABLE 2

Supplement effects of amino acids and protein concentrates on cereal protein[1]

Products	% Protein Content	% RNV[2]	Usable Protein[3]
White flour	13.75	24±1.5	3.2
White flour + 0.2 L-lysine HCl	13.94	38±1.7	5.3
White flour + 5% fish flour	16.66	42±1.1	7.0
White bread (92.2%) + skim milk powder (8.1%)	16.80	41±1.4	6.9

1. Data from D. M. Hegsted in "Protein Enriched Cereal Foods for World Needs," published by the American Association of Cereal Chemists, Minneapolis 1969.
2. RNV—Relative Nutritive Value which is a measure of a biological value.
3. Usable Protein = Protein Content .RNV/100.

protein achieved by fortification with lysine. Jansen shows an increase to 10 grams NPV from 7.3 when 0.3 gram lysine is added to water bread. This is an increment of 0.97 grams NPV per gram of lysine. Hegsted shows an increase to 5.3 grams usable protein from 3.2 when 0.2 gram lysine is added to white wheat flour. This is an increment increase of 1.05 grams of usable protein per gram of lysine.

By far the largest immediate possibility for improving protein nutrition lies in the fortification of cereals and cereal products with protein concentrates and/or amino acids. Cereals probably supply sufficient protein for healthy adults when consumed in large quantities. When fortified with the essential amino acids they are low in, the extra available protein can extend their effectiveness to most of the population. This extra protein can be the difference between well-being and illness to those on the border line of adequate protein nutrition. This holds true for adults as well as infants.

On page 50 are some examples of development in which cereals fortified with amino acids and/or a protein concentrate are either made available or being evaluated.

Complete foods

The examples are just a part of what is being done to increase the protein impact of the major source of the world's protein supplies — the cereals. The rationale for these efforts is that cereals can be made into complete foods by adding most of the needed minerals and vitamins and fortified with amino acids and protein concentrates to a level such that 10% of their calories are from usable protein. Costs will vary depending on types and amounts of added nutrients. It can be calculated that fortification is the least expensive method for adding protein to the diet. For example, we have calculated the expense of adding protein to the diets from milk products and wheat fortified with lysine. One gram of protein from non-fat dry milk and one gram from fluid milk costs 10 and 24 times as much as the cost of one gram of additional usable protein in lysine-fortified wheat.

In summary, fortification of wheat, rice and corn which are already being widely consumed can have immediate beneficial effect on large numbers of people.

In the course of a nation's history, as its income increases, so does its consumption of animal products. Current consumption levels of animal products are outstandingly low in underdeveloped countries. Even increases of two to five times current animal supplies would have negligible impact in satisfying protein needs in most such countries. And to achieve these increases, exceptional progress in economic and technical development would have to be made. It may be concluded that animal resources cannot have any short term impact in alleviating poverty-caused protein deficiencies.

Also, so-called "green" or "agricultural" revolution cannot have significant beneficial effects for the short term. A total agricultural and economic progress of a developed agrarian society, together with large capital investments, must be built up in the less developed world. This will take time as anyone active in economic development would attest.

Fortunately, the raw material supplies, be they cereals, legumes, oilseeds, fish protein concentrate or synthetic amino acids, are available today for alleviating protein and much caloric deprivation. The technology for their use is also available or being actively developed. But a great deal of creative nerve in production development and marketing is needed to transform protein resources into products which people will accept and buy. We are witnessing some of this today, more will be required to win the battle for better nutrition throughout the world. ◄

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Cereal fortification projects around the world

WHEAT

1. Over 30% of the bread in Japanese school lunch programs is fortified with the addition of lysine.
2. Modern Bread in India, baked in government-controlled bakeries in India's major cities and reaching a production goal of 100 million loaves annually, is fortified with lysine, vitamins and minerals.
3. Pillsbury Co. is market testing at the retail level five-pound bags of flour containing double the amounts of vitamins and minerals normally used in enriching wheat flour and with 0.3% lysine.
4. Macaroni fortified with skim milk powder or soy flour will be added to foods in the family food distribution program of the U. S. Dept. of Agriculture.
5. The U. S. government has announced the purchase of 4 million pounds of lysine-fortified bulgur for emergency shipment to Nigeria under the Food For Peace Act.
6. Dr. George Graham, professor of pediatrics at the Johns Hopkins School of Medicine and Director of the British American Hospital in Lima, Peru, and his associates have reported increased rates of weight gain and nitrogen retention, stability of serum albumin, and elevation of the molar ratio of plasma lysine when wheat flour fortified with 0.12% was fed as the sole source of protein in the diets of rapidly growing children.
7. Dr. Sheila Pereira, professor of pediatrics at the Christian Medical College and Hospital in Vellore, South India, and her colleagues found that preschool children in an orphanage showed a statistically significant increase in height when fed wheat fortified with lysine at the 0.25% level. This fortified wheat provided 54% of daily calories and 85% of the daily protein.
8. In Tunisia, the Tunisian National Institute of Nutrition and the Department of Nutrition of Harvard University have a cooperative project to determine physiologic, economic and social effects of fortifying the major portion of a nation's cereal products—wheat—with various vitamins, minerals, and lysine. The Pillsbury Co. of Minneapolis and the Ajinomoto Co. of Tokyo are cooperating in this study.
9. Countrywide fortification of wheat is being seriously considered by the government of Peru. They have asked the assistance of the Food and Agriculture Organization of the United Nations.

CORN

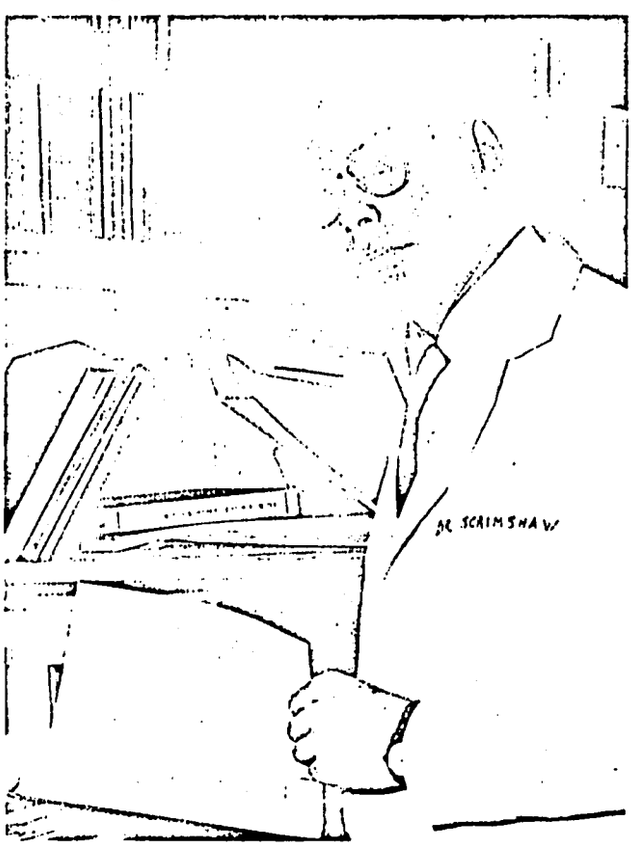
1. General Mills is testing the market possibilities in Guatemala for a prepared, instant tortilla flour fortified with soy protein.
2. The Department of Food Science of Rutgers and the Institute of Nutrition for Central America and Panama are studying the technological possibilities for fortifying corn with the amino acids lysine and tryptophan at small mills.
3. General Foods is market testing in Brazil and the United States a corn macaroni which is fortified with soy protein. It contains 10% wheat flour for functional purposes.
4. CPC International is market testing a baby food prepared from precooked high lysine corn. It is fortified with soy flour and skim milk powder.

RICE

1. In northwest Thailand a project with the fortification of rice, somewhat similar to the Tunisian wheat study, is being carried out cooperatively with the Division of Nutrition of the Thai Ministry of Health, Harvard's Department of Nutrition, and with assistance from Ajinomoto of Tokyo. The rice is fortified with ricelike granules containing various vitamins, minerals, lysine and threonine. These granules are added to regular rice kernels at the mill. The nutrients are protected by loss from soaking and boiling in water by a protective coating that is removed when in contact with the acid of the stomach.
2. Dr. Pereira and her associates in India are carrying out with fortified ricelike granules studies similar to their work with lysine-fortified wheat reported above.
3. The government of Pakistan is actively investigating the potential for fortified rice in East Pakistan.

UNICEF News Interview: Prof. Nevin S. Scrimshaw

Prof. Nevin S. Scrimshaw
Head of Dept. of Nutrition and Food Science
Massachusetts Institute of Technology,
Cambridge, Massachusetts



One of the foremost international authorities in the field of food technology and nutrition, Professor Nevin S. Scrimshaw chaired the recent session of the Protein Advisory Group (PAG)—sponsored by UNICEF, FAO, and WHO—at U.N. headquarters last spring. This interview took place at the Massachusetts Institute of Technology, at Cambridge, Mass., where Professor Scrimshaw heads the Department of Nutrition and Food Science.

Q. Are the global famines of the mid-1970's inevitable as some experts have predicted? What are the scientific and technological breakthroughs that may prevent them?

A. Fortunately, there are no longer any serious prospects for global famines in the mid-70's because of the potential achievements of the so-called "green revolution," the finding and introduction of cereal varieties of greatly improved yields, particularly in Southeast Asia but also in some of the developing countries in other parts of the world. This represents merely a brief reprieve, however, because population increase will soon catch up with the capabilities of even "the green revolution" to feed the world.

Furthermore, the increased yields anticipated are of cereals, and, while these provide adequate calories, they do not have the quality and concentration of protein necessary for the optimum growth and development of infants and young children, or, indeed, for the proper nutrition of pregnant and nursing mothers or the individuals with acute and chronic infections so common in the developing world. Fortunately, there are a number of other applications of scientific and technical knowledge that will make it possible for the world to feed greatly increased numbers of people. The problem is that we really don't know how to bring about the rapid application of this scientific and technological knowledge within the developing countries. Moreover, the industrialized countries are not doing enough to help in this process either through the United Nations or through bilateral efforts.

Q. What must be done now to boost food production in the coming decade enough to meet the nutritional requirements of the expanding populations?

A. First, there must be an increase in the application of present scientific and technical knowledge to the production of food from conventional sources within the developing countries. This means an increase in the production of plants and animals for food purposes and increased utilization of food from the sea. The indus-

trialized countries are, for the most part, producing far more food per capita than they need and the developing countries often much less.

There simply must be an improvement in the techniques of production of conventional foods in the developing countries and, fortunately, there are signs that this is beginning to take place. New seeds, fertilizers, pesticides, irrigation, and better cultivation practices are the basis of the "green revolution" and improved animal production practices are being introduced. A second major necessity is reduction of the tremendous waste of food in the developing countries, due to insects, rodents, molds and simple spoilage. There are indications that at least a third and, sometimes, as much as half of the food produced is wasted. A considerable proportion of this waste is preventable.

The third task will be the utilization of protein resources not yet considered conventional, particularly the oilseed meals, and, further, the development of wholly unconventional sources of protein and other essential nutrients.

Q. Must measures to increase food production be coupled with strong population control regulations?

A. There is no question but that the rate of growth of the world population must decrease if mankind is to provide adequately for human health and welfare. Moreover, it is the rapid rate of population growth in the developing countries which makes it so difficult for these countries to increase their food production fast enough to maintain even the status quo, let alone provide the more nutritious diets really required. The truly heroic effort that some developing countries are making with international assistance to improve the availability of food would be a dramatic success story if the gains were not swallowed by the high population growth. Actually, enormously greater populations could be well-fed either by application of present knowledge to conventional agriculture or the use of new and unconventional food sources or, more likely, a combination of both. But, the knowledge and resources to bring this about in the short period required are simply not available. Therefore, regardless of world potential, continuation of population increase at present rates does threaten world famine, perhaps no longer in the 1970's, but by the end of the century.

Q. Do you think this will actually happen?

A. No. I have faith that a gradual strengthening of the United Nations machinery and greater understanding of the problem within both the developing and industrialized countries will result in our facing up to these problems and solving them in time.

Q. Looking ahead, what do you feel will be the most significant challenge to those working in the field of nutrition in the Second Development Decade?

A. The application within the developing countries of the scientific and technical knowledge which we now possess and that which we shall continue to acquire in the years ahead.

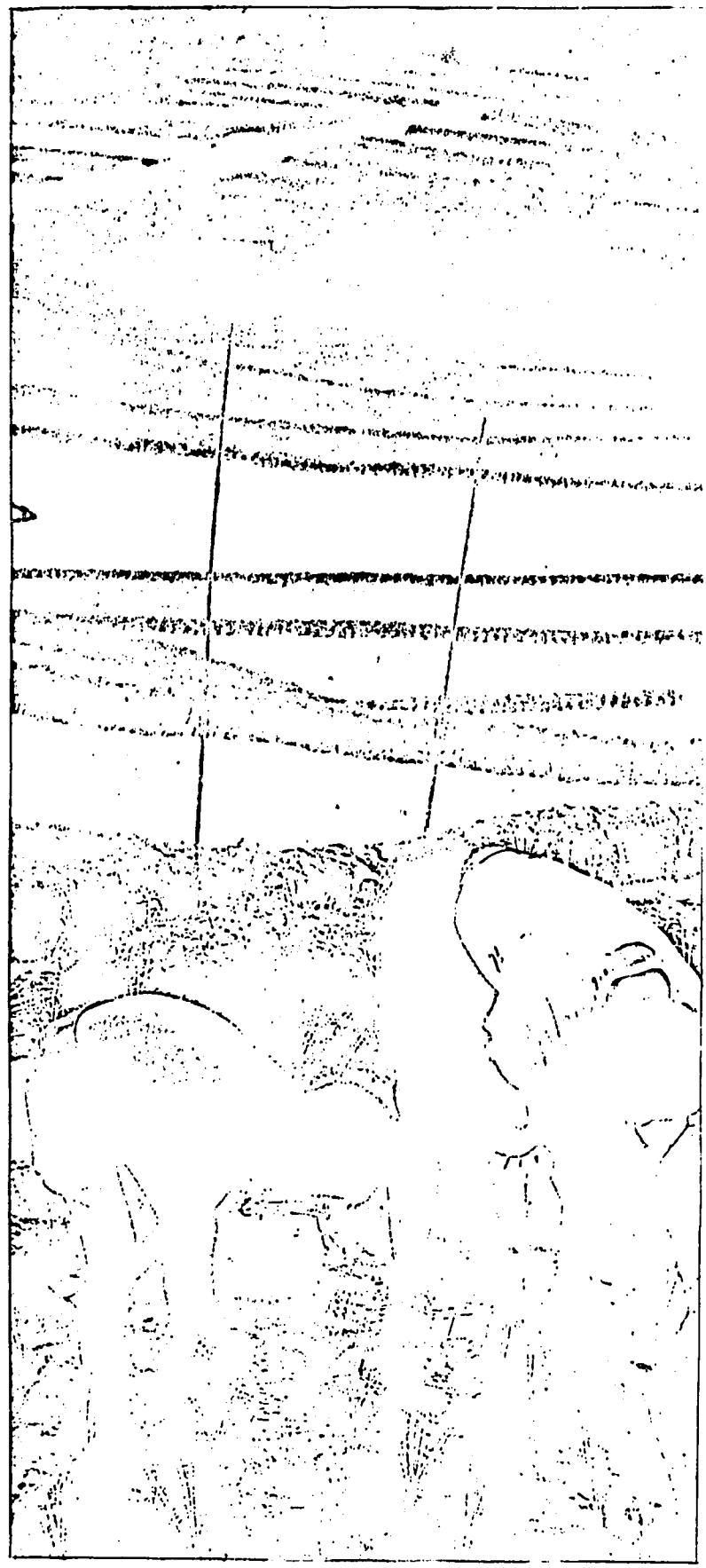
Q. Why is so much emphasis placed on the need for protein rather than simply on the production of more food?

A. The shortage of food is not just one of quantity but also of quality to meet human nutritional requirements. Protein of good quality is more scarce and far more costly than calories, which can be readily supplied by cereals and root crops. But cereals do not contain a high enough concentration of protein to meet the needs of infants and young children, who require proportionately more protein for normal growth and development than adults. Moreover, cassava or manioc, a staple crop in several tropical countries, is almost wholly lacking in protein, yet it forms the principal food for such areas. In the industrialized countries, protein needs are met by meat, milk, poultry, eggs and fish, but these commodities are so costly that they are consumed in only limited quantities by the bulk of the populations of most developing countries. If the people of these countries could afford to eat more foods of animal origin at present prices, supplies would be grossly inadequate and prices would spiral. Yet, until the young children of developing countries receive more adequate protein either from conventional or unconventional sources, malnutrition will continue to impair the health and productivity of present and future generations.

Q. Won't the new higher-yielding cereal varieties solve part of the problem?

A. Certainly. Despite the relatively low concentration of the protein in most cereals, the quantities consumed are so enormous that they account for more dietary protein than all other sources combined. However, the quality of protein in most cereal grains is so poor that much of it cannot be utilized. A major means of increasing the value of existing protein supplied by cereal grains would be to improve its quality, either by the addition of limiting essential amino acids in synthetic form or of protein concentrates in which essential amino acid composition complements that of the cereal. For example, only about one-half of the protein in wheat is utilized because the essential amino acid lysine is deficient; corn protein is poorly utilized because both lysine and tryptophan are inadequate. Where wheat is milled

Indonesian farmer and son plant rice seedlings an even distance apart as they have been taught to do by government agriculture teams.
UNICEF Photo 4605 by Jack Ling.



into flour on a large commercial scale, lysine can be added at the time of milling. When limiting amino acids are added to plant protein, their protein quality can be made comparable to the best animal proteins, providing other factors do not interfere. The limiting amino acids can be added in synthetic form, by breeding them in, in protein concentrates, by genetic improvement, or by a combination of these approaches.

Furthermore, we must have adequate calories in the diet for best utilization of protein; otherwise part of the protein will be used to meet calorie needs. Availability of adequate supplies of cereals is the best way of assuring caloric sufficiency in the developing countries.

Q. If cereals alone are not adequate to supply sufficient protein for vulnerable population groups, such as children and nursing mothers, and animal protein tends to be too expensive for the majority of people in the developing countries, where is the needed additional protein to come from?

A. The most important immediately available source lies in improved use of legumes and, in the utilization of the protein of oilseed meals. In India, Bengal gram (chick pea) and other grams, and in much of Latin America the common beans *(Phaseola vulgaris)* represent the major supplementary protein source.

In much of Asia, the soybean in various forms is the major source of protein supplementary to that in the cereal staple. Legume production should be increased and varieties and techniques of both cultivation and utilization should be exchanged among the various regions of the world.

The principal limiting factor here is the difficulty of introducing any new food. This problem also applies to the utilization of the oilseed meals. There are, however, many methods of incorporating oilseed meals, into traditional foods in ways which improve their protein value without impairing their acceptability. Approximately eight million metric tons of fermented or cooked soybean products are consumed annually in the Far East and another three million metric tons of peanuts, coconuts and other oilseeds are eaten in various parts of the world. Almost no use is being made for human feeding of the remaining nearly seventy million metric tons of oilseeds. The meal left after soy, peanut, cotton, sesame, sunflower and other oilseeds have been processed to extract their oil contains 40 to 50% good quality protein suited to human consumption and is particularly useful in combination with cereal grains. Because the extracted oil (and in the case of cottonseed, the fiber as well) pays part of the cost, these meals are the world's cheapest sources of protein and are likely to remain so. They provide protein at a cost of 8 to 12 U.S. cents per pound

compared with 60 to 70 U.S. cents for non-fat dry milk at the current world market price, and U.S. $1.00 to $2.00 for most other protein of animal origin. Although available in large quantities in most developing areas, this nutritious and low-cost protein-rich material is now largely exported, fed to ruminants, or wasted as inefficient fertilizer. Most of the developing countries have enough oilseed meal, if properly processed, to meet the present protein needs of their children.

Q. How would these oilseed meals be utilized in human feeding?

A. Existing technology is adequate to produce oilseed meals suitable for simple low-cost, protein-rich food mixtures such as "Incaparina" (Central America and Colombia); "Fortifex" (Brazil); "Bal Ahar" (India); "Pro-Nutro" (South Africa); and Laubina (Middle East). Infant foods containing processed full-fat soya have been successfully tested in China (Taiwan). While additional processing research is desirable, the main obstacles to the general use of products containing oilseed protein are the lack of market research to determine the best form and manner of presentation of the product, lack of the kind of promotional and distributional efforts essential to effective marketing, and insufficient understanding and support on the part of governments.

Q. Much has been written about fish protein concentrate (FPC). Will this be an important protein source in the future?

A. Fish protein concentrate is a stable form of protein which can be fed even to infants, and it can be made from fish available in very large quantities because they are lower in the food chain of the sea and not considered palatable as fresh fish. Popular ocean fish such as halibut, tuna and salmon are not available on a sustained yield basis in the quantities required for production of fish protein concentrate. Moreover, they would be too expensive for this purpose. FPC can be made from more abundant fish which would otherwise not have a ready market except for animal feed or fertilizer.

The obstacles to major contribution by FPC to the protein needs of the infants and young children in developing countries are: (a) the need for modern fishing industries to provide raw material; (b) the construction and operation of plants to make acceptable FPC at low cost; (c) the finding of acceptable ways of using the products in foods; and (d) the marketing and promotion of the product.

While FPC may become useful in a few countries, I do not expect it to make the kind of major contribution to world protein supplies sometimes envisaged.

A schoolgirl in India tends her school garden as part of an applied nutrition programme.
UNICEF Photo 4699 by Jack Ling.

Q. Are there really any significant "new sources of food" in the world or must we depend on agricultural improvements to increase food production?

A. No major differences exist between protein derived from the single cells of yeast or bacteria and the protein of other plants and animals. Sufficient information has accumulated to indicate that single-cell proteins are readily utilized by animals and man. The advantages of microorganisms as sources of protein are their rapid growth and ability to convert cheap energy sources and nitrogen into high-quality protein. These microorganisms can obtain energy from petroleum fractions, natural gas, or starchy vegetables and vegetable residues. Protein from single-cell organisms has the special merit that it is produced without the need for agricultural land or the products of agriculture.

In my opinion, low cost and immediate availability give oilseed proteins first priority in the development of new unconventional sources of edible protein to meet world needs. Fish protein concentrates merit second choice, since they are closer to achieving large-scale industrial production than single-cell proteins and have been approved for human use. Single-cell protein deserves at least third priority. Despite formidable technical problems remaining, there is little doubt that wholesome and nutritious single-cell products can be developed and produced in almost unlimited quantities within a decade.

Q. What about the protein in green leaves, seaweed and algae?

A. These materials all contain protein of relatively good quality in their cells which can be precipitated from the expressed juice. However, crude protein from either algae or greenleaves has a somewhat unpleasant taste. This can be removed by further processing but the production costs are greater than for single-cell protein or FPC. Nevertheless since the efficiency of photosynthesis for converting inorganic nitrogen to protein is high, it would be unwise to underestimate the possibility of a technological breakthrough. Moreover, it is comforting to know that it will be feasible to use algae protein for human food when mankind exhausts both available agricultural land and fossil fuels as energy substrates for non-photosynthetic single-cell production.

Q. What about the possibilities for the purely synthetic foods?

A. All essential amino acids are available in chemically pure form although for some, production costs are still extremely high. It should be technically feasible to combine these into palatable synthetic foods, fully satisfying the protein requirements of man, but the present cost would be prohibitive. As synthetic amino acids are used increasingly in fortification of natural foods and as synthetic processes are developed further, the cost will decrease.

Even at a conservative estimate, synthetic foods which meet protein requirements by supplying the proper proportions of essential amino acids and other available nitrogen are unlikely to become significant before the end of the century. They are almost certain to be more costly to produce for a long time to come than the other new protein sources described.

Q. Is there a substantial difference between nutrition problems found in rural areas and those found in urban areas?

A. There are a number of important differences. People in urban areas have definitely entered the cash economy and can be reached through fortification and other measures to improve processed foods. Moreover, the commercial production of low-cost protein foods is possible for urban areas. On other hand, many of the persons in urban areas of the developing countries today have migrated from the countryside and have been forced to abandon many of their traditional food practices without either the knowledge or the financial ability to replace them in a satisfactory manner. Thus, nutrition education and the availability of nutritious foods at a reasonable price become major factors in improving nutrition in urban areas along with the fortification of staple foods.

In rural areas, increased production of food becomes a major need along with a variety of foods which will ensure a balanced and adequate diet. Persons in rural areas in developing countries frequently participate very little in the cash economy and cannot be reached by improvements in the nutritional value of processed foods. By and large for them improvement must come in the availability and utilization of traditional foods in kinds and quantities to ensure good nutrition.

. What is your appraisal of FAO's Indicative World Plan for Agricultural Development as a framework and guide for governmental policies and action in the areas of agriculture, food, population, trade and development?

A. FAO's Indicative World Plan (IWP) provides the most comprehensive statistical information yet available on the food supply in developing countries. According to this, the average supply per caput in the developing world as a whole, falls short of physiological requirements by *at least 6% for calories and 7% for protein.* The projections for the next 15 years indicate that the gap between demand and supply will be particularly evident for protein of good quality. Yet, the figures given in the IWP are averaged figures and therefore tend to understate the problem. Apart from uncertainty as to the reliability of the statistical data, it must be emphasized that aggregate and per capita data are not a sufficient base for the formulation of nutrition policies having particular reference to vulnerable population groups. Because of the large inequalities in protein supply and distribution, even when supplies are 20% above the average national requirements, a significant part of the population may not have its requirements satisfied.

Obviously, the protein intake within a population differs according to its economic status. Whereas high and middle income groups usually have a satisfactory protein

A Tokyo family on a Sunday outing reflects physical changes resulting from improved diet. Recent nutritional studies show that because of greater animal protein in the diet, the average Japanese will grow to be taller (about four inches) than his parents. UNICEF Photo 6077 by Dorka Raynor.

intake, low income groups, representing a high percentage of the population of developing countries, often have protein intakes that are too low.

Protein malnutrition is frequent in urban and semi-urban low income groups who rely completely on the market for their food supply and also in such groups in rural areas which produce a major part of their own food supply.

When family intakes of protein appear adequate, protein malnutrition may still occur because individual family members who have special needs, such as the pre-school child and the pregnant and lactating woman, do not necessarily receive a share proportionate to their needs. The problem is particularly acute with respect to the pre-school child.

The problem of insufficient dietary protein is augmented by the fact that when the calorie intake is insufficient, as is frequently the case, part of the dietary protein is used to meet calorie needs. Another factor is the high prevalance of infectious and parasitic diseases, in most developing countries, particularly in children, which increase protein requirements while decreasing dietary protein utilization.

In summary, the IWP is an extremely useful exercise, but it is not and it was never intended to be a detailed blueprint for action in individual countries in the decades ahead. By outlining present prospects in such dramatic detail, it is hoped that the IWP will motivate the nations of the world to take more effective measures to overcome the problems identified and projected.

It is not scientifically correct to say that a present shortage exists specifically for animal protein. The need is only for adequate amounts and proportions of the eight essential amino acids that protein of good quality contains, and enough additional nitrogens from any utilizable source to enable the body to synthesize the remaining amino acids of which protein is made up. It's true that protein of animal origin has traditionally been a major contributor to supplying these essential amino acids in human diets. However, large populations of the world already obtain the bulk of their proteins from cereal and legume combinations, with little or no animal protein. Furthermore, we now have a powerful new tool to bring the quality of protein of plant origin into the range of that for animal protein. This is amino acid fortification, the addition in synthetic form of those amino acids in which the plant protein is relatively deficient.

Addition of $\frac{3}{10}$ of 1% of lysine brings the quality of the protein in wheat flour up to that of meat. In the case of more concentrated sources of protein, such as the oilseed meals or single cell protein, the addition of *methionine* has the same effect.

Thus, mankind is not tied to a physiological need for animal protein however much he may enjoy it.

Q. What assurance can you give that people will eat the new and unconventional foods of the future you say will become available and help prevent nutritional disaster?

A. Most foods of different cultures are rejected by most people to whom they are unfamiliar. Many of the staples upon which large populations in the developing countries depend would be very unconventional on a European or American table. The tortillas of Latin America, the chappaties of India, the tempeh of Indonesia, the mealie meal of South Africa, would be rejected by most persons not accustomed to them, to say nothing of the maguey worms which are delicacies in parts of Latin America, termites in Australia and Africa, locusts in the Middle East, raw turtle eggs, or the meat from dogs, monkeys, snakes and rats, consumed by various populations.

Conversely, caviar, artichokes, truffles, limburger and roquefort cheese, snails, frog legs, whale steak, and blood sausage would be just as hard to introduce to societies not familiar with them. Beef steak delights us and is intolerable to an orthodox Hindu. Pork is very much liked by some populations and violently rejected as "unclean" by others. One of the hardest tasks of my life was to convince the population of a small Guatemalan village wholly unfamiliar with milk, that the dried skim milk provided by UNICEF would not make their children sick.

Synthetic and substitute foods should be nutritionally equal to or better than the conventional foods they supplement or replace because this is technologically feasible, socially desirable and economically profitable. The limiting factors in the adoption of synthetic and substitute foods are not ones of either nutritional value or safety, but rather, as your question implies, they are concerned with palatability, cultural acceptability, and economics.

Food habits have always been determined by environmental and cultural factors which vary widely from one population to another and which change with time. In recent decades the rate of change has been enormously accelerated. Most of the processed foods of Europe and America were not even available a generation ago. Within the life span of a single generation, many new and substitute foods have become conventional. Some of these are more nutritious, more palatable and more satisfying and interesting than ever before available to the general population. Precedent, human desire, technology and need all suggest that our foods will continue to evolve in ways which will increase rather than decrease the pleasures of eating by promoting good health through a more balanced nutrient content.

Q. Is it fairly well established in scientific circles that malnutrition definitely causes mental retardation?

A. Two-thirds of the world's children live in the developing countries of the world, and for most of them malnutrition during their early years is a fact of existence. The consequent retardation in physical growth and development is reflected in the almost universally smaller body size of members of low-income populations in these countries. Genetic differences are a minor factor. Many underprivileged children among poor families in the industrialized countries are also malnourished at an early age.

Attention was focused until recently mainly on the high mortality of malnourished infants and preschool children of developing countries, with no particular concern for the smaller body size of the survivors. In the 1920s, experiments with rats began to show that nutritional deficiencies not only retarded physical growth and development but affected the central nervous system as well. In recent decades, early malnutrition sufficient to impair growth in experimental animals has repeatedly and conclusively demonstrated its effect on their subsequent learning, memory and adaptive behavior. This has led to widespread concern that infants and young children whose physical growth is retarded by malnutrition may also be impaired in brain development and subsequent learning and behavior. The smaller head circumference of such children when they reach maturity, observed in many parts of the world, has added to this concern. Recent field studies in several developing countries are confirming poorer performance on some tests of intelligence and learning in children with a history of early severe malnutrition, but psychological and social as well as nutritional factors are certainly involved.

45.11.18

FAO/WHO/UNICEF
Protein Advisory Group

24 August 1970

PAG Statement No. 9
Amino Acid Fortification

Unclassified

PAG STATEMENT ON AMINO ACID FORTIFICATION OF FOODS

SUMMARY

There is abundant evidence from animal studies and observations on humans under controlled situations in institutions such as hospitals, schools and orphanages that improvement in nitrogen retention or growth occurs when either simple experimental diets or mixed diets typical of food intake patterns in certain regions are supplemented with the limiting amino acid(s). This is particularly apparent in infants and children who have been malnourished or have low protein intakes. At higher protein intakes, cereal-based diets can usually provide sufficient protein for disease-free adults, but this may not be true for adults suffering from acute and chronic infections or women who are lactating.

Supplementation effects have been observed mainly with lysine and methionine; in maize-based diets tryptophan is also limiting.

More precise information is needed on the protein and amino acid requirements of various population groups and the extent to which the local diets meet these needs.

There is evidence that baking and cooking processes reduce levels of amino acids added to food products. Further studies are requested to assess the loss due to different types of storage and from foods cooked for home consumption. There is a need to examine the nutritional, technological and commercial possibilities of using vehicles other than staple cereals for amino acid fortification.

The decision as to fortification of staple foods with amino acids will have to be made on a national basis. The target groups that can be expected to benefit should be identified and the desirability of amino acid fortification should be judged in comparison with alternative approaches to meeting national protein needs.

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PAG recommendation on amino acid fortification of foods

At its 15th Meeting in Rome, 9 - 13 September 1968, the PAG stated: "There is a growing interest among countries in the use of synthetic amino acids for the improvement of the protein quality of cereal grains and vegetable mixtures for human feeding. While the PAG has encouraged exploration of such fortification where it is likely that such supplementation could make a significant contribution at an economically justifiable cost, there remains great uncertainty or controversy as to when these conditions are met.

"The increasing availability at low cost of the most frequent limiting amino acids in the diets of low-income populations, lysine and methionine, has increased pressures on governments to approve their use in the fortification of cereals. The choice of amino acid fortification, the addition of protein from fish protein concentrates and oilseed flour, or both must be made on a combination of economic, nutritional and policy grounds which are still controversial."

Because this is a real problem confronting countries today, background information and guidelines have been developed to assist the United Nations Agencies and Member Governments in evaluating the desirability of instituting programmes of amino acid fortification.

The PAG has been helped in this task by an ad hoc Working Group with the following membership: Dr. N.S. Scrimshaw (Chairman) U.S.A., Dr. David Call, U.S.A., Dr. C. Engel, the Netherlands, Dr. D. M. Hegsted, U.S.A., and Dr. T. Oiso, Japan, with Dr. U. Kracht, Federal Republic of Germany, and Dr. P.S. Venkatachalam, India, participating as consultants. Dr. L.J. Teply, UNICEF, served as technical secretary of the ad hoc Working Group.

The following Statement was adopted by the PAG at its 17th Meeting in New York, U.S.A., 25 - 28 May 1970.

1. Amino acid fortification studies in man

The effectiveness of amino acid fortification in increasing the utilizable protein of cereals and legumes has been demonstrated in experimental animals. There is also abundant evidence of the biological effectiveness of amino acid fortification from metabolic and growth studies in man. In these studies, carried out in different parts of the world, the methodology has varied. Also many of these experiments have used a single cereal, grain, legume, or oilseed as either the sole source of protein or the main source of protein in a simple mixture.

PAG Statement No. 9
Amino Acid Fortification

1.1 Studies using nitrogen balance methods

Nitrogen balance studies in various age groups have indicated that for humans lysine is the most limiting amino acid in a number of cereal proteins (in the experiments the monohydrochloride of L- or DL-lysine was used).

1.1.1 Wheat Hoffman and McNeil (1) observed in ten adult hospital patients that the Allison nitrogen balance index increased from 0.62 to 0.76 when L-lysine was added at a 4% level to wheat gluten serving as the sole source of protein; the index for a casein preparation was 0.80.

Cremer et al. (2) fed 400g of 80% extraction wheat per day in the form of bread as the sole source of protein to nine normal adult males. Separate supplementation with lysine, corresponding to the addition of 0.1% DL-lysine to the flour, raised the average Biological Value (BV) from 41.8 to 61.7 in three subjects. In nine subjects addition of 0.2% DL-lysine to the flour prior to baking resulted in raising the BV only from 40.5 to 45.0; this was attributed to losses in the baking process.

Rice et al. (3) observed statistically significant nitrogen balance responses in young healthy adults fed diets in which protein came mostly from lysine-supplemented, white-flour bread.

Bressani et al. (4) observed increased nitrogen retention in six children aged 18 to 69 months, who had recently recovered from severe protein malnutrition, when 0.64% L-lysine was added to a diet in which the main source of protein was wheat flour and wheat gluten. The subjects consumed 2g protein and 80 to 100 calories per kg body weight per day. Bressani et al. (5) later showed that addition of L-lysine to a wheat diet fed to seven children of 3 to 6 1/2 years of age at a level of 2 to 3g protein per kg body weight clearly increased the nitrogen retention to close to that obtained with an equal intake of milk protein.

Barness et al. (6) fed wheat diets to 22 malnourished infants at levels of 1.2 to 4.0g protein and 75 to 120 calories per kg body weight per day. Addition of 0.35% L-lysine to the wheat flour used as the protein source brought the protein value close to that for milk, according to nitrogen balance measurements; potassium had to be added to the diet to get this effect. Consistent results were obtained at a consumption level of 1.75 to 3g protein and 75 to 100 calories per kg body weight per day.

Daniel et al. (7) supplemented a poor wheat-based diet of seven boys aged 10 to 12 years with L-lysine and DL-threonine. The diet provided approximately 1.8g protein per kg body weight per day. L-lysine significantly

increased nitrogen retention and BV; simultaneous supplementation with DL-threonine brought some further increases.

Graham et al. (8) measured nitrogen retention in six infants and young children, 10 to 48 months of age, recovering from protein-calorie malnutrition. The sole protein source in the experimental diet (wheat, cottonseed oil, cane sugar, vitamins, and minerals) was a wheat flour prepared by air classification to contain 21% protein. The amino acid composition of the protein in this preparation was found to be similar to that in ordinary white wheat flour. Protein intake was 1.5 to 2.0g per kg body weight per day. L-lysine was added to the wheat flour at three levels: 0.215%, 0.359% and 0.725%. These levels were considered to be analogous to the following levels of fortification for ordinary wheat flour with 11% protein; 0.12%, 0.20% and 0.40%. A clear supplementary effect was observed even at the lowest level of fortification, with some additional benefit in going from the intermediate to the highest level.

1.1.2 Maize Scrimshaw et al. (9), in a series of balance studies on two hospitalized children recovering from protein-calorie malnutrition, fed lime-treated "maize-masa" (used for making tortillas) as the main protein source at a level of 3g protein per kg body weight per day. L-lysine together with DL-tryptophan had to be added to get satisfactory nitrogen retention. In an extension of these studies, Bressani et al. (10) fed "maize-masa" as the sole source of protein to three children at an intermediate level of 1.5 and 2g protein per kg body weight per day. Again, when both lysine and tryptophan were added, good nitrogen retention was obtained. In these investigations the levels of supplementation were in accord with the FAO reference protein amino acid pattern (11). In nitrogen retention studies in ten children of 1 1/2 to 5 years of age where dietary protein came entirely from "maize-masa" Bressani (12) got equally good results with somewhat lower levels of the amino acids. The protein was fed at a level of 2g and 3g per kg body weight per day. Although addition of DL-tryptophan had no effect in these latter experiments, supplementation with L-lysine improved nitrogen retention slightly; the combination of lysine plus tryptophan was highly effective. The further addition of DL-isoleucine had a slight additional effect. In a recent summary of this whole series of experiments, Bressani (13) reviewed the decreased nitrogen retention observed when other amino acids (DL-methionine, DL-valine) were added to the diets and the importance of an appropriate balance among the amino acids present in children's diets.

Truswell and Brock(14) conducted nitrogen balance studies in eight normal males aged 22 - 56 years who customarily ate 500 to 600g maize per day. At a protein intake of approximately 1g per kg body weight per day, addition of L-lysine increased nitrogen retention and addition of DL-tryptophan had a further enhancing effect.

Gomez et al. (15) reported that a combined supplement of L-lysine and DL-tryptophan improved nitrogen absorption and retention in four preschool children on a maize-beans diet.

1.1.3 Sorghum and millet Doraiswamy et al. (16) reported a significant increase in nitrogen retention in studies on forty-eight school girls aged 7-12 years when L-lysine was added to a poor sorghum diet which provided 2.0g protein per kg body weight per day.

Daniel et al. (17) added L-lysine to a millet diet of eight school girls aged 11-12 years, which provided 1.3g protein per kg body weight per day. The lysine supplement doubled the nitrogen retention; DL-threonine in addition to the lysine gave a slight further improvement. The same investigators (18) reported similar results using a sorghum diet under the same experimental conditions.

1.1.4 Rice Hundley et al. (19) fed rice diets furnishing 26 to 31.7g protein per day to five young adult males and studied effects on nitrogen retention of L-lysine plus DL-threonine, a mixture of eight essential amino acids, and a mixture of nonessential amino acids. The investigators concluded that the diets were primarily deficient in total protein. Lysine or lysine plus threonine produced a positive shift in nitrogen retention in some of the subjects but so did a mixture of nonessential amino acids. Negative responses to lysine plus threonine were observed in one case and to a mixture of eight essential amino acids in another; the significance of these observations is not clear.

Parthasarathy et al. (20) fed a diet consisting mainly of rice (250g rice in 375g total daily food intake) to six girls aged 8 to 9 years. Effects of supplementation on nitrogen retention indicated lysine and threonine were most limiting, followed by methionine.

Bressani(13) measured nitrogen balance in hospitalized children between 1.5 and 5 years of age who had recovered from malnutrition. Polished rice was fed at two levels of protein intake (320 mg N and 235 mg N per kg body weight per day). At the higher levels only lysine increases nitrogen balance. Simultaneous addition of other amino acids, except for methionine, tended to decrease nitrogen balance. At the lower level of protein intake lysine had no effect but addition of lysine plus methionine improved nitrogen retention (L-lysine and DL-methionine were used).

1.1.5 Mixed diet Hegsted et al. (21) found that the addition of L-lysine to a cereal-vegetable-fruit diet, fed at a minimum protein intake level of approximately 24g per day, increased nitrogen retention moderately in female university students; further supplementation with DL-methionine gave

slight additional retention. It should be noted that the protein level of the experimental diet was at or below requirement for the individual and the subjects had been on a protein depletion diet prior to the tests.

1.1.6 Methionine supplementation of mixed diets Goyco (22) observed increased nitrogen retention in young adults when torula yeast plus DL-methionine was added to a rice-bean diet; torula yeast alone produced a lesser effect. In three young men fed torula yeast at a low level of protein intake, Young and Scrimshaw (23) also report increased nitrogen retention with the addition of DL-methionine.

Nicol and Phillips (24) increased nitrogen retention in adult Nigerian males eating a diet of cassava gari, groundnut flour, and vegetable soup at a protein intake of 0.4g per kg body weight by adding 500 mg DL-methionine to the daily diet. No significant change was observed, however, when the methionine was added to a diet of rice, fish and vegetable soup.

Graham (25) observed "striking improvement" in nitrogen retention when DL-methionine was added to soy protein isolates, full-fat soy flour or a soy milk made with defatted soy flour fed at critical levels of protein intake to infants and small children (6 to 23 months of age) recovering from malnutrition.

1.1.7 All of these studies carried out under the controlled conditions of a metabolic unit have demonstrated increased nitrogen retention when experimental diets fed at relatively low levels of protein intake or to depleted subjects are supplemented with the limiting amino acids. On sustained higher intakes of these same proteins the effects of the amino acid supplement might not be as pronounced. It should also be noted that predominantly cereal diets ordinarily provide adequate protein for most normal adults if sufficient calories are consumed, although this may not be true for adults with acute or chronic infections or for lactating women.

1.2 Growth studies

Albanese et al. (26) observed increased growth in thirteen infants 1 week to 14 months of age when L-lysine was added to a wheat gluten diet furnishing 3.5g protein and 100 calories per kg body weight per day, but also observed this effect when the protein of the basal diet came from lactalbumin, casein, or condensed milk.

Several studies in institutions such as schools or orphanages have been conducted in various parts of the world. Fukui et al. (27) fed 0.5 to 1.5g supplemental lysine for six months to three hundred and fifty children 5 to 15

years of age whose height and weight were below the national average. The diet consisted mainly of rice. The authors concluded that the children receiving either DL- or L-lysine gained more height and weight than the controls. Recently Oiso (28) has described additional experiments that are underway in remote mountain villages in Japan.

Krut et al. (29) fed two groups of children aged 2 to 8 1/2 years (29 per group) staying temporarily in an institution, a basal diet of bread, fats, vegetables, and fruit plus vitamins and minerals. Bread supplied 88.8% of the protein and 52.4% of the calories. Protein consumption was 1.5-1.8g per kg body weight per day. One group received 1g L-lysine per child per day while the other received 0.822g glycine per child per day; the supplements were given in a beverage taken immediately after meals. After six weeks the supplements for the two groups were switched. Lysine addition to this low-protein diet gave superior weight gain (protein efficiency ratio, PER 0.22 compared with that on glycine supplementation (PER 0.04).

King et al. (30) fed 150g bread or 150g bread plus L-lysine to four hundred and fifty Haitian school children between 4 and 18 years of age for 150 days. The basal diets supplied approximately 1580 calories and 37g protein per day. The bread supplement raised caloric intake by 25% and protein intake by 34%, assuming consumption of the basal diet was maintained. Although the effects on height and weight were moderate, they were statistically significant in favour of the bread plus lysine.

Doraiswamy et al. (16) supplemented a "poor" sorghum diet of twenty-four school girls aged 7 to 12 years with 1.0g L-lysine per day divided into three doses given with meals. Twenty-four unsupplemented controls were paired with experimental subjects according to initial height and weight. The basal diet provided 2.0g protein per kg body weight per day. Over a six-month period the controls gained an average of 0.80kg in weight and 1.82cm in height. The supplemented group gained an average of 1.74kg in weight and 2.93cm in height.

Pereira et al. (31) observed a moderate but statistically significant ($p < 0.05$) increase in height over a six-month period when L-lysine was added to wheat diets of children aged 2 to 5 years in an orphanage. The average increase in height was 3.26cm ($\pm$1.19) in the experimental group and 2.61 ($\pm$0.99) in the control. The basal diet (wheat, pulses, oil, vegetables, fruit, sugar and spices) provided 2g vegetable protein and 100 calories per kg body weight per day. For the lysine supplementation, wheat flour was fortified at a level of 0.25% and wheat grains were impregnated at a 0.1% level. The wheat and wheat flour were consumed in boiled, roasted and fried foods. The controls had a daily lysine intake of 0.63g and the supplemental wheat provided an additional 0.37g per day. However, cooking losses reduced the effective

levels, as measured by chemical determination of available lysine, by 21% in the control group and by 30% in the experimental group. (Incidentally, in this experiment significant differences were not observed in nitrogen retention between the two groups.)

These studies have demonstrated convincingly in some cases and marginally in others that the growth response of the children receiving the amino acid supplemented diets was superior to that of the control groups. The investigations are difficult to compare quantitatively since the methodology varied greatly. Although the pitfalls in interpretation of these results are realized, the studies indicate that increased growth can be observed in well-designed experiments, especially those involving preschool children studied under carefully controlled conditions. Additional studies are required to determine the limiting amino acids in the diets of vulnerable groups in various developing countries.

1.3 Guidelines for future studies in man under controlled conditions

At present, convincing estimates of the nutritive value of proteins for human consumption and determination of the effects of amino acid supplements on man require the use of human subjects in experiments. Nitrogen retention or balance studies are difficult and expensive and of necessity limited to only a few centres. Unless strict precautions are taken, such studies are likely to give variable and unreliable results. PAG provides guidelines (No. 7) for both metabolic and growth studies, and WHO is sponsoring a series of regional centres for such testing.

Widely varying values for the BV of the same protein have been reported, and it is clear that the conditions necessary for this determination are inadequately defined. There should be increased efforts to establish the appropriate standard conditions for the estimation of BV and net protein utilization (NPU) in human subjects and to obtain additional data on the effects of amino acid fortification using these measures of protein quality in human subjects.

2. Possible adverse effects

Amino acid imbalances, even when the amino acids involved are not otherwise limiting, have been extensively documented in studies of animals on low protein intakes (32, 33, 34). The PAG considered the available evidence on toxicity and imbalance of amino acids and concluded that there is no hazard from excess lysine even at levels considerably above those used for fortification purposes. The level of methionine supplementation, however, requires careful control in view of the reduced nitrogen retention induced by higher intakes of methionine when other amino acids are limiting (9, 10, 35) and its known toxicity when ingested by experimental animals in amounts considerably above requirement. The question was considered by the PAG in

1960 on the basis of a detailed working paper. It seems clear that menthionine can be added to foods at safe levels. There is a degree of self-limitation due to flavour effects.

3. Losses in processing, storage and home preparation of foods for consumption

Essential amino acids may be rendered unavailable through chemical reactions which are accelerated by heat and moisture. Lysine loss has been observed, for example, in the browned portions of baked cereal products, in roller dried milk powder or in milk powder stored under high humidity. Losses of free amino acids in foods may be more than losses of amino acids in intact food proteins, especially if there is leaching into cooking water, as in preparation of fortified rice or pasta products. Some indications of this are provided from studies in which processing first releases amino acids from food proteins and then subjects them to conditions that make them physiologically unavailable.

Kretovich and Ponomareva (36) found that during fermentation of bread dough, amino acids are released and the concentration of these free amino acids, particularly of lysine, decreases on baking. Rubenthaler et al. (37) and Morimoto (38) have reported similar findings. Jenneskens (39) reported that lysine added before baking of bread survives to about 90% and that losses occur only in the crust. Stillings and Hackler (40) reported that free amino acids released during the fermentation of the soybean product tempeh were rendered nutritionally inactive during the traditional deep fat frying, lysine and cystine being most sensitive.

Rosenberg and Rohdenburg (41) found that the loss of added L-lysine in baking of bread, as measured by microbiological assay, averaged 32 percent. Most of the loss occurred in the crust. (When DL-lysine was added, the loss of nutritionally active lysine averaged 11%.) Other workers have also observed losses of the added lysine as high as 25% during baking (42, 43).

Matthews et al. (44) reported a loss of only 4% of added lysine during baking of chapatis. Bains and Tara (45) found a negligible loss of added lysine in optimally baked traditional breads such as chapatis, parathas and poories. The same authors found that the losses of L-lysine and L-threonine in cooking raw and parboiled rice were negligible in model systems with and without added amino acids and without draining the gruel.

Bressani et al. (46) found no significant loss of 0.3% L-lysine added to Incaparina in cooking (boiling) up to 24 minutes in the presence of sucrose. However, Planella et al. (47) reported losses of amino acids and decrease in PER value in the cooking of a maize-soybean mixture to which lysine and

methionine had been added. Akiro (43) observed losses of 50-60% of added lysine in the boiling of noodles. Pereira et al. (31) reported lysine losses of 21% in a control diet prepared by boiling and frying of foods and a 30% loss when the wheat components were fortified. The calculated loss of added lysine was 43%.

It is known that control of sugar concentrations in eggs, meat and fish before dehydration can greatly diminish the susceptibility of protein amino acids to damage during subsequent storage. However, relatively few studies have been reported on the stability of added amino acids in storage. Hunter et al. (49) reported losses of free amino acids in aged parboiled rice. On the other hand, Rohdenburg and Rosenberg (50) found DL-methionine added to animal feeds to be stable for more than a year even at 50°C. Bains and Tara (45) found the lysine in fortified atta fairly stable over a period of six months when stored at room temperature.

4. Estimation of the effects of amino acid fortification

4.1 Amino acid scores

Scoring procedures have been recommended by the 1955 FAO Expert Committee on Protein Requirements (11), the 1964 FAO/WHO Expert Group on Protein Requirements (34), and several others (51, 52). It is clear that different estimates of the nutritive value of proteins will be obtained using these different approaches. If the essential amino acid composition of egg is used as a reference, the results will depend upon the particular amino acid values used. There is presumptive evidence that the concentrations of the essential amino acids of egg protein, as percent of total protein, are high relative to the essential amino acid requirements of man. Among these essential amino acids, isoleucine and methionine are probably particularly high. The use of egg as a reference will often overestimate the extent to which isoleucine and methionine are limiting and thus underestimate the quality of a protein for human use.

Similarly, the literature contains a wide range of values for the amino acid composition of food proteins. Estimates of their nutritive value will vary markedly with the amino acid composition data which are used in the calculation. Moreover, in some foods, particularly processed and cooked foods, certain amino acids may be relatively unavailable (as for example some of the lysine in most baked products); in such cases amino acid scoring will yield falsely high values.

The significance of amino acid scores, which are useful as a preliminary screening method for predicting the limiting amino acid(s) and the approximate protein value of the diet, can be judged by comparison with biological

determination of nutritive value. Unfortunately, the correlations between biological measurements and amino acid scores are poor. Errors in the estimates can be greater than the calculated improvement from amino acid supplementation. The extent to which the discrepancies are due to errors in estimation of the amino acid composition of the protein, availability of the amino acids, or inappropriateness of the scoring patterns has not been determined.

4.2 Biological evaluation of protein quality

Improvement of PER, NPU, or values obtained by other techniques for determining nutritional quality of protein (53, 54. 55) can be readily demonstrated with appropriate amino acid supplementation of deficient proteins.

5. Economic and nutritional evaluation of specific national situations

The task of evaluating amino acid fortification programmes is a difficult one because any proposed programme should be compared with other alternatives in the context of the local situation. Ideally, each country should have well-defined objectives for nutritional improvement and a national nutrition plan. Such a statement of objectives and time-oriented goals should have priorities assigned so as to provide a basis for preproject evaluation of any programmes proposed. It is important that nutritional intervention programmes be evaluated in relation to he long-range nutritional plans of a country, because ultimately such programmes involve the allocation of limited resources. Every effort must be made to use these resources in the most efficient manner possible, in the light of carefully considered and defined objectives.

The definition of national objectives is primarily the task of the national health, agriculture, and other responsible authorities in each country. It would be inappropriate for the PAG or international agencies to perform this task, but they can provide guidelines which will help governments to choose among various strategies for improving the nutrition of their people. The following economic and social considerations are advanced as initial steps in developing PAG guidelines for national nutrition intervention programmes.

5.1 It is essential to evaluate proposed nutritional intervention programmes on a national basis, taking into consideration the limiting amino acids in the diets of the target group(s). It is not sufficient to make broad global judgements based on the efficacy of amino acid fortification of cereal grains alone.

5.2 In the examination of an individual programme, calculation of its probable cost should be based upon the expected total cost divided by the estimated number of people likely to benefit. Per capita cost estimates may

tend to seriously understate the actual cost in relation to benefits to needy beneficiary groups within the population.

5.3 The target group should be defined quantitatively as precisely as possible, even though this will be difficult and, to a certain extent, arbitrary. In most developing countries it will normally include a high proportion of the preschool children and most pregnant and lactating women. In addition, some of the other adults whose protein intake is marginal, and who are suffering from malaria, tuberculosis, hookworm disease or other chronic infection, may benefit.

5.4 In determining the effectiveness of amino acid fortification, the question of the calorie adequacy of the diet must be carefully considered. If calories are inadequate, the added protein value will not be utilized.

5.5 An attempt should be made to compare the costs of an amino acid fortification programme with costs of other programmes designed to meet the same problems in approximately the same target groups. Ideally, the programme which will make the best use of national resources will be selected. In some cases there may appear to be no logical alternatives to fortification, but an attempt should be made to search out any that are reasonable for comparison purposes.

5.6 Programmes which will cause even a moderate increase in the retail price of a food staple can be justified only if it can be shown that the expected overall benefits outweigh the cost of the programmes.

5.7 In analyzing the economic feasibility of an amino acid fortification programme in a specific country, the following must be considered:

5.7.1 Local prices for various foodstuffs should be used in the comparative analysis.

5.7.2 Since the costs of transporting, storing, and handling a protein ingredient may be quite high relative to the value of the ingredient itself, it is essential that these costs be included in the analysis, with appropriate credit for increase in volume of product obtained. The comparative processing cost of adding an amino acid or a protein supplement to a food product should be closely examined.

5.7.3 Comparisons of the relative costs of fortification may be presented in different forms. A key measure is the relative cost of utilizable protein in the final product. Also of major concern is the potential impact of fortification on the retail cost of the foodstuffs.

5.7.4 Consumer acceptability of proposed food mixtures is important and in many cases will limit the flexibility of mixture formulation. Within these limits, attempts should be made to compare the relative costs of different formulations.

5.7.5 It is important to consider the proposed channels of distribution for a fortified product. If a product is to be distributed through noncommercial channels, such as government feeding schemes, the limits of acceptability may be somewhat wider.

5.7.6 In evaluating alternative programmes, social factors should also be considered. Some of these are the potential impact through nutrition education, employment in manufacturing industries, influence on the development of agriculture, the availability and use of foreign exchange, and other such factors.

In evaluating the potential effects of amino acid fortification, particular attention should be given to the effect that a programme might have on the development of other industries. For example, amino acid fortification programmes should not be considered as substitutes for promoting the increased availability and use of edible oilseed protein concentrates. Oilseeds are still the cheapest source of good quality proteins and can provide a multitude of useful products ranging from oil to highly-refined protein materials. Similarly, in those countries in which it becomes available for human consumption at a relatively low cost, fish protein concentrate (FPC) may in the long run be a more effective means of adding nutritionally balancing proteins to bread and other cereal products than amino acid fortification.

6. Alternative vehicles for fortification

Cereals have received the greatest attention as potential vehicles for amino acid fortification, but this practice poses special processing and distribution difficulties in some countries. These difficulties should stimulate consideration of other possible carriers from the nutritional, technological and commercial points of view. A variety of other items in the daily diet might be suitable vehicles for amino acid fortification.

The choice of a vehicle for amino acid fortification depends on several factors. The processing of the carrier food should be relatively centralized and its distribution through normal commercial or other channels should be amenable to regulatory control.

The product chosen for fortification should be one which is consumed consistently and regularly by a significant proportion of the target groups. These

will include low-income-group preschool children, adolescents, women during the reproductive period of life and other adults exposed to chronic infection and other factors affecting protein requirement. Since the ultimate objective of the amino acid fortification programme is to upgrade the protein quality of the daily diet as a whole and not necessarily that of the carrier product, due attention must be given to amino acid deficiencies of the total diet. These will be influenced by seasonal variations and differences in daily meal patterns.

From the technological point of view the carrier should retain its characteristic taste, flavour, odour and appearance after the fortification and should withstand, without loss of the amino acid, the variety of domestic processing and cocking procedures practiced in the community. In addition, the fortified product should have an adequate shelf-life under varying climatic conditions.

The cost of fortification should not change the price sufficiently to affect consumption.

7. Economic and nutritional analysis of specific programmes and proposals

The following general comments apply:

7.1 Any feasible commercial project for improving the protein quality of staple foods in a developing country should be encouraged provided:

7.1.1 The measure adopted has been demonstrated by animal assay or clinical studies to bring about a significant improvement in protein quality of the diet of the target group(s).

7.1.2 There is no cost to the national government or, if the commercial distribution must be subsidized by the national government, the cost of such subsidy is not out of proportion to the nutritional benefits within target groups.

7.1.3 Any appreciable additional retail cost to the public is justified. A project reaching largely middle and upper income groups, as for example the introduction of fortified western-style white breads, may still make a valuable contribution by stimulating interest in improving protein quality of foods, by contributing to the education of the public, and by alerting the food industry to its responsibilities for ensuring good nutritive value and wholesomeness of its products and by promoting improvement in its efficiency. Moreover, the number of persons within target groups benefited by such a project is likely to increase as urbanization proceeds.

7.2 The probable value of amino acid supplementation of a local staple will vary from country to country as a function of the local diet and other circumstances so that each proposal must be analyzed on its own merits.

7.3 Like many other nutritional and health measures, amino acid fortification of a specific product may initally benefit a relatively small proportion of the total population in need. This, in itself, should not be sufficient reason for discouraging a proposed programme. Any measure which appears to offer positive benefits to a significant part of the target group at a reasonable cost should be encouraged, even though it is far from a total solution to the problem.

7.4 Programmes should include plans for continuation should they prove successful. This need not apply to pilot or field experiments, where the outcome will determine whether or not a long-range programme should be developed.

3. Evaluation of established fortification programmes

Amino acid fortification programmes involve a significant cost which must be evaluated in the light of limited national resources. It is therefore essential to obtain information on the biological and social effects of such programmes. However, this presents very difficult problems of experimental design, technique, and interpretation. Poorly designed or executed studies are likely to give misleading results. For this reason the PAG is developing guidelines for the evaluation of supplementary feeding and fortification programmes. Such a document will include consideration of sample selection and size; nature of controls; number of replications; duration; anthropometric, clinical, biochemical, demographic and other criteria; statistical handling of the data and limitations to their interpretation.

The general problem of assessment of nutritional status has been reviewed in WHO Expert Committee Reports and by Jelliffe (56), but specific guidance should be provided as to the selection of measures for evaluation programmes of varying degrees of sophistication.

A major factor interfering with the effectiveness of nutrition intervention programmes among the underprivileged population of the developing countries is infectious disease. This subject has been extensively reviewed in a WHO monograph by Scrimshaw et al. (57). The frequency and severity of diarrhoeal respiratory, and other infectious diseases is often so great that little or no growth response is obtained from feeding programmes alone. Moreover, epidemics of a particular infectious disease in either an experimental or control group may seriously bias the results.

If experimental and control groups cannot be randomly drawn from the same population, great care must be taken to ensure that they are comparable, and in practice this may prove impossible. The guidelines should provide the best advice possible for circumventing these obstacles to the evaluation of the effectiveness of nutrition intervention programmes. Since the cost and feasibility of meeting the necessary conditions for a sound field evaluation vary considerably with the experimental design, guidelines should classify the various measures according to their sensitivity and indicate those which may be most readily eliminated without significantly reducing the value of a study.

9. Relation to other programmes

When a situation is identified as suitable for the application of amino acid fortification of staple foods, the foregoing factors and considerations having been taken into account, fortification programmes of this nature should be considered supplementary to a country's overall efforts to increase protein supplies through conventional and unconventional means. Amino acid fortification projects should be judged in comparison with other means of solving the protein problem, with full consideration of the economic and social factors involved.

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NATIONAL FOOD AND NUTRITION POLICY FOR THAILAND

1972 - 76

(abridged)

INTRODUCTION

In an economically developed society, higher income bears no direct relationship to the increase in food consumption expenditure (Fig. 1) Such increase does not account for more than 30 percent of the total increase in income.[2] Evidence suggests that when income increases, people tend to spend a good proportion of their earning on commodities and services other than food.

On the other hand, in a typical rural community where income level is low with consequently less money transactions, variations in the eating pattern of the populace generally are limited and markedly influenced by the community's ecology. Available but limited data reveals no influence of an increase in income on the eating pattern. For example, foods which are normally consumed by a villager will in no way be different from those of the village chief who is relatively better off.

However, with improved economic conditions of a family coupled with improved market and buying power, deviation from traditional eating pattern may result. More money may be spent on items which are previously out of reach, such as entertainment (radio), transport (motorcycle). This is done usually at the expense of the family's food quality. The phenomenon is painfully true especially in city slums where one finds unsettled rural families which migrate into town to seek employment.

ANALYSIS

As a basis for the food and nutrition policy, data from the national food balance sheet are used [2] It should be pointed out that these data indicate the country's averages and do not show any variation which exists among different population groups. Such statistics should be regarded only as a guide to the identification of problem areas, hence they serve to minimize error in the policy formulation. When better and more complete data are available, adjustment of the policy will be in order as is deemed necessary.

Fig. 1 Household expenditure survey 1962 [1]

Household expenditures by levels of income 1962, Bangkok - Dhonburi Municipal area

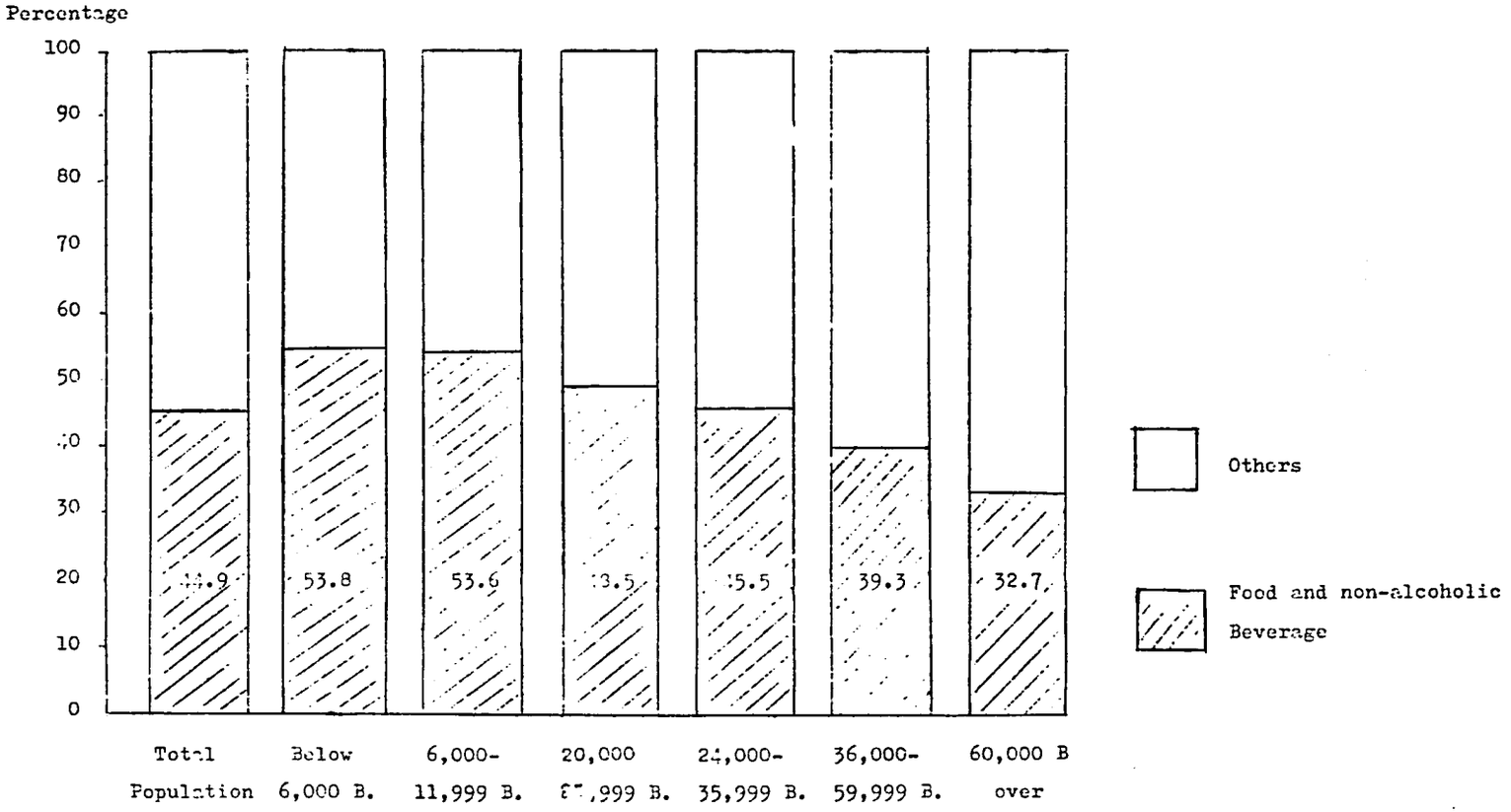


Table 1

Average per Caput Food Consumption - Thailand 1962

(from the food balance sheet[3])

	Kg. per year	Calorie per day	Protein	Fat
			gm. per day	
Total	-	2,127	46.5	33.6
— Plants	-	1,973	35.9	23.1
— Animals	-	149	10.6	10.5
Food Groups				
Rice	226.0	1,513	28.4	3.1
Cereals	44.0	98	1.0	0.3
Sugar	9.8	97	0.2	-
Pulses	36.9	184	4.1	15.8
Vegetables	39.7	24	1.5	0.2
Vegetable oils	1.2	29	-	3.2
Plants, fruits	1.0	8	0.4	0.3
Animals and animal products	14.6	91	4.9	7.7
Eggs	3.0	12	0.9	0.9
Fish, crustaceans	13.5	24	4.2	0.7
Dairy and dairy products	6.6	14	0.5	0.4
Animal oil and fats	0.3	8	-	0.8

Table 2

Average daily per Caput Intake of Nutrients - Thai Civilian[4]

	Number of Family	Number of Population	Calories	Total gms.	protein % of Calories	Animal gms.	protein % of Total protein	Fat gms.
1. Calculated from food table	93	513	1,821	49.1	10.8	15.2	31.0	18.0
2. Food analysis	93	513	1,770	47.2	-	-	-	17.3

CALORIC CONSUMPTION STATUS

Data on food comsumption in Thailand as derived from the country's food balance sheet[3] are shown in Table 1 while Table 2 shows results of the dietary surveys in selected population from each region. It may be noted that the data are agreeable and indicate small intake deficit as judged from the recommended daily allowance for Thailand.[5]

The average calorie consumption of the population is slightly less but acceptable.

Table 3

Nutrition Indices for Thailand

Data	Average	Indices	
Temperature	27 °C	Protein Calorie Ratio	8.7
Weight Male	54 Kg.	NDp Cal %	5.3
Female	47 Kg.	Fat/Calorie Ratio	14.2
Calorie requirement	2,195 Cal.	Calorie Consumption %	97.8
Protein requirement (local)	50.5 Gm./day	Protein Consumption %	92.0

Somehow, the figure may conceal variations among population groups due to different economic status. Consequently, it is possible to find in a certain segment the population calorie-deficient individuals or groups.

Furthermore, the average figure tends to mask any seasonal or geographical variation. These ecologic constraints do play very decisive role in rural communities because most of the foods consumed are locally produced.

Thus, variations in calorie consumption of rural community will depend largely on the level of production of local foodstuff. Evidence[6] suggests that in such a place the decline in food production will affect more than proportion to number of families. Bigger families will be more affected by the change and children of those families, in particular will be the first to show signs of deficiency.

Hence, policy in calorie provision for the population may emphasize the programme to increase food supply for local consumption so that foods become more available to the under-privileged group.

PROTEIN CONSUMPTION STATUS

The average protein intake of the population is 46.5 - 47.0 gm. per caput per day or 0.9 gm. per kg. body weight per day (Table 1, 2). This range, although on the low side (Table 3), is acceptable.

However, if one considers recommended age-specific protein allowance for young Thai children, the protein intake should start at over 2 gm. of local protein per kg. per day for infant, then gradually decline to the level of 1 gm. per kg. per day when the child reaches adolescence (Table 4).

Table 4

Local Protein Requirements (B.V. 70)

Thai Population by age[5]

	Age Year	Weight Kg.	Local protein Gm.	Local protein Gm./Kg. body weight
Infant	0-1	6	14	2.3
Children	1-3	10	17	1.7
	4-6	16	21	1.3
	7-9	20	24	1.2
	10-12	25	32	1.2
Young adult	13-15	37	39	1.0
	16-19	48	41	0.9
Adult				1.0
Pregnancy increased 20 gm./day				
Lactating women increased 40 gm./day				

Considering the eating habit of rural Thais, one finds that food other than rice are usually shared by member of the family from the common dish. No extra amount of protein is provided for children. This practice leads to the assumption that children could get from their diet the same proportion of nutrients as adults. Because of the difficulty in conducting individual dietary survey under such condition, the available data on children's intake are limited. Table 5 gives the result of such survey made in rural Thailand among children of the age group 1-5. It reveals that the amount of rice a child could take in a day would yield approximately 1.1 gm. per kilo body weight of local protein. Older children may get more protein from

the side dishes in the form of animal or pulse protein (which would amount to no more than 30% of total protein according to the Thai food pattern- Table 6). If this is the case, total intake of protein may be raised to approximately 1.7 gm./Kg./day. However, for young rural children, it is customary that supplementation of rice by animal protein is restricted due to certain taboos, with the result that children receive almost all their supplement to breast milk in the form of rice or other carbohydrate foods. Against this background, it may be estimated that the child receives not more than 1.1 - 1.2 gm. of local protein per Kg. body weight per day.

Table 5

Amounts of Rice Consumed by Children 1-5 years of age

Ubol Rural 1966[7]

Age year	Number Total (male/female)	Weight (average) Kg.	Rice Gm./day	Rice protein Gm./day	Rice Protein Gm./Kg. body w
1	2 (1/1)	8.4	136	9.9	1.2
1 ½	3 (0/3)	9.1	152	11.1	1.2
2	4 (3/1)	10.8	164	12.0	1.1
2 ½	1 (1/0)	11.7	169	12.3	1.0
3	10 (6/4)	12.1	190	13.9	1.1
4	5 (3/2)	13.6	213	15.6	1.1
5	9 (5/4)	14.8	222	16.2	1.1

Table 6

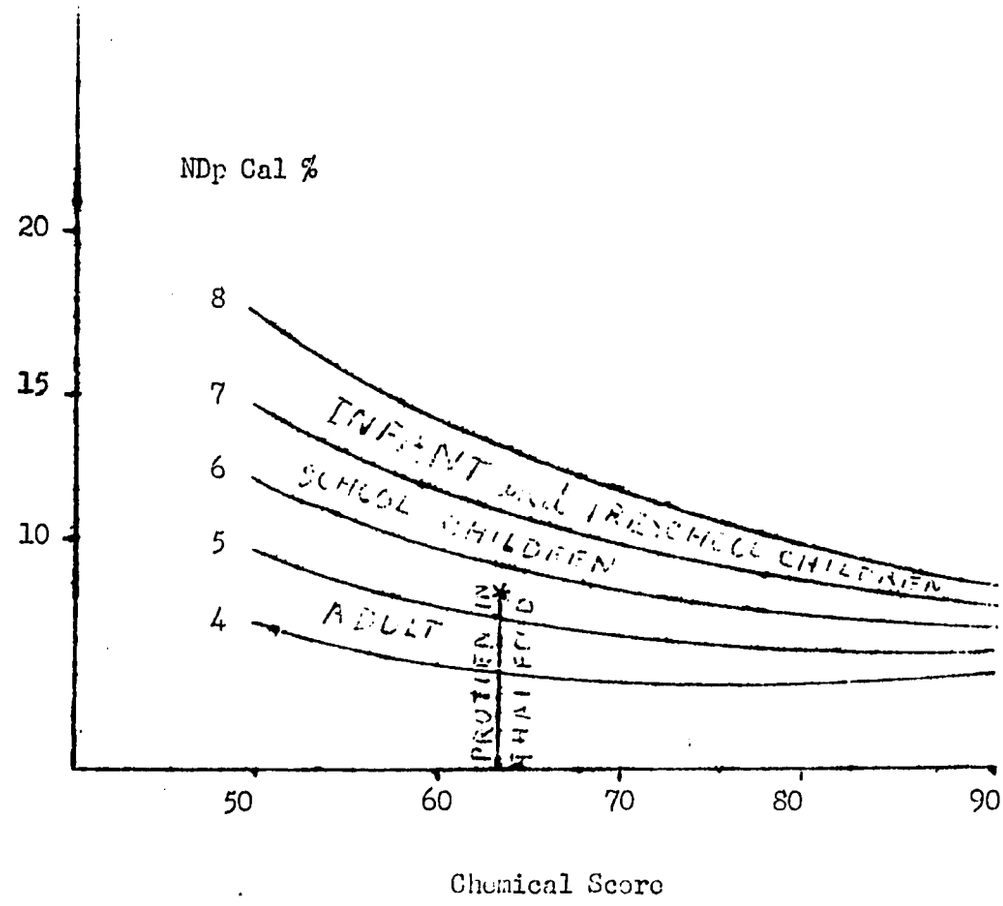
Protein Contents of Thai Rice-based Diet[3]

1. Total protein	49.5 gm./day
2. Protein sources:	
Rice	61 %
Animal	21 %
Pulse	9 %
Others	9 %
3. Chemical score	
Isoleucine	64
Leucine	89
Lysine	73
Sulfur-Containing Amino Acid	65
Phenylalanine	78
Tyrosine	73
Threonine	70
Tryptophan	80
Valine	76

Furthermore, to attain optimal growth, the protein calorie ratio of the diet must also be satisfactory. For a pre-school child, this ratio should range from 13-15% while in a school child, 10-13% is considered adequate. The Thai rice-based diet, on the other hand, with a chemical score of 64 (Table 6) will give a protein calorie ratio of 8.7%. This level may be considered satisfactory for adults, but definitely not for children (Fig. 2).

Fig. 2: The Protein status of rice-based diet[8] (expressed as NDP Cal. %)

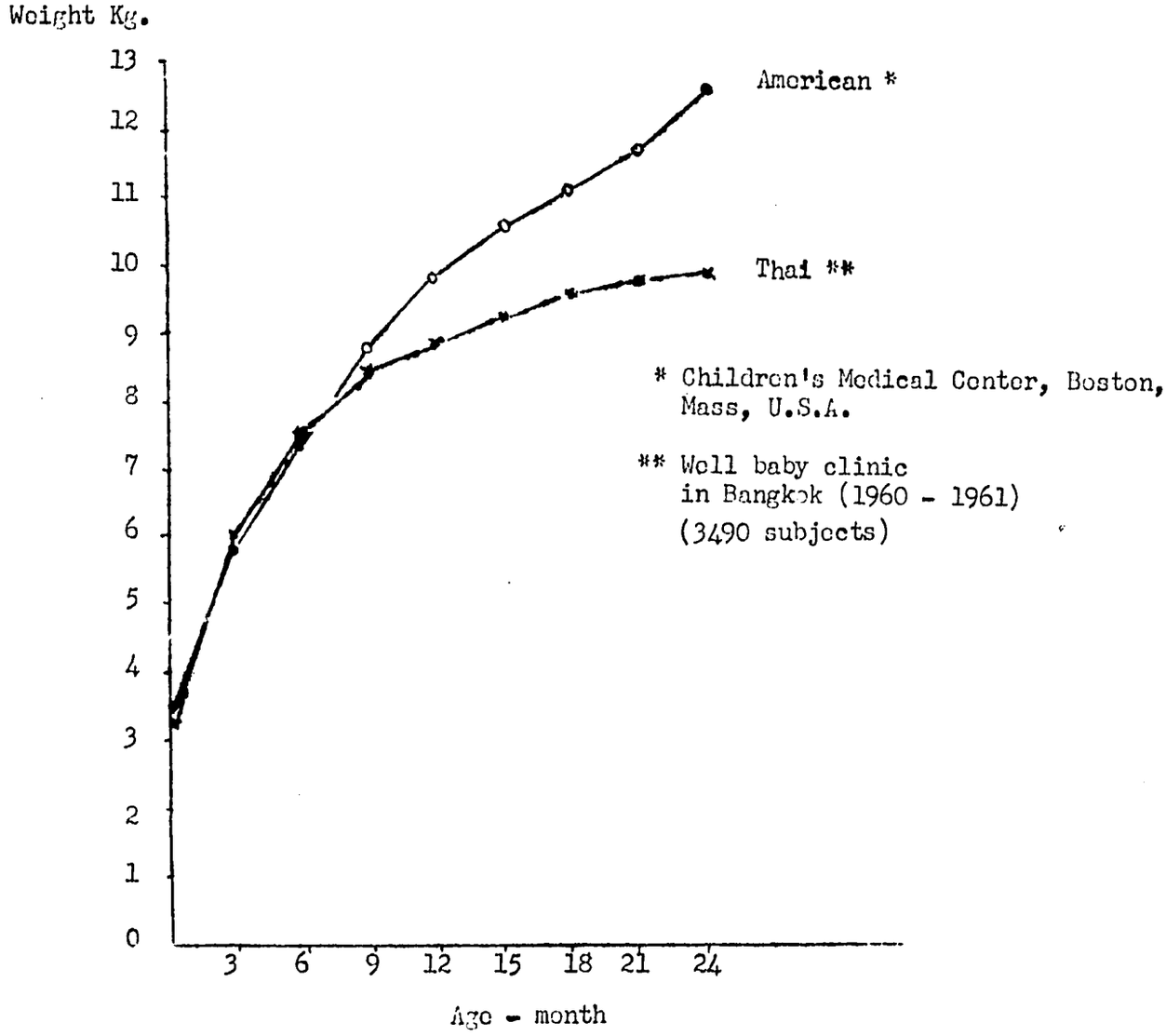
Protein Calorie Ratio



Consequently, the growth performance of a Thai child could match with his western counterpart only as long as he is fully breast fed. After 6 months of age, when supplementary feeding begins to play a role the rate of growth declines[9] (Fig. 3).

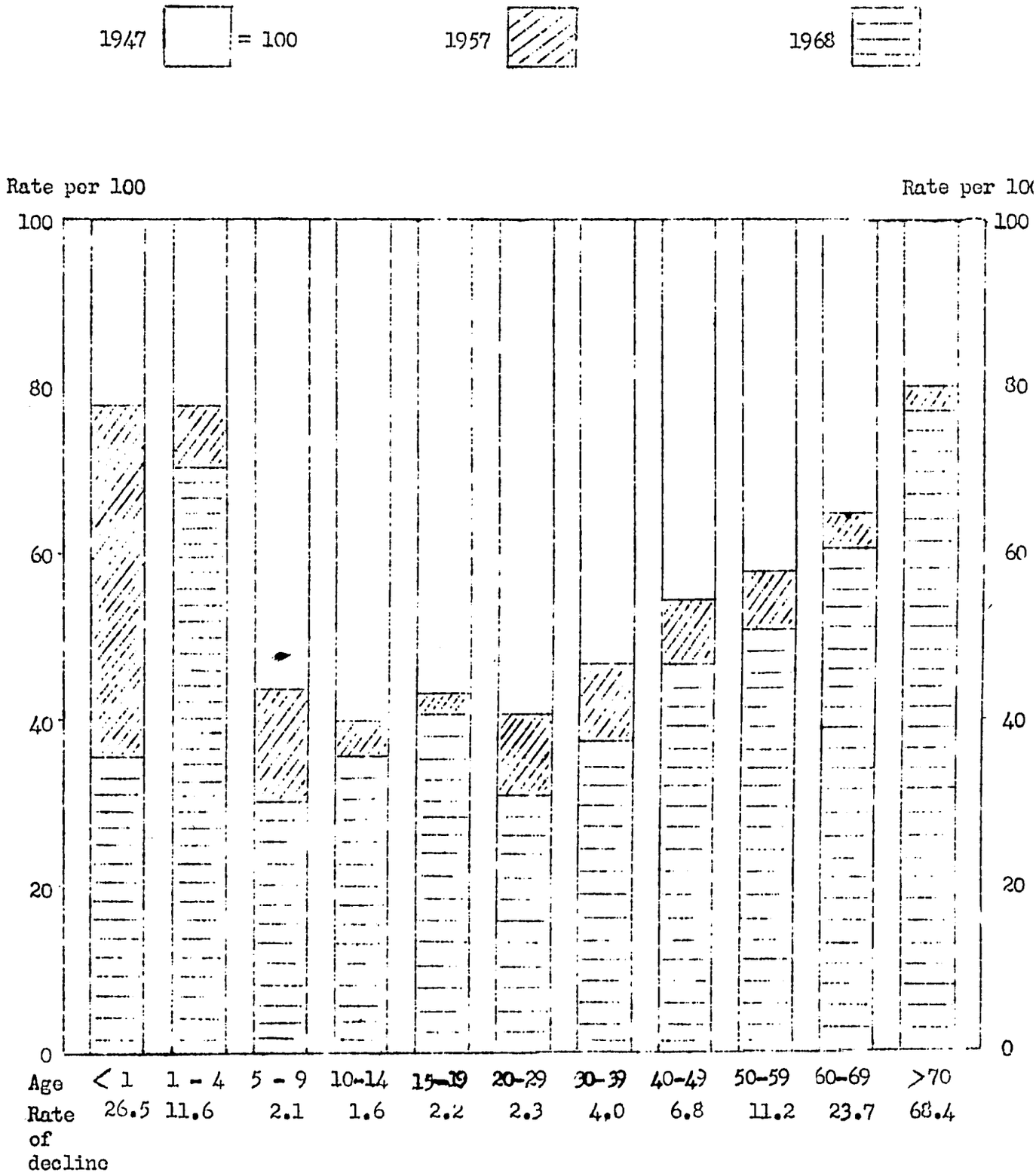
Aside from physical growth, severe protein deficiency also affects mental development. Damage to the brain, from protein malnutrition, once occurred, cannot be fully restores.[10]

Fig. 3: Comparison of Weight of Thai and American Children[9]



Apart of hindering growth and development of the young child (especially during the post weaning and preschool period), protein malnutrition also gives way to decreased resistance to infection. The phenomenon is reflected in the high morbidity and mortality rates of infectious diseases (especially those of the gastrointestinal and respiratory systems) in 1-4 year old children. These high rates may not be brought down successfully if the child nutritional status is not taken care of. Figure 4 shows that the age specific mortality of 1-4 year old Thai children exhibits least decline within the last 22 years (from 1947 - 1968).

Fig. 4: DECREASE OF DEATH RATE BY AGE - THAILAND 1947, 1957, 1968



PROTEIN QUALITY OF RICE-BASED DIET

The source of protein in the food is from plant or animal, its quality could be measured against egg protein which is considered best natural source. Protein of lower quality must be consumed in greater amount in order to achieve the same advantage.

Estimation of protein quality could be done using laboratory animals (expressed in units such as biological values- B.V. protein officiency ratio- PER, etc.). To obtain quick overall estimation of protein quality, calculation method by which amino acid contents in the protein are compared against those in the egg may be used. The amino acid which gives lowest percentage by such comparison is considered the limiting factor to the quality of that protein and is called "protein score" or "chemical score" (Table 6).

In Thailand where rice is staple in the diet, the protein calorie ratio is somewhat low. This is due to the low protein content of rice which is considered its main drawback. However, the low protein calorie ratio will mostly affect the young population in which more protein of high quality is essential for optimal growth. The quality of the rice-based Thai diet, on the other hand, is more or less satisfactory (giving a protein score of as high as 64) because of the relatively well balanced amino acid contents of the rice protein. Rice protein, the major source of protein in the diet, is considered to be one of the best vegetable proteins nature produces.

Based on its quality index (expressed in NDp Cal %), Thai diet has been shown to have an NDp Cal of 5.3% which is satisfactory for adult (Fig. 2) but, as is previously discussed, not for children. Thus the problem with this type of diet is rather one of insufficient quantity than poor quality.

RELATIONSHIP OF INCOME TO THE FOOD PATTERN

In a society with market economy, the income level bears no relationship to the protein calorie ratio but will affect the type of protein of the diet. Higher income will see increased animal protein, fat and sugar intake while there is corresponding decrease in the consumption of vegetable protein hence, there is no change in the overall protein calorie ratio (Fig. 5).

In developed countries, the average protein calorie ratio in the food is approximately 11 - 12 %[3]. The figures in developing countries are lower (Thailand 8.7 %). The ratio can be increased by raising the level of animal protein intake or changing staple diet. Available data point to the fact that when economy improves, protein calorie ratio will gradually increase and eventually maintain an

equilibrium at 11 - 12 %.

PROJECTION

In planning for future policy on food and nutrition, more data are needed on economy, agriculture and population. Any change in the dietary pattern of a society as a result of the change in either of these components needs further studies.

Because the changing dietary pattern of a society is a slow process while the production of most of the animal protein sources within the country does not show any significant rise in relation to population growth (Table 7) it can be predicted with reasonable accuracy that any change in the dietary pattern, if there is at all, will be minimal during a short period of 5 years for which recommended policy will be formulated.

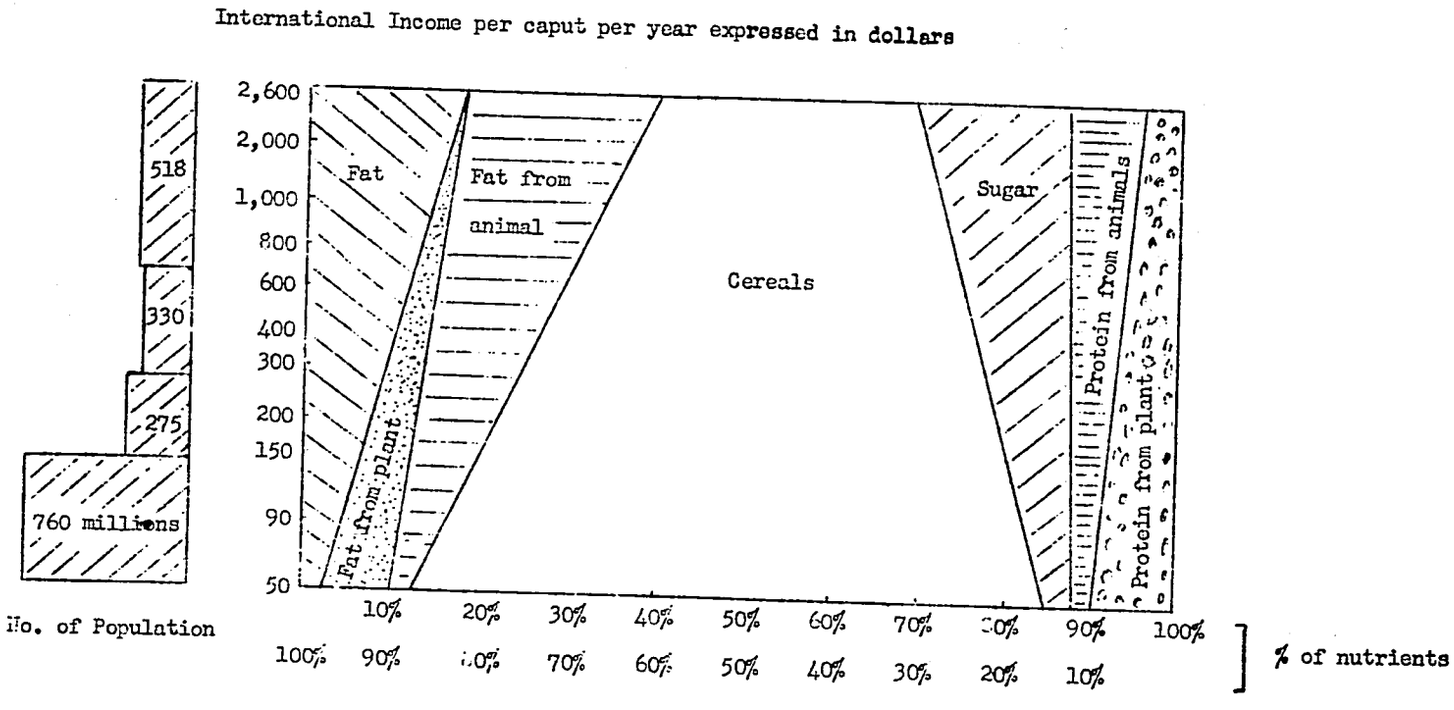


FIG. 5 Calories from fat, Carbohydrate and Protein expressed in percentage of total calories, by international income of 84 countries 1962 [2]

Animal Food Sources 1957 - 1966[12] for Thailand

Year	Cattle	Cow	Pig	Chicken (1000)	Duck (1000)	Fish (1000 tons) Sea	Fish (1000 tons) Water	Thai population*
2500	5,938,077	4,983,417	3,738,672	23,861	9,410	171	64	
2501	6,293,620	5,044,807	3,921,926	28,810	8,617	145	51	
2502	6,422,253	5,114,567	4,205,620	24,632	6,324	148	57	
2503	6,666,120	5,264,765	4,231,248	24,003	8,719	146	73	26,392,000
2504	6,749,344	5,099,181	5,246,230	25,170	7,236	233	72	27,210,000
2505	6,914,774	5,440,784	4,389,140	23,223	7,029	270	70	28,054,000
2506	7,087,137	5,347,044	4,466,834	24,895	10,155	323	95	28,923,000
2507	6,877,965	5,235,821	4,291,283	31,005	11,670	494	83	29,820,000
2508	6,691,103	5,103,854	4,805,370	33,992	11,719	529	86	30,744,000
2509	6,877,584	5,167,350	4,045,104	35,323	9,699	635	85	31,698,000
Rate Percentage increase in 10 years	15.82	3.69	8.19	48.04	3.07	271.34	32.81	
Rate Percentage increase in 1 year	1.58	0.37	0.82	4.80	0.31	27.13	3.28	3.2

* Population and Vital Statistics Report

Based on the quality analysis of rice-based diet, it can be predicted that the most vulnerable group of population will be the preschool children, the infant, pregnant and lactating women and the school children. Top priority should be given to the preschool age group because of the fact that rice-based diet does not supply sufficient amount of protein needed for their optimal growth, and the traditional eating pattern does not allow supplementation of good protein for this age group.

It is not expected that the situation will correct itself even if economy improves for the reason mentioned elsewhere in this paper. The rice in income level will exert only limited influence on the nutritional status of the population and that is due mainly to the better quality of more animal protein being consumed.

Table 8

Protein Quality of Selected Plants and Animal[13]

Type	Chemical score
Plants	
Polished rice	56
Wheat	32
Potato	34
Pulse	47
Animals	
Meat	69
Pork	69
Chicken	64
Fish	70

FOOD AND NUTRITION POLICY

1. PROTEIN SUPPLEMENTATION FOR THE TARGET GROUP

One measure to cope with the protein problem is to increase, by supplementation, the protein calorie ratio in the child's diet up to the level of 13 - 15%. Such an increase cannot be expected to occur automatically as a result of increased income, since protein-calorie ratio will reach an equilibrium at 11 -

12% and the traditional eating pattern does not allow for extra protein to be given to the vulnerable age group.

It is considered necessary that supplementary feeding be established for the vulnerable groups, especially the pre-school child, the infant and school child in that order of priority.

One objective of such a program is to supplement, not substitute, the daily protein intake of the child while nutrition education is given to his parents, the final aim of such a program is to affect change in the eating pattern within the family in a way that the child could get more share of the protein in the family's diet.

Since protein supplementation must be carried out on a continuous basis. The success of the outcome will lay in part on the methodology used in reaching the target group, especially the pre-school child.

2. PROMOTION OF PROTEIN FOOD PRODUCTION AT LOCAL LEVEL

In a traditional society, the majority of food consumed is produced by the family. For this type of society, it is essential to support protein food production at local level. Priority is given to protein of animal origin followed by pulses because the quantity required to serve the target group is limited while pulses, on the other hand, are not commonly used in Thai foods. The promotion program should also aim at raising the income level of the producer for incentive purpose.

3. PROTEIN FOOD DEVELOPMENT

Other venue which should be seriously probed is the development of cheap protein foods. Cheap sources of protein are mostly vegetable in origin. Utilization of such protein would also help alleviate the need for higher production of animal protein to satisfy the demand of increasing population. For this type of program to last, the source of protein to be utilized should be produced in adequate quantity with relatively stable price.

The development of protein foods should also aim at producing formulae of highest protein quality as is technically and economically feasible.

Because high quality vegetable protein sources such as pulses are not commonly included in the Thai foods, utilization of these sources should involve food processing techniques which would give the product form and properties acceptable to the general public.

It is also deemed necessary that a corps of food technologists be developed

in the country and their work be coordinated with the nutritionist under an integral food and nutrition plan.

The final consideration in the development of protein foods is that the success of the program would depend on the plan for marketing and distribution of the finished products.

4. RESEARCH ON HIGH-PROTEIN RICE VARIETIES

Research on genetics and ecology of plants has recently produced significantly high yielding rice varieties. This discovery should solve the problem of calorie deficiency at least for the time being. However, high-yielding rice does not serve to alleviate protein deficiency in the population unless protein content of such rice can be improved.

In a country with rice-based diet such as Thailand, lysine is generally not a constraint to the protein quality. Even though the gaps between the first few amino acids in these diets have not been fully studied, it could still be recommended that high protein rice varieties should be the object of rice research, and should be given serious consideration.

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นโยบายอาหาร

และ

โภชนาการสำหรับประเทศไทย

ระหว่าง พ.ศ. 2515–2519 (1972–1976)

ซึ่ง

ค.ร.ม. รับ เป็นโครงการระดับชาติ

เมื่อ

27 ต.ค. 2513

ข้อเสนอแนะนโยบายอาหารและโภชนาการสำหรับประเทศไทยนี้ ได้จัดทำโดยมุ่งหวังที่จะให้สอดคล้องกับแผนพัฒนาเศรษฐกิจแห่งชาติ โดยได้ทำการศึกษาถึงสถานะทางอาหารและโภชนาการในประเทศ ตลอดจนความสัมพันธ์ที่จะมีต่อฐานะเศรษฐกิจของประชาชาติ การศึกษาเรื่องนี้ ข้อมูลส่วนใหญ่ได้มาจากการวิเคราะห์บัญชีดุลย์การใช้อาหารสำหรับประเทศไทย (National Food Balance Sheet) ซึ่งเป็นข้อมูลที่เป็นอัตราเฉลี่ยของทั้งประเทศ ดังนั้น จึงมิอาจแสดงถึงความแตกต่างที่อาจมี ในระดับสังคมแต่ละชั้น ในประชากรแต่ละกลุ่มอายุ หรือในภูมิภาคที่แตกต่างกันได้

ในปีที่ทำการวิเคราะห์ (พ.ศ. 2505) เมื่อคิดคำนวณค่าเฉลี่ยของแคลอรี* และโปรตีน** ที่ประชากรจะได้รับจากปริมาณอาหารที่มีเพื่อบริโภคในประเทศ ปรากฏว่าได้ปริมาณแคลอรี่เพียงพอ คือ ใกล้เคียงกับที่กำหนดไว้สำหรับความต้องการของประชากร (97.8% ของความต้องการ) สำหรับโปรตีน ต่ำไปเล็กน้อย (92.0% ของความต้องการ) ปริมาณโปรตีนในระดับนี้ ไม่เพียงพอสำหรับการเจริญเติบโตเต็มที่ของเด็ก โดยเฉพาะเด็กวัยก่อนเรียน การขาดโปรตีนในวัยอันสำคัญ คือวัยก่อนเรียนนอกจากจะมีผลทางร่างกาย ทำให้เด็กไทยไม่เติบโตทัดเทียมกับเด็กในประเทศที่พัฒนาแล้ว ยังมีผลทางการพัฒนาทางสมองและสติปัญญาซึ่งจะไม่สมบูรณ์เต็มที่อีกด้วย อันจะเป็นผลร้ายที่ติดตัวเด็กไปตลอดชีวิต และเป็นอุปสรรคต่อการพัฒนาประเทศเป็นส่วนรวมด้วย

อย่างไรก็ดี สำหรับประเทศไทยซึ่งมีข้าวเป็นอาหารหลักนั้น คุณภาพของโปรตีนที่ได้จากข้าวเป็นโปรตีนที่มีคุณภาพดี แต่ข้อบกพร่องอยู่ที่ปริมาณของโปรตีนที่มีในข้าวมีน้อยเกินไปเท่านั้น

จากการศึกษาความสัมพันธ์ของลักษณะการบริโภคอาหารกับรายได้นั้นพบว่า เมื่อรายได้สูงขึ้นคุณภาพของโปรตีนที่บริโภคจะดีขึ้นบ้าง แต่ไม่มากนัก เนื่องจากมีการบริโภคเนื้อสัตว์เพิ่มขึ้น

จากการศึกษาและวิเคราะห์ข้อมูลดังกล่าว นโยบายด้านอาหารและโภชนาการควรกำหนดดังต่อไปนี้.—

1. เรื่องที่มีความสำคัญเป็นอันดับแรก และมีความจำเป็นมากได้แก่การจัดโครงการเพื่อเสริมโปรตีนในอาหารของเด็กวัยก่อนเรียน พร้อมกันนั้น ต้องดำเนินการให้โภชนศึกษาแก่มารดาหรือผู้ดูแลเด็ก เพื่อให้มีการจัดสรรอาหารโปรตีนให้กับเด็กเป็นพิเศษด้วย หากทำได้ดังนี้ ผลดีที่ได้รับจะเป็นการถาวร

แคลอรี* เป็นหน่วยวัดพลังงานที่ได้จากอาหาร

โปรตีน** เป็นสารอาหารที่จำเป็นแก่การเจริญเติบโตและซ่อมแซมร่างกาย มีอยู่ในอาหารประเภทเนื้อสัตว์ และพืชผักต่าง ๆ

2. เพื่อที่จะให้การจัดเสริมอาหารโปรตีนให้เด็กวัยก่อนเรียนได้รับความสำเร็จ จำเป็นต้องจัดโครงการสนับสนุน โดยให้มีการผลิตอาหารประเภทเนื้อสัตว์ เช่น ไก่ ปลา ฯลฯ ในระดับหมู่บ้านควบคู่กันไปด้วย แล้วใช้ผลิตผลเหล่านี้ประกอบเป็นอาหารเด็กวัยก่อนเรียนอีกทีหนึ่ง

3. งานอีกด้านหนึ่งที่ควรกระทำคือ การจัดโครงการพัฒนาอาหารโปรตีนขึ้น เพื่อใช้ประโยชน์จากโปรตีนที่ยังไม่มีการใช้กันมาก เช่นโปรตีนจากพืช การพัฒนาดังกล่าวจะสำเร็จได้ก็ต่อเมื่อมีการพิจารณาอย่างละเอียดถึงเรื่องต่าง ๆ ต่อไปนี้ คือ ปริมาณของแหล่งโปรตีน ราคา รูปลักษณะ รส ตลอดจนวิธีเผยแพร่และค้าอาหารโปรตีนเหล่านั้น

4. ในระยะยาวนั้น เห็นว่า การวิจัยและค้นคว้าเพื่อหาพันธุ์ข้าวที่ให้ทั้งผลผลิต และปริมาณโปรตีนสูงจะช่วยให้การแก้ปัญหาเรื่องโปรตีนประสบความสำเร็จอย่างถาวรและกว้างขวางยิ่งขึ้น จึงเป็นงานที่ควรสนับสนุนทุกวิถีทางตั้งแต่บัดนี้

นโยบายอาหารและโภชนาการสำหรับประเทศไทย

ระหว่าง พ.ศ. 2515–2519

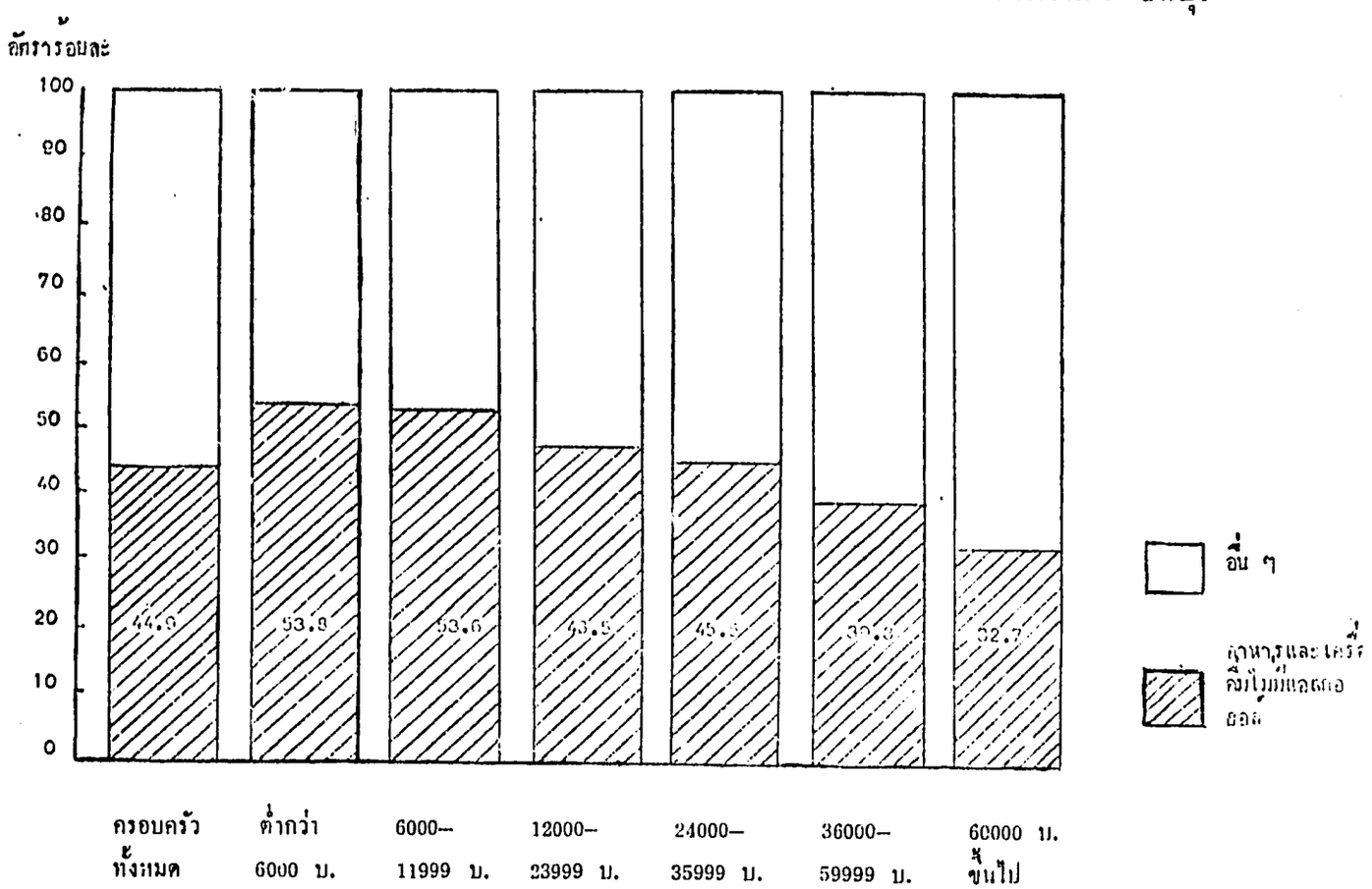
คำนำ

1. ในชุมชนที่มีรายได้สูง กำลังซื้อที่เพิ่มขึ้นมิได้มีส่วนสัมพันธ์กับลักษณะการบริโภคอาหารโดยตรง จากข้อมูลสถิติ[1/] ได้แสดงให้เห็นว่าเมื่อรายได้ของครอบครัวสูงขึ้น รายการใช้จ่ายเกี่ยวกับอาหารหาได้สูงขึ้นเป็นสัดส่วนตามกันไม่ (ภาพที่ 1) มีรายงานอื่น[2/] ซึ่งแสดงว่า ลักษณะการบริโภคอาหารที่เปลี่ยนแปลงเนื่องจากรายได้นั้นมีไม่เกิน 30 % นอกนั้นเป็นเพราะสาเหตุอื่น ทั้งนี้แสดงให้เห็นว่า ในชุมชนที่มีการเศรษฐกิจระบบตลาด (Market Economy) ประชากรที่มีรายได้เพิ่มขึ้นจะมีโอกาสจับจ่ายใช้สอยเพื่อซื้อหาอุปโภคและบริการอื่น ๆ ที่นอกเหนือไปจากอาหารได้มากขึ้นและจะใช้จ่ายไปทางนั้น

2. ในทางตรงกันข้าม ในชนบททั่วไปซึ่งประชากรมีรายได้ต่ำการหารายได้ การซื้อขายหรือใช้เงินตราจะมีบ้างก็เป็นส่วนน้อย ลักษณะการบริโภคอาหารจะเป็นไปตามแบบที่ยึดถือกันมาแต่ดั้งเดิม คือแล้วแต่ลักษณะภูมิประเทศและสิ่งแวดล้อมของชุมชนนั้น ๆ ข้อมูลเท่าที่มีอยู่โดยจำกัดขณะนี้ แสดงให้เห็นว่า ในชุมชนดังกล่าวอิทธิพลของรายได้ที่สูงขึ้นเกือบจะไม่มีผลต่อแบบอย่างอาหารที่บริโภค (Food Pattern) เช่น อาหารที่ชาวบ้านธรรมดาบริโภคก็มิได้แตกต่างอย่างเห็นได้ชัดจากอาหารที่กำนันผู้ใหญ่บ้านบริโภคเลย

3. เมื่อชุมชนมีการเปลี่ยนแปลงสภาวะทางเศรษฐกิจไปในทางที่ดีขึ้น ก็จะทำให้สามารถจับจ่ายใช้สอยเงินตราเพิ่มขึ้น แบบอย่างอาหารที่บริโภคก็จะเริ่มหันเหออกไปจากแบบที่ยึดถือกันมาแต่ดั้งเดิม เมื่อถึงระยะนี้ หากไม่มีนโยบายที่จะนำครอบครัวให้เลือกซื้ออาหารที่เป็นประโยชน์เพื่อทดแทน หรือเสริมอาหารแบบดั้งเดิมของตนแล้ว ครอบครัวส่วนใหญ่จะใช้จ่ายเงินที่หามาได้ไปในทางที่ไม่เคยใช้มาก่อน เช่นซื้อการบันเทิง (วิทยุทรานซิสเตอร์) ยานพาหนะ (รถจักรยานยนต์) ฯลฯ การใช้จ่ายดังกล่าวจะมีผลให้คุณภาพของอาหารเสื่อมทรามลง ดังนั้น ในบางครั้ง ผลร้ายที่เกิดขึ้นกลับมีมากกว่าผลดีที่รายได้เพิ่มขึ้นอีก ตัวอย่างเช่นนี้จะพบได้เสมอในแหล่งเสื่อมโทรมตามเมืองใหญ่ ๆ ซึ่งครอบครัวชนบทอพยพมาหางานทำและยังไม่สามารถจะตั้งหลักฐานได้มั่นคง

ภาพที่ 1 การสำรวจรายการใช้จ่ายของครอบครัว พ.ศ. 2505[1/] อัตราร้อยละของค่าใช้จ่ายต่าง ๆ ของครอบครัว จำแนกตามชั้นของรายได้ของครอบครัว พ.ศ. 2505 เขตเทศบาลจังหวัดพระนคร ธนบุรี



4. ความพยายามเพื่อวางนโยบายทางด้านอาหารและโภชนาการในขั้นนี้ ได้เริ่มขึ้นโดยอาศัยบัญชีดุลย์การใช้อาหารของประเทศ[3/] เป็นสำคัญ ทั้งนี้ พึงระลึกไว้เสมอว่า สถิติตัวเลขต่าง ๆ ที่จะอ้างถึงต่อไปนี้ เป็นผลเฉลี่ย ของทั้งประเทศ ย่อมจะไม่สามารถชี้ให้เห็นความผิดแผกแตกต่าง ซึ่งมีอยู่เป็นปกติธรรมดาในกลุ่มต่าง ๆ ของชุมชน สถิติเหล่านี้จะชี้บ่งให้เห็นแต่ปัญหาใหญ่ ๆ ซึ่งพอที่จะช่วยให้การตัดสินใจวางนโยบายต่าง ๆ มีความผิดพลาดน้อยลง เท่านั้น เมื่อได้ข้อมูลจากการสำรวจอาหารการใช้จ่ายและอื่น ๆ อย่างครบถ้วนยิ่งกว่าในปัจจุบัน การวางนโยบายต่าง ๆ จะทำได้รัดกุมและถูกต้องตรงกับสถานการณ์ที่เป็นจริงมากยิ่งขึ้น

ตารางที่ 1 ปริมาณอาหารที่ใช้เพื่อบริโภคในประเทศไทย

พ.ศ. 2505 (จากบัญชีดุลย์การใช้อาหาร)[3/]

	จำนวน ก.ก./ปี	แคลอรี่ ต่อวัน	โปรตีน	ไขมัน
			กรัม/วัน	
ทั้งหมด	—	2,127	46.5	33.6
— จากพืช	—	1,973	35.9	23.1
— จากสัตว์	—	149	10.6	10.5
กลุ่มอาหาร				
ข้าว	226.0	1,513	28.4	3.1
แป้ง	41.0	98	1.0	0.3
น้ำตาล	9.8	97	0.2	—
ถั่วต่าง ๆ	36.9	184	4.1	15.8
ผัก	39.7	24	1 5	0.2
น้ำมันพืช	1.2	29	—	3.2
พืช ผลไม้เบ็ดเตล็ด	1.0	8	0.4	0.3
เนื้อสัตว์และผลิตภัณฑ์เนื้อ	14.6	91	4.9	7.7
ไข่	3.0	12	0.9	0.9
ปลา หอย	13.5	24	4.2	0.7
นม และผลิตภัณฑ์นม	6.6	14	0.5	0.4
น้ำมันสัตว์ ไขมัน	0.3	8	—	0.8

ตารางที่ 2 ปริมาณสารอาหารที่บริโภคต่อคนต่อวัน สำหรับพลเรือนไทย[4/]

วิธีที่ใช้	จำนวนครอบครัว	จำนวนคน	แคลอรี่	โปรตีนทั้งสิ้น		โปรตีนจากสัตว์		ไขมัน
				กรัม	% ของแคลอรี่	กรัม	% ของโปรตีนทั้งสิ้น	กรัม
1. คำนวณจากตารางแสดงคุณค่าอาหาร	93	513	1,821	49.1	10.8	15.2	31.0	18.0
2. วิเคราะห์อาหาร	93	513	1,770	47.2	—	—	—	17.3

การวิเคราะห์ข้อมูล

สถานะทางแคลอรี่ของอาหารไทย

5. การศึกษาข้อมูลเกี่ยวกับการบริโภคอาหารในประเทศไทย ตามที่ปรากฏในบัญชีดุลย์การใช้อาหารของประเทศ[3/] (ตารางที่ 1) และจากการสำรวจอาหาร (dietary survey) ครั้งใหญ่ทั่วประเทศโดยกรมอนามัยร่วมกับ Interdepartmental Committee on Nutrition for National Defense (ICNND)[4/] (ตารางที่ 2) แสดงว่าโดยเฉลี่ยการบริโภคแคลอรี่ของประชากรไทยอยู่ในระดับ 1,770--2,100 แคลอรี่ต่อคนต่อวัน จำนวนนี้น้อยกว่าอัตราความต้องการที่กำหนดไว้สำหรับประเทศไทยอยู่เพียงเล็กน้อย แต่นับว่าอยู่ในเกณฑ์ที่ยอมรับได้ (ตารางที่ 3)

6. อาจกล่าวได้ว่า อัตราเฉลี่ยของการบริโภคที่ได้มานี้ จะไม่แสดงถึงความแตกต่างของระดับการบริโภคในครอบครัวที่มีเศรษฐฐานะต่าง ๆ กัน โดยเหตุนี้ จึงอนุมานได้ว่า จะมีครอบครัวที่ด้อยฐานะอีกเป็นจำนวนไม่น้อยที่ได้รับแคลอรี่เป็นรายวันต่ำกว่าเกณฑ์ที่ควร

7. นอกจากนี้ อัตราเฉลี่ยดังกล่าวจะไม่แสดงความแตกต่างของการบริโภคอันเนื่องจากลักษณะของภูมิประเทศและฤดูกาล องค์ประกอบทั้งสองนี้ จะเป็นข้อจำกัดที่มีอิทธิพลต่อชนิดของอาหารที่บริโภคเป็นอย่างมาก โดยเฉพาะในสังคมชนบทซึ่งระบบเศรษฐกิจยังเป็นแบบดั้งเดิม (Traditional Economy) คือ อาหารที่บริโภคส่วนใหญ่ได้มาจากที่ผลิตขึ้นเอง

ตารางที่ 3 ดัชนีทางโภชนาการของประเทศไทย
คำนวณจากบัญชีดุลย์การใช้อาหาร [3] และ
สารอาหารที่ควรได้ประจำวัน [5]

ข้อมูล	ค่าเฉลี่ย	ดัชนีทางโภชนาการ	
อุณหภูมิ	27° ซ.	Protein Calorie Ratio	8.7
น้ำหนักชาย	54 ก.ก.	NDp Cal %	5.3
น้ำหนักหญิง	47 ก.ก.	อัตราส่วนไขมัน/แคลอรี่	14.2
ความต้องการแคลอรี่	2195 แคลอรี่	อัตราการบริโภคแคลอรี่%	97.8
ความต้องการโปรตีน (ท้องถิ่น)	50.5 กรัม/วัน	อัตราการบริโภคโปรตีน%	92.0

8. ความเปลี่ยนแปลงของการบริโภคแคลอรี่ในสังคมชนบทดังกล่าวแล้ว จึงขึ้นอยู่กับปริมาณการผลิตโดยส่วนรวมของสังคมนั้น ๆ เอง หลักฐานจากการศึกษา[6] แสดงว่า เมื่อระดับการผลิตลดลง อัตราส่วนของจำนวนครอบครัวที่ได้รับอาหารไม่เพียงพอจะสูงกว่าอัตราการลดลงของผลผลิตนั้น และครอบครัวใหญ่ที่มีบุตรมากจะได้รับผลร้ายก่อนและมากกว่าครอบครัวเล็ก โดยเฉพาะเด็ก ๆ ของครอบครัวเหล่านี้ จะเป็นพวกแรกที่แสดงการขาดอาหาร

9. โดยเหตุนี้ การวางนโยบายเกี่ยวกับแคลอรี่จึงมีทางเลือกอยู่ 2 ทาง คือ ทางแรกอาจแก้ไขความแตกต่างของระดับการบริโภคระหว่างกลุ่มประชากรที่มีเศรษฐฐานะแตกต่างกัน หากทำได้ดังนี้ ปริมาณการผลิตเพื่อบริโภคเท่าที่เป็นอยู่ก็นับได้ว่าเพียงพอสำหรับความต้องการ แต่อย่างไรก็ดี วิธีแก้ไขดังกล่าวจะทำได้ยาก หรือทำไม่ได้เลย ทางเลือกที่สองจึงได้แก่การส่งเสริมการผลิตเพื่อบริโภคให้มากขึ้น การมีอาหารไว้บริโภคจะได้สูงกว่าความต้องการ การกระทำดังกล่าวจำเป็นต้องพิจารณาองค์ประกอบสำคัญทั้ง 3 คือ จำนวนประชากร อัตราการผลิตอาหาร และปริมาณการค้าผลิตผลที่เป็นอาหารกับต่างประเทศ

สถานะทางโปรตีนของอาหารไทย

10. สำหรับปริมาณการบริโภคโปรตีนนั้น มีอัตราเฉลี่ยอยู่ในระดับ 46.5– 47.0 กรัมต่อคนต่อวันหรือ 0.9 กรัมต่อน้ำหนักตัว 1 ก.ก. ต่อวัน (ตารางที่ 1 และ 2) เมื่อเปรียบเทียบกับอัตราความต้องการโปรตีนท้องถิ่นของประชากรซึ่งกำหนดไว้ประมาณ 1 กรัมต่อน้ำหนักตัว 1 ก.ก. ต่อวันแล้วก็จะต่ำไปเล็กน้อย แต่ก็เป็นปริมาณที่พอยอมรับได้เช่นกัน (ตารางที่ 3)

11. อย่างไรก็ดี เมื่อพิจารณาอัตรเฉลี่ยความต้องการโปรตีนท้องถิ่นแยกตามอายุ (ตารางที่ 4) จะเห็นว่า ความต้องการในกลุ่มเด็กตั้งแต่อายุ 15 ปี ลงไป จนถึงแรกเกิด จะค่อยเพิ่มขึ้นจาก 1 กรัมต่อน้ำหนักตัว 1 ก.ก. ต่อวัน ขึ้นไป จนกระทั่งสูงกว่า 2 กรัมต่อน้ำหนักตัว 1 ก.ก. ต่อวัน

ตารางที่ 4 ความต้องการโปรตีนท้องถิ่น (B.V. 70) ของประชากรไทยแยกตามอายุ [5]

ประเภท	อายุ ปี	น้ำหนัก ก.ก.	โปรตีนท้องถิ่น กรัม	โปรตีนท้องถิ่น กรัม/น.น.ตัว 1 ก.ก.
ทารก	0–1	6	14	2.3
เด็ก	1–3	10	17	1.7
	4–6	16	21	1.3
	7–9	20	24	1.2
	10–12	25	32	1.2
วัยรุ่น	13–15	37	39	1.0
	16–19	48	41	0.9
ผู้ใหญ่				1.0
หญิงมีครรภ์ เพิ่มอีก 20 กรัม/วัน				
แม่ลูกอ่อน เพิ่มอีก 40 กรัม/วัน				

12. ในสังคมชนบท ลักษณะการบริโภคอาหารในครอบครัวเป็นแบบกินร่วมสำรับ ไม่มีการจัดสรรอาหารเป็นพิเศษเฉพาะเด็กแต่อย่างใด จึงอาจอนุมานได้ว่า อาหารของเด็กเหล่านั้น มีส่วนประกอบเช่นเดียวกับอาหารของผู้ใหญ่ การกินอาหารร่วมสำรับดังกล่าวทำให้การสำรวจอาหารเป็นรายบุคคล (Individual dietary survey) ทำได้ยาก อย่างไรก็ตามจากหลักฐานการบริโภคอาหารของเด็กอายุ 1—5 ปี เป็นรายบุคคล[7] (ตารางที่ 5) แสดงว่าปริมาณข้าวเท่าที่เด็กวัย 1 5 ปี จะกินได้ใน 1 วัน จะให้ปริมาณโปรตีนประมาณ 1.1 กรัมต่อน้ำหนักตัว 1 ก.ก. เท่านั้น สำหรับเด็กที่โตพอที่จะกินอาหารร่วมสำรับ หากได้กินกับข้าวไปพร้อมกันด้วยปริมาณโปรตีนที่เพิ่มขึ้นจากเนื้อสัตว์และถั่วในกับข้าว (ซึ่งอาจกล่าวได้ว่าจะไม่เกิน 30% ของโปรตีนทั้งหมดตามลักษณะอาหารของประชากรไทย ตารางที่ 6) ก็จะช่วยยกระดับปริมาณโปรตีนต่อวันขึ้นไปได้เป็นไม่เกิน 1.7 กรัม ต่อน้ำหนักตัว 1 ก.ก อย่างไรก็ดี สำหรับทารกและเด็กเล็กนั้น ประเพณีความเชื่อถือดั้งเดิมเกี่ยวกับของแสลงทำให้เด็กได้รับอาหารเสริมที่มีโปรตีนต่ำ ส่วนใหญ่จะเป็นอาหารประเภทแป้งทั้งสิ้น จะมีเนื้อสัตว์บ้างก็เป็นปริมาณน้อยที่สุด จึงพอคาดคะเนได้ว่า ปริมาณโปรตีนที่ได้รับ จะอยู่ในอัตรา 1.1 - 1.2 กรัมต่อน้ำหนักตัว 1 ก.ก. เท่านั้น

ตารางที่ 5 ปริมาณข้าวที่เด็กอายุ 1—5 ปี สามารถบริโภคได้
(จากการสำรวจอาหารรายบุคคลนอกเขตเทศบาล
จังหวัดอุบลราชธานี 2509 [7])

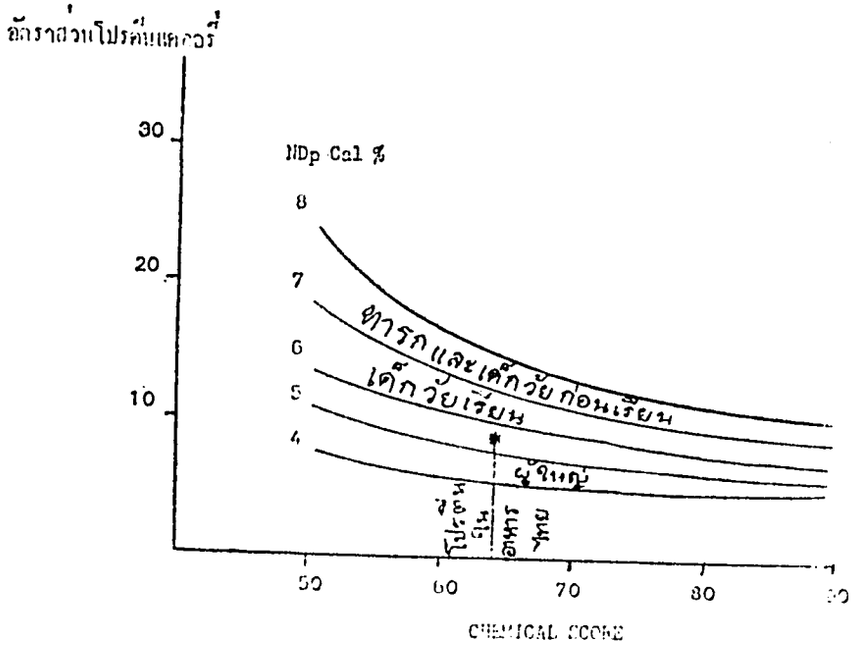
อายุ ปี	จำนวน รวม (ชาย/หญิง)	น.น. เฉลี่ย ก.ก.	ข้าว กรัม/วัน	โปรตีน จากข้าว กรัม/วัน	โปรตีนจากข้าว กรัม/น.น.ตัว 1 ก.ก.
1	2 (1/1)	8.4	136	9.9	1.2
1 1/2	3 (0/3)	9.1	152	11.1	1.2
2	4 (3/1)	10.8	164	12.0	1.1
2 1/2	1 (1/0)	11.7	169	12.3	1.0
3	10 (6/4)	12.1	190	13.9	1.1
4	5 (3/2)	13.6	213	15.6	1.1
5	9 (5/4)	14.8	222	16.2	1.1

ตารางที่ 6 สถานะทางโปรตีนของอาหารที่มีข้าวเป็นหลัก สำหรับประเทศไทย (จากบัญชีดุลย์การใช้อาหาร) [3]

1. โปรตีนทั้งหมด	46.5 กรัม/วัน
2. แหล่งของโปรตีน	
ข้าว	61 %
เนื้อสัตว์	21 %
ถั่วเมล็ด	9 %
อื่น ๆ	9 %
3. Chemical score	
Isoleucine	64
Leucine	89
Lysine	73
Sulfur-Containing Amino Acid	65
Phenylalanine	78
Tyrosine	73
Threonine	70
Tryptophan	80
Valine	76

13. ในการเสริมสร้างความเจริญเติบโตของร่างกายนั้น ปริมาณโปรตีนที่สูงพออย่างเดียวหาใช่คำตอบที่แท้จริงไม่ แต่อัตราส่วนของเคลอรี่ทั้งหมด (อัตราส่วนโปรตีนเคลอรี่*) ย่อมมีความสำคัญด้วย สำหรับเด็กวัยเรียนที่จะเติบโตเต็มที่ (Optimal weight) อัตราส่วนโปรตีนเคลอรี่ควรอยู่ในระดับ 10—13% และเด็กวัยก่อนเรียน 13—15% (ภาพที่ 2) เมื่อคุณภาพของโปรตีนอยู่ในระดับของอาหารไทย (Chemical score – ดูรายละเอียด ข้อ 16) ในปีที่ทำการวิเคราะห์นี้ อาหารไทยมีอัตราส่วนโปรตีนแคลอรี่เพียง 8.7 %

ภาพที่ 2 สถานะทางโปรตีนของอาหารที่มีข้าวเป็นหลัก[8]
(ตีค่าด้วย ND_p Cal%)



*อัตราส่วนโปรตีนแคลอรี่ (Protein Calorie Ratio)

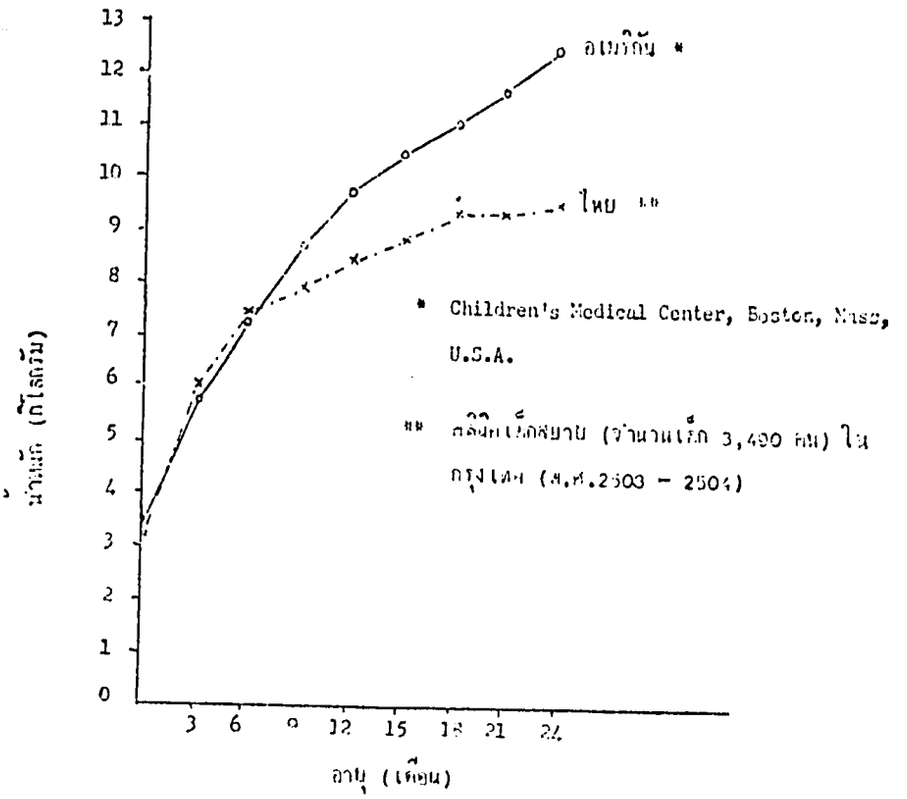
ในอาหารที่บริโภค อัตราส่วนของปริมาณแคลอรี่ที่ได้จากโปรตีนต่อปริมาณแคลอรี่ ทั้งหมดที่ได้ใน 1 วัน จะแตกต่างกันไป อัตราส่วนดังกล่าวเรียกว่า อัตราส่วนโปรตีนแคลอรี่ คำนวณโดยสูตรดังนี้

$$\frac{\text{แคลอรี่จากโปรตีน (กรัมโปรตีน} \cdot 4)}{\text{แคลอรี่ที่ใช้ได้ทั้งหมด}} \times 100 = \text{อัตราส่วนโปรตีนแคลอรี่}$$

อัตราส่วนนี้ถือว่าเหมาะสมถ้ามีค่าประมาณ 11 ถ้าค่าต่ำกว่า 10 จะแสดงว่า อาหารนั้นอาจจะให้แคลอรี่เพียงพอ แต่ปริมาณโปรตีนจะต่ำกว่าที่ต้องการ

14. โดยเหตุนี้จึงปรากฏว่า เด็กไทยแรกเกิดในระยะที่เลี้ยงด้วยนมมารดา จะมีน้ำหนักตัวดี เทียบได้กับเด็กในประเทศที่พัฒนาแล้ว แต่ภายหลัง 6 เดือน เมื่ออาหารเสริมเริ่มมีบทบาททดแทนนมมารดา การเพิ่มน้ำหนักของเด็กไทยก็เริ่มช้าลง[9] (ภาพที่ 3) สำหรับความเจริญของสติปัญญานั้น มีรายงานหลายฉบับยืนยันว่า การขาดโปรตีนแคลอรี่ในระยะเยาว์วัย จะมีผลให้การพัฒนาทางสมองเสื่อมโดยไม่อาจกู้สภาพให้กลับคืนได้อีก[10]

ภาพที่ 3 เปรียบเทียบน้ำหนักเด็กไทยและอเมริกัน [9]

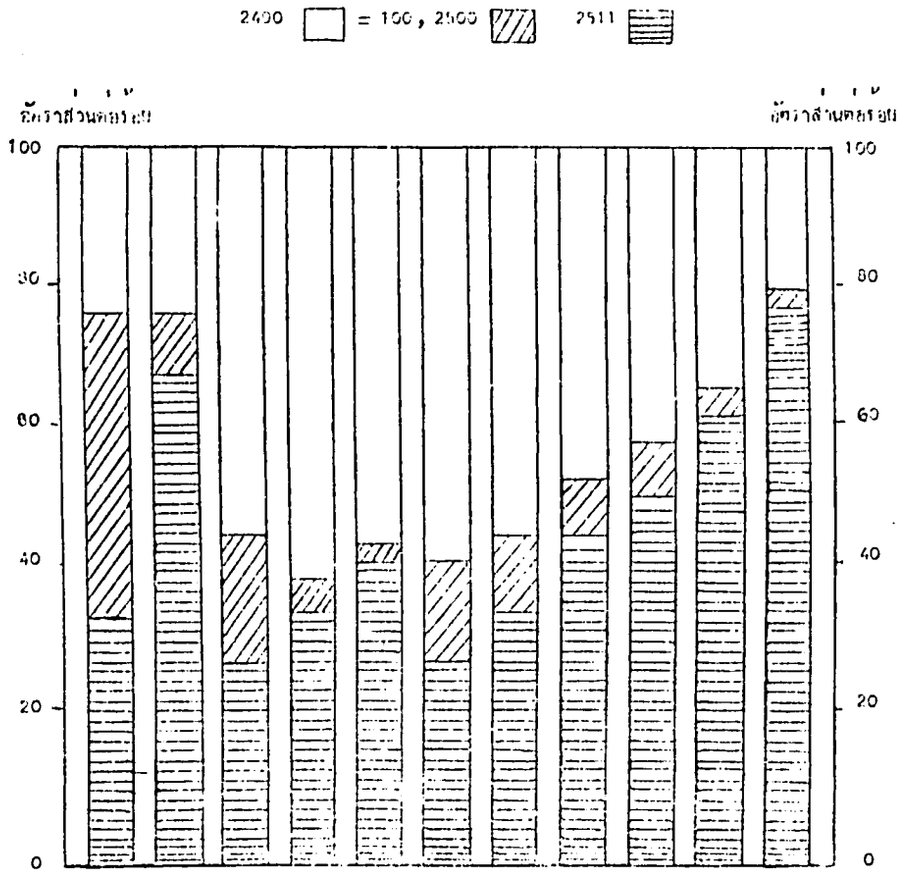


15. นอกจากความบกพร่องทาง สภาวะโภชนาการจะมีผลร้าย ต่อความเจริญเติบโตของร่างกายและสมองของเด็ก โดยเฉพาะในวัยก่อนเรียนแล้ว ยังจะมีผลให้ความต้านทานโรคของเด็กวัยนี้ต่ำกว่าปกติ ทำให้มีอัตราป่วยและตายจากโรคติดต่อต่าง ๆ สูง อัตราป่วยและตายของเด็กวัยนี้ จะลดลงได้ยาก ถ้าไม่มีการปรับปรุงสภาวะทางโภชนาการควบคู่ไปกับ การบริการ อนามัยอื่น ๆ หากพิจารณา การลดของอัตราตาย เป็นรายอายุสำหรับประเทศไทยระหว่าง พ.ศ. 2490, 2500 และ 2511 [11] (ภาพที่ 4) จะเห็นว่า ในช่วงระยะ 20 ปีที่ผ่านมานี้ การลดของอัตราตายสำหรับเด็กวัยก่อนเรียน (1--4 ปี) มีน้อยที่สุด (ยกเว้นอัตราตายของคนชราอายุกว่า 70 ปี)

คุณภาพของโปรตีนในอาหารที่มีข้าวเป็นหลัก

16. โปรตีนในอาหารนั้น มีแหล่งกำเนิดทั้งจาก พืชและสัตว์คุณภาพของโปรตีนของอาหารจะดีหรือเลวเพียงใด จะวัดได้โดยเปรียบเทียบกับโปรตีนจากไข่ ซึ่งถือว่าเป็นโปรตีนธรรมชาติที่ดีที่สุด ถ้าโปรตีนมีคุณภาพต่ำกว่ามาตรฐาน ก็ต้องบริโภคโปรตีนนั้นเป็นปริมาณมากขึ้นตามส่วน จึงจะเกิดประโยชน์ต่อร่างกายได้เท่ากัน

ภาพที่ 4 การลดของอัตราตายรายอายุ ประเทศไทย :
พ.ศ. 2490, 2500 และ 2511 /11



อายุ	<1	1-4	5-9	10-14	15-19	20-29	30-39	40-49	50-59	60-69	>70
อัตรา 2511	26.5	11.6	2.1	1.6	2.2	2.3	4.0	6.8	11.2	23.7	68.4

การวัดคุณภาพของโปรตีนจะทำได้โดยการทดลองกับสัตว์ทดลอง (แสดงค่าเป็น Biological value, protein efficiency ratio, standard net protein utilization เป็นต้น) แต่เพื่อความรวดเร็วและเพื่อทราบคุณภาพพอเป็นสังเขป จึงได้มีผู้คิดวิธีคำนวณขึ้น โดยคำนวณจากปริมาณกรดอมิโนที่มีอยู่ในโปรตีนนั้น คิดเป็นอัตราร้อยละเทียบกับปริมาณกรดอมิโนชนิดเดียวกันที่มีในไข่ กรดอมิโนใดให้อัตราร้อยละต่ำที่สุด ถือว่ากรดอมิโนนั้นเป็นตัวจำกัดคุณภาพ (limiting factor) และอัตราร้อยละนั้นเรียก protein score หรือ chemical-score (ตารางที่ 6)

17. สำหรับประเทศไทยซึ่งข้าวเป็นอาหารของประชากรอย่างแท้จริงนั้น อัตราส่วนโปรตีนแคลอรี่ค่อนข้างต่ำดังได้กล่าวแล้ว ปริมาณของโปรตีนที่น้อยไปนี้ นับว่าเป็นข้อเสียของอาหารประเภทดังกล่าว อย่างไรก็ดีความ

บกพร่องนี้จะก่อให้เกิดความยุ่งยากเฉพาะในวัยเด็กเท่านั้น มิได้มีผลต่อผู้ใหญ่มากนัก เนื่องจากคุณภาพซึ่งสูงของโปรตีนจากข้าวมีส่วนช่วยไว้ได้มาก อาหารของประเทศไทยจะให้ protein score ประมาณ 64 ซึ่งนับว่าสูงพอสมควร ทั้งนี้เพราะโปรตีนจากข้าวมีส่วนประกอบของกรดอมิโนที่อยู่ในลักษณะค่อนข้างสมดุลย์ นับว่าดีกว่าพันธุ์ประเภทแป้ง (cereal) อื่น ๆ ทั้งหมด รวมทั้งข้าวสาลี ฉะนั้น ความบกพร่องของข้าวจึงอยู่ที่ปริมาณโปรตีนซึ่งต่ำไป (ประมาณ 7%) หาใช่อยู่ที่คุณภาพไม่

ผลของรายได้ต่อลักษณะของอาหารที่บริโภค

18. ในชุมชนที่มีเศรษฐกิจระบบตลาด (market economy) ระดับรายได้หามีอิทธิพลต่ออัตราส่วนโปรตีนแคลอรี่ที่บริโภคไม่ แต่กลับมีอิทธิพลโดยตรงต่อชนิดของโปรตีนที่บริโภค

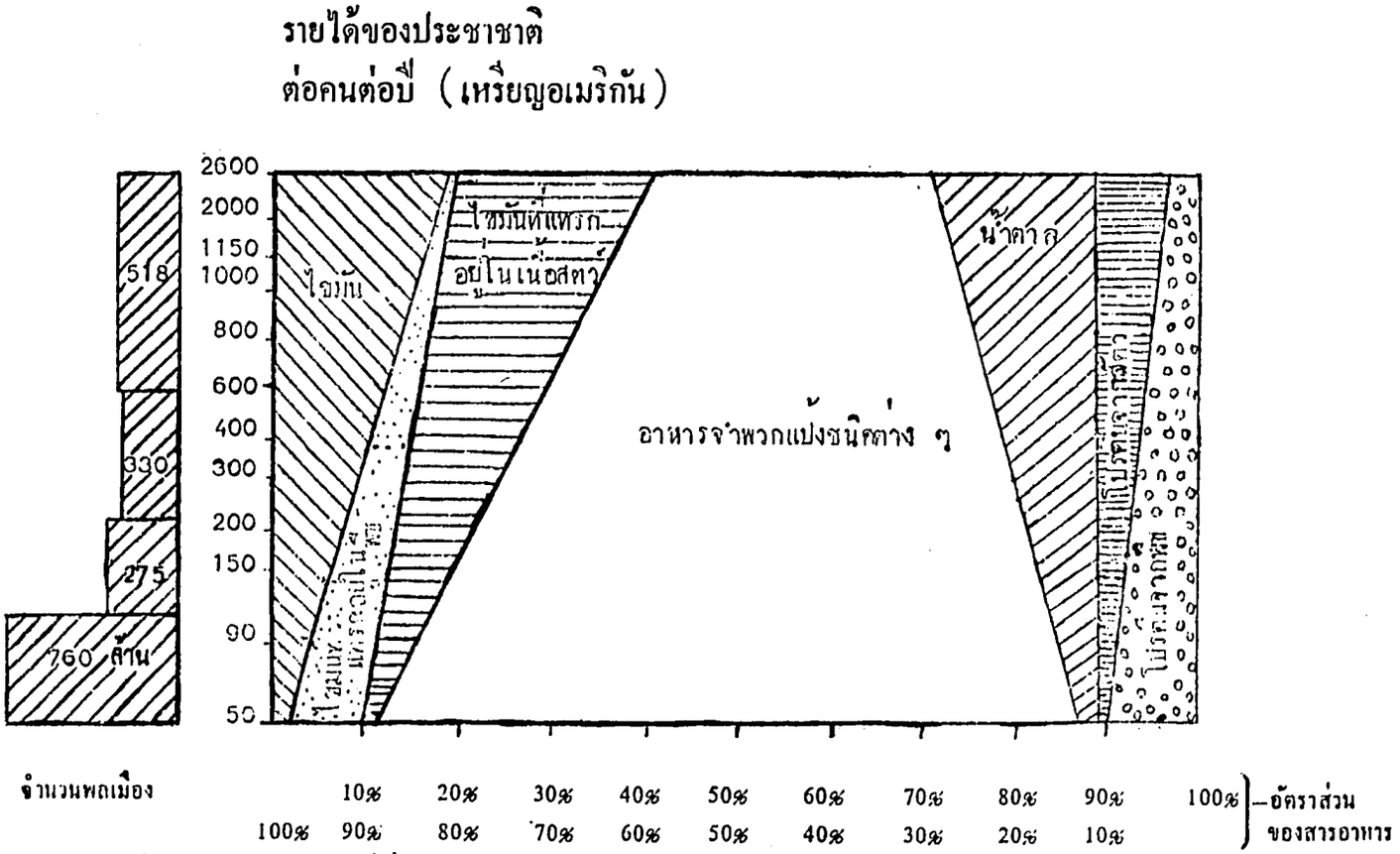
จากการศึกษา พบว่า เมื่อรายได้เพิ่มขึ้น จะมีการการเปลี่ยนแปลงในชนิดของโปรตีนที่บริโภค โดยจะมีอัตราส่วนโปรตีนจากเนื้อสัตว์เพิ่มขึ้นเท่ากับที่โปรตีนจากพืชลดลง ทำให้อัตราส่วนโปรตีนแคลอรี่ทั้งหมดไม่เปลี่ยน-แปลง หรือเปลี่ยนแปลงแต่เพียงเล็กน้อย (ภาพที่ 5)

19. สำหรับปริมาณโปรตีนนั้น ในประเทศที่พัฒนาแล้วจะมีอัตราส่วนโปรตีนแคลอรี่โดยเฉลี่ยประมาณ 11—12% [13] ส่วนประเทศที่กำลังพัฒนา จะมีอัตราต่ำกว่านั้น (ประเทศไทย 8.7 %) การเพิ่มอัตราให้สูงขึ้นจะทำได้ก็โดยการเพิ่มอาหารประเภทเนื้อสัตว์ หรือเปลี่ยนอาหารหลัก ได้มีการค้นพบในประเทศญี่ปุ่นว่า การที่ครอบครัวจะบริโภคอาหารโปรตีนให้สูงขึ้นจากระดับต่ำ 3 เท่า จะต้องมีรายได้สูงขึ้นไม่น้อยกว่า 16 เท่า จึงจะเป็นไปได้

20. หลักฐานต่าง ๆ เท่าที่มีอยู่นี้ชี้บ่งไปในทำนองที่ว่า เมื่อระดับเศรษฐกิจของสังคมดีขึ้น อัตราส่วนโปรตีนแคลอรี่จะค่อยขยับสูงขึ้น และจะเข้าสู่ดุลยภาพเมื่ออัตรานี้ถึงระดับ 11—12% การเพิ่มของอัตราส่วนโปรตีนแคลอรี่จะเป็นไปอย่างช้า ๆ เนื่องจากเมื่อรายได้สูงขึ้น การใช้อาหารประเภท น้ำตาล เครื่องดื่ม ขนมหวาน ตลอดจนไขมัน จะเพิ่มขึ้นด้วย อาหารเหล่านี้จะไปช่วยยกระดับแคลอรี่ให้สูงขึ้น จึงเป็นสาเหตุหนึ่งที่ทำให้อัตราส่วนโปรตีนแคลอรี่มิได้เปลี่ยนแปลงไป

การทำนายเหตุการณ์ล่วงหน้า

21. ในการกำหนดนโยบายอาหารและโภชนาการสำหรับอนาคตนั้น จำเป็นต้องอาศัยข้อมูลเพิ่มขึ้นจากที่มีอยู่เพื่อให้สามารถทำนายสถานะการณ์ในอนาคต (Projection) ของสภาวะทางเศรษฐกิจการผลิตอาหารหลัก การผลิตโปรตีนจากสัตว์ และการเพิ่มของประชากรได้ ลักษณะการบริโภคอาหาร (dietary structure) ย่อมจะผันแปรไปตามการเปลี่ยนแปลงขององค์ประกอบต่าง ๆ ที่กล่าวมาแล้วข้างต้น ซึ่งเป็นสิ่งที่จะต้องศึกษาต่อไป สำหรับปัจจุบันในระหว่างที่กำลังทำการรวบรวม วิจัยข้อมูลดังกล่าวอยู่ สิ่งที่พอจะทำได้คือการวางนโยบายในช่วงระยะเวลาอันสั้นภายในระยะเวลาไม่เกิน 5 ปี พ.ศ. (2515—2519)



ภาพที่ 5 จำนวนแคลอรี่ที่ได้จากไขมัน คาร์โบไฮเดรท โปรตีน คิดเป็นร้อยละของแคลอรี่ทั้งหมด แยกตามรายได้ของประชาชาติจาก 84 ประเทศ (2505) [12]

22. โดยเหตุที่เชื่อว่าลักษณะการบริโภคอาหารของประชากร ซึ่งเป็นสิ่งที่เปลี่ยนแปลงได้ยากจะยังคงเดิมอยู่ต่อไปอีกเป็นเวลานาน ตลอดจนแนวโน้มของการผลิตอาหารโปรตีนในระยะนี้จะไม่มีการเปลี่ยนแปลงในทางที่เพิ่มขึ้น (ตารางที่ 7) แต่ในทางตรงกันข้าม กลับน้อยลงเมื่อเปรียบเทียบกับอัตราการเพิ่มของประชากร (เว้นแต่ปลาทะเล) ฉะนั้น การขาดโปรตีนจะยังคงเป็นปัญหาสำคัญอยู่ต่อไป

23. ประชากรกลุ่มใหญ่ที่จะเป็นปัญหาทางด้านอาหารและโภชนาการมากที่สุดจะ ได้แก่กลุ่มเด็กวัยก่อนเรียน ทารก และเด็กวัยเรียน ตามลำดับ กลุ่มที่ย่อยลงไปคือกลุ่มหญิงมีครรภ์และแม่ลูกอ่อน ทั้งนี้ เนื่องจาก เหตุผลสำคัญ 2 ประการ คือ ประการที่หนึ่ง ลักษณะของอาหารที่บริโภค (rice — based diet) ซึ่งมีข้าวเป็นหลัก ถ้าแม้ว่าจะมีโปรตีนคุณภาพดี แต่ปริมาณโปรตีนในข้าวไม่เพียงพอที่จะสนองความต้องการ ของกลุ่มประชากรเหล่านั้นได้ (ภาพที่ 2) ถ้าไม่มีการจัดสรรปริมาณอาหารโปรตีนที่บริโภคกันในครอบครัว เพื่อให้เด็กได้รับส่วนแบ่งของอาหารโปรตีนมากขึ้นเป็นพิเศษ ประการที่สอง ได้แก่ลักษณะประเพณีการบริโภคอาหารของคนไทย ด้วยวิธีร่วมสำรับ ทำให้โอกาสที่จะจัดสรรอาหารโปรตีนในระหว่างสมาชิกในครอบครัว เป็นไปได้ยาก การเพิ่มอาหารโปรตีนให้กับเด็กด้วยวิธีจัดสรรอาหารในครอบครัว จึงเป็นสิ่งที่ทำไม่ได้ในระยะเวลาอันเร็ววัน

24. เมื่อเป็นเช่นนี้ ปัญหาต่อไปจึงมีอยู่ว่า จะรอให้สภาวะทางเศรษฐกิจดีขึ้นก่อนหรือไม่ โดยหวังว่าเมื่อเศรษฐกิจดีขึ้น โภชนาการก็จะดีขึ้นตาม โดยเฉพาะในด้านการบริโภคโปรตีน ข้อมูลเท่าที่แสดงไว้แล้วจะชี้ให้เห็นได้ว่า การเพิ่มของอัตราส่วนโปรตีนแคลอรี่หาได้มีส่วนสัมพันธ์กับรายได้ไม่ ถ้าอัตราส่วนโปรตีนแคลอรี่เมื่อตั้งต้นต่ำ (ประเทศไทย 8.7 %) อาจจะสูงขึ้นได้บ้างถ้ารายได้เพิ่มขึ้น และจะสู่ดุลยภาพเมื่อถึงระดับ 11 – 12 % ไม่ว่ารายได้จะเพิ่มต่อไปอีกเพียงใด ในอัตราส่วนโปรตีนแคลอรี่ ที่ค่อนข้างคงที่นี้ อัตราส่วนของโปรตีนจากเนื้อสัตว์จะเพิ่มขึ้นเป็นสัดส่วนกับรายได้ที่สูงขึ้น ฉะนั้นอาจกล่าวได้ว่า รายได้ที่สูงขึ้นจะมีอิทธิพลต่อสภาวะโภชนาการของประชากรบ้างก็แต่ในขอบเขตอันจำกัด ซึ่งเนื่องจากการที่โปรตีนมีคุณภาพดีขึ้นเพราะเป็นโปรตีนจากเนื้อสัตว์นั่นเอง

25. การเปลี่ยนแปลงของคุณภาพของโปรตีนไปในทางที่ดีขึ้น เนื่องจากผลการมีรายได้สูงขึ้นนั้น จะช่วยสภาวะทางโภชนาการสูงขึ้นได้ไม่มากนัก ทั้งนี้ เพราะอัตราส่วนโปรตีนแคลอรี่ ซึ่งจะคงที่หรือเกือบคงที่ เป็นตัวจำกัด (constraint) อยู่ ยิ่งไปกว่านั้น โปรตีนจากข้าว ซึ่งประกอบเป็นส่วนใหญ่ในอาหาร (ประมาณ 60 %) ก็มีคุณภาพสูงพอสมควรอยู่แล้ว โดยที่ chemical score ของข้าวมีระดับสูงเปรียบเทียบได้กับของเนื้อสัตว์ โดยจะต่ำกว่าเนื้อสัตว์แต่เพียงเล็กน้อย แต่ยังสูงกว่าถั่วเมล็ด (ตารางที่ 8)

ตารางที่ 7 จำนวนสัตว์ที่เป็นอาหารในประเทศไทย

ระหว่าง พ.ศ. 2500–2509 /12

ปี พ.ศ.	กระบือ	โค	สุกร	ไก่ (1000)	เป็ด (1000)	ปลา (1000 ตัน)		ประชากรไทย*
						ทะเล	น้ำจืด	
2500	5,938,077	4,983,417	3,738,672	23,861	9,410	171	64	
2501	6,293,620	5,044,807	3,921,926	28,810	8,617	145	51	
2502	6,422,253	5,114,567	4,205,620	24,632	6,324	148	57	
2503	6,666 120	5,264,765	4,231,248	24,003	8,719	146	73	26,392,000
2504	6,749,344	5,099,181	5,246,230	25,170	7,236	233	72	27,210,000
2505	6,914,774	5,440,784	4,389,140	23,223	7,029	270	70	28,054,000
2506	7,087,137	5,347,041	4,466,834	24,895	10,155	323	95	28,923,000
2507	6,877,965	5,235,821	4,291,283	31,005	11,670	494	83	29,820,000
2508	6,691 308	5,103,854	4,805,370	33,992	11,719	529	86	30,744,000
2509	6,877,584	5,167,350	4,045,104	35,323	9,699	635	85	31,698,000

ปี พ.ศ.	กระบือ	โค	สุกร	ไก่ (1000)	เป็ด (1000)	ปลา (1000 ตัน)		ประชากรไทย*
						ทะเล	น้ำจืด	
อัตราร้อยละที่เพิ่มใน 10 ปี	15.82	3.69	8.19	48.04	3.07	271.34	32.81	
อัตราร้อยละที่เพิ่มใน 1 ปี	1.58	0.37	0.82	4.80	0.31	27 13	3.28	3.2

*หนังสือประชากรและสถิติชีพ

ตารางที่ 8 คุณภาพของโปรตีนจากพืชและสัตว์บางชนิด [13]

ประเภท	Chemical Score
พืช	
ข้าวสารขาว	56
แป้งข้าวสาลี (70 — 80 %)	32
มันสัมปะหลัง	41
มันเทศ	34
ถั่วลิสง	43
ถั่วเหลือง	47
สัตว์	
เนื้อวัว	69
เนื้อหมู	69
เนื้อไก่	64
เนื้อปลา	70

26. เมื่อกลับมาพิจารณาดัชนีคุณภาพ (แสดงเป็น Net dietary protein calories Percent — NDp Cal % *) ซึ่งได้นำทั้งคุณภาพและปริมาณของโปรตีนเข้ามาพิจารณาควบคู่กันไปแล้วจะเห็นได้ว่า อาหารซึ่งมีข้าวเป็นหลักสำหรับประเทศไทย ให้ดัชนีดังกล่าวเท่ากับ 5.3 นับว่าเป็นการเพียงพอสำหรับผู้ใหญ่ (ภาพที่ 2) แต่สำหรับเด็ก จะต้องการอาหารที่มีดัชนีสูงขึ้นไปอีก (เด็กวัยเรียนประมาณ 6 — 7 เด็กวัยก่อนเรียน 7 — 8) จึงสรุปได้ว่า ในประเพณีการบริโภคของไทยเด็กจะไม่ได้รับอาหารโปรตีนในปริมาณที่เพียงพอกับความต้องการ

นโยบายอาหารและโภชนาการ

การเสริมอาหารโปรตีนในกลุ่มประชากรเป้าหมาย

27. วิธีแก้ปัญหาทางหนึ่งได้แก่การเพิ่มอัตราส่วนโปรตีนแคลอรี่สำหรับเด็กให้สูงขึ้น เช่นสำหรับเด็กวัยก่อนเรียนให้ได้อัตราส่วนโปรตีนแคลอรี่ 13 — 15 % แต่การเพิ่มดังกล่าวจะได้เกิดขึ้นเองในประเทศไทย ถึงแม้ว่า

รายได้ของประชากรจะสูงขึ้นสักเพียงใด ทั้งนี้เนื่องจากระดับอัตราส่วนโปรตีนแคลอรี่จะมีดุลยภาพอยู่เพียง 11 — 12% และลักษณะประเพณีการบริโภคอาหารของไทยโดยวิธีร่วมสำรับ ไม่เปิดโอกาสให้เด็กได้รับอาหารโปรตีนเป็นพิเศษ

28. เพื่อให้เด็กได้รับอัตราส่วนโปรตีนแคลอรี่เพียงพอ จึงจำเป็นต้องจัดให้มีโครงการอย่างใดอย่างหนึ่ง ซึ่งมีวัตถุประสงค์ ในการเสริมอาหารโปรตีนให้แก่เด็กเป็นพิเศษ การจัดโครงการดังกล่าว ควรทำทั้งในกลุ่มเด็กวัยก่อนเรียน ทารก และเด็กวัยเรียน โดยกำหนดความสำคัญตามลำดับ

29. การเสริมอาหารโปรตีนสำหรับเด็กนั้น ต้องพิจารณาว่ามิใช่เพื่อวัตถุประสงค์จะให้เด็กได้รับโปรตีนเพียงพอแต่อย่างเดียว แต่เพื่อใช้วิธีการนั้นเป็นเครื่องมือในการให้โภชนศึกษาแก่มารดา และผู้มีหน้าที่เลี้ยงดูเด็ก อันจะเป็นสื่อชักนำให้มีการเปลี่ยนแปลงบริโภคนิสสัยภายในครอบครัวด้วย

30. การจัดโครงการสำหรับเด็กนี้ มิได้มี วัตถุประสงค์ ที่จะทดแทนอาหารโปรตีนที่เด็กได้รับอยู่เป็นประจำวันแล้ว แต่จะช่วย **เสริม** ระดับการบริโภคอาหารโปรตีนให้สูงขึ้นในขณะที่บริโภคนิสสัยเรื่องการเสริมอาหารโปรตีนแก่เด็กภายในครอบครัวยังไม่เกิดขึ้น และกำลังดำเนินการทางด้านโภชนศึกษาในเรื่องนี้ให้แก่มารดาหรือผู้เกี่ยวข้องอยู่

31. เนื่องจากการเสริมอาหารโปรตีนสำหรับเด็ก เป็นงานที่ต้องกระทำต่อเนื่องกันเป็นประจำ จึงจะเกิดประโยชน์ การพิจารณาปัญหาเรื่องการเข้าถึงเด็ก โดยเฉพาะเด็กวัยก่อนเรียนและทารก จึงเป็นเรื่องสำคัญ เพราะเด็กวัยนี้ ตามปกติยังอยู่กระจัดกระจายกันตามบ้าน ไม่มีการรวมกลุ่มเหมือนเด็กวัยเรียน การเสริมอาหารโปรตีนจะสำเร็จหรือไม่ขึ้นอยู่กับความสำเร็จของการจัดโครงการเพื่อเข้าถึงเด็กวัยก่อนเรียน และทารกด้วย

การส่งเสริมการผลิตโปรตีนในระดับหมู่บ้าน

32. ในสังคมที่มีระดับเศรษฐกิจแบบดั้งเดิม การใช้เงินตราเพื่อการซื้อขายยังมีน้อย อาหารส่วนใหญ่ได้จากที่ครอบครัวผลิตขึ้นเพื่อบริโภคเอง การส่งเสริมผลิตผลอาหารโปรตีนในระดับหมู่บ้านจึงเป็นสิ่งที่ต้องกระทำ ซึ่งควรจะได้แก่อาหารประเภทเนื้อสัตว์ เช่น ไก่ ปลา ฯลฯ เป็นอันดับแรก ถัดไปจึงเป็นถั่วเมล็ดชนิดต่าง ๆ

33. การที่จัดระดับความสำคัญของการผลิตอาหารประเภทเนื้อสัตว์ ไว้สูงกว่าพืชประเภทถั่วเมล็ดต่าง ๆ นั้น มิใช่เป็นเพราะคุณภาพของโปรตีนที่เหนือกว่าอาหารประเภทแรกเท่านั้น แต่เป็นเพราะการเลี้ยงสัตว์ดังกล่าวมิได้ตกอยู่ภายใต้ข้อจำกัด (constraint) ทางสภาพแวดล้อมหลายประการเหมือนกับการปลูกพืช (เช่น ปริมาณน้ำ เนื้อที่เพาะปลูก ลักษณะดินฤดูกาล) ยิ่งกว่านั้น ลักษณะทางสังคมและวัฒนธรรมไทย ได้ถือเอาเนื้อสัตว์ประเภทนี้เป็นส่วนของอาหารประจำวันอยู่แล้ว แตกต่างกับอาหารประเภทถั่วเมล็ดต่าง ๆ ซึ่งบริโภคกันเฉพาะเป็นบางโอกาส มิได้เป็นองค์ประกอบของตำรับอาหารไทยส่วนใหญ่แต่อย่างใด

34. อย่างไรก็ตาม การผลิตอาหารโปรตีนจากสัตว์ มิใช่ว่าจะกระทำได้ โดยไม่มีขอบเขตก็หาไม่ ลักษณะแนวโน้มของการผลิตอาหารประเภทนี้ ได้แสดงให้เห็นแล้วว่า มีข้อจำกัดของตนเองเช่นกันสำหรับสภาวะที่เป็นอยู่ในปัจจุบัน การผลิตให้มากและทันต่อความต้องการของประชากรทุกคน จะเป็นสิ่งที่ทำได้ยาก หรือไม่ได้เลย ฉะนั้น วัตถุประสงค์ของการจัดโครงการ ผลิตอาหารประเภทเนื้อสัตว์ เพื่อการโภชนาการในระดับหมู่บ้าน จึงต้องเพ่งเล็ง เพื่อให้ได้ผลผลิตนั้นในปริมาณเพียงพอ ที่จะเสริมระดับการบริโภคโปรตีนของประชากรกลุ่มเด็กอ่อน (โดยเฉพาะเด็กวัยก่อนเรียน) ในขณะเดียวกันควรพิจารณาให้ผลผลิตนั้นมีส่วนส่งเสริมรายได้ของผู้ผลิตให้สูงขึ้นด้วย

การพัฒนาอาหารโปรตีนต่าง ๆ

35. ในสังคมที่มีการเศรษฐกิจระบบตลาด มีการใช้เงินตราเพื่อการซื้อขายมากขึ้น ชุมชนมิได้ทำการผลิตเพื่อบริโภคเอง แต่จะเลือกซื้ออาหารบางส่วน หรือทั้งหมดจากตลาด โอกาสที่จะได้บริโภคอาหารประเภทต่าง ๆ จึงมีมากขึ้น ในชุมนุมประเภทนี้ โครงการส่งเสริมการผลิตอาหารประเภทโปรตีนเพื่อบริโภคภายในครัวเรือนจะมีความสำคัญน้อยลง ในขณะที่โครงการพัฒนาอาหารโปรตีนใหม่ ๆ ที่มีราคาถูกเพื่อเผยแพร่ในตลาดจะมีความสำคัญมากขึ้น

36. การพัฒนาอาหารโปรตีนนั้น จะทำสำเร็จและช่วยแก้ปัญหาได้ก็ต่อเมื่อได้มีการใช้โปรตีนราคาถูก เช่น โปรตีนจากพืชเป็นหลัก เพราะนอกจากจะช่วยให้ชุมชนมีโอกาสได้บริโภคอาหารโปรตีนราคาถูกกว่าเนื้อสัตว์แล้ว ยังจะช่วยบรรเทาปัญหาขัดข้องเรื่องการผลิตโปรตีนจากเนื้อสัตว์ ให้มีปริมาณเพียงพอกับความต้องการของประชาชนทุกกลุ่มด้วย

37. เพื่อให้บังเกิดผลดีควร จะต้องพิจารณาด้วยว่า พืชที่จะให้โปรตีนซึ่งจะนำไปใช้นั้น มีปริมาณเพียงพอและมีราคาคงที่ต่อไปเป็นระยะเวลานานพอสมควร

38. ในการพัฒนาอาหารโปรตีนเหล่านี้ ถ้าปรับปรุงปริมาณกรดอมิโน ซึ่งเป็นส่วนประกอบให้เหมาะสมแล้ว ก็สามารถทำให้มีคุณภาพสูงเท่าโปรตีนจากเนื้อสัตว์ได้ การสร้างสูตรอาหารประเภทนี้ จึงควรปรับปรุงคุณภาพให้ดีที่สุดเท่าที่ขอบเขตทางเทคนิคและเศรษฐกิจจะอำนวยให้

39. โดยที่พืชซึ่งมีโปรตีนสูงเช่นถั่วเมล็ดต่าง ๆ มิได้เป็นส่วนประกอบของตำหรับอาหารไทยตามปกติ กรรมเผยแพร่อาหารโปรตีนซึ่งทำจากพืชเหล่านี้ จำเป็นต้องดัดแปรงรูป รส ให้กลมกลืนกับลักษณะอาหารที่ชุมชนยอมรับอยู่แล้ว เพื่อช่วยให้สามารถใช้อาหารโปรตีนนั้นในตำหรับอาหารที่เคยบริโภคอยู่เป็นประจำ และทำให้มีการยอมรับอาหารโปรตีนนั้นง่ายยิ่งขึ้น

40. โดยเหตุที่การปรับปรุงคุณภาพและรูป รส ให้เหมาะสม เป็นสิ่งที่จำเป็นในการพัฒนาอาหารโปรตีน การกระทำดังจะได้ผลดีก็ต่อเมื่อได้ใช้วิชาเทคโนโลยีอาหาร (Food Technology) เข้าช่วย

สำหรับในประเทศไทย วิชานี้นับเป็นวิชาใหม่ที่มีผู้ศึกษาเชี่ยวชาญอยู่เป็นจำนวนน้อยจึงนับว่าเป็นความจำเป็นที่จะต้องส่งเสริมสาขาวิชาเทคโนโลยีอาหารให้ก้าวหน้ามากยิ่งขึ้น ทั้งนี้ โดยกำหนดให้งานด้านเทคโนโลยีอาหารกับด้านโภชนาการ มีการปฏิบัติสอดคล้องโดยมีนโยบายร่วมกันด้วย

41. ถึงแม้ว่าจะสามารถพัฒนาอาหารโปรตีนให้มีคุณประโยชน์ รูปร่าง อันเหมาะสม และมีราคาถูกพอสมควรแล้วก็ตาม แต่การที่จะตัดสินความสำเร็จขั้นสุดท้ายจะอยู่ที่วิธีเผยแพร่และการค้าอาหารเหล่านั้น

การวิจัยและส่งเสริมพันธุ์ข้าวที่ให้ผลผลิตสูง

42. จากการวิจัยทางด้านพันธุกรรมและสิ่งแวดล้อมของพืชพันธุ์ ในขณะนี้ ทำให้ฝ่ายเกษตรสามารถผลิตพันธ์ข้าวและพืชอย่างอื่นที่ให้ผลผลิตต่อไร่สูงเป็นหลายเท่า การค้นพบดังกล่าวเป็นสิ่งที่น่าภูมิใจ และเชื่อว่าจะเป็นเหตุบรรเทาหรือแก้ปัญหาการขาดแคลนรี่ในประชากรไปได้ อย่างน้อยก็ชั่วระยะหนึ่ง จนกว่าจำนวนประชากรจะเพิ่มสูงขึ้นถึงระดับใหม่ อันจะทำให้เกิดปัญหาขึ้นอีก

43. อย่างไรก็ดี พันธุ์ข้าวที่ให้ผลผลิตสูงแต่อย่างเดียวจะไม่สามารถช่วยแก้ปัญหาการขาดโปรตีน อันเป็นปัญหาหนักหน่วงยิ่งกว่าได้ เว้นแต่จะได้มีการพัฒนาการวิจัยเพื่อให้ได้พันธุ์ที่มีทั้งผลผลิตและปริมาณโปรตีนสูงพร้อมกัน

44. โดยเหตุที่อาหารของประเทศไทยซึ่งใช้ข้าวเป็นหลัก มิได้แสดงว่า กรดอมิโนไลซีนเป็นตัวจำกัดคุณภาพ (ตารางที่ 6) และถึงแม้ว่าจะยังมิได้มีการศึกษาระดับความแตกต่างระหว่างกรดอมิโน ซึ่งเป็นตัวจำกัดคุณภาพตัวแรก ตัวที่สอง และถัดไปก็ตาม ก็พอจะกำหนดได้ว่า การพยายามที่จะผลิตพันธุ์ข้าวที่มีปริมาณไลซีนสูงจะไม่ช่วยแก้ไขสถานการณ์ขาดโปรตีนได้ดีเท่ากับความพยายามผลิตพันธุ์ที่มีปริมาณโปรตีนสูง

45. อาจยกตัวอย่างให้เห็นได้ว่า ถ้าในปีที่นำข้อมูลมาวิเคราะห์นี้ประชากรได้บริโภคข้าวที่มีปริมาณโปรตีนสูง (ประมาณ 11% จากเดิม 7%) เพียงครึ่งหนึ่งของปริมาณข้าวที่บริโภคในประเทศทั้งหมด ก็จะทำให้ได้โปรตีนจากข้าวเพิ่มขึ้นเป็นพิเศษอีกปีละประมาณ 90,000 ตัน จากปริมาณเดิมประมาณ 315,000 ตัน ปริมาณโปรตีนที่เพิ่มขึ้นนี้ จะช่วยยกระดับการบริโภคโปรตีนของประชาชาติให้สูงขึ้นจาก 49 กรัมต่อคนต่อวัน เป็น 54 กรัมต่อคนต่อวัน (ดูบทต่อท้าย) จำนวนนี้นับว่าเพียงพอสำหรับความต้องการเฉลี่ยของประชากร (ตารางที่ 4) และช่วยทดแทนความล้าหลังของการผลิตโปรตีนจากเนื้อสัตว์ไปได้

การเสริมคุณภาพของโปรตีนด้วยกรดอมิโน

46. ในปัจจุบันนี้ วิธีแก้ปัญหาการขาดโปรตีน นอกจากจะกระทำโดยการเพิ่มปริมาณโปรตีนที่บริโภคให้สูงขึ้นแล้ว ยังมีวิธีแก้ไขโดยยกระดับคุณภาพของโปรตีนให้สูงขึ้น เพื่อให้โปรตีนที่มีปริมาณเท่าเดิมสามารถให้คุณประโยชน์ต่อร่างกายได้มากขึ้นไปอีก การยกระดับคุณภาพของโปรตีนขึ้นอยู่กับการเสริมปริมาณกรดอมิโนชนิด

ต่าง ๆ ที่มีอยู่ในโปรตีนนั้นให้มีระดับใกล้เคียงกับโปรตีนที่มีคุณภาพดี เช่น ไข่ กรดอมิโนตัวที่จะต้องปรับระดับให้สูงขึ้นก่อนได้แก่ตัวที่จำกัดคุณภาพของโปรตีน (Limiting Amine Acid) เมื่อทำดังนี้ ก็จะช่วยให้การยกระดับคุณภาพได้ผลดีและมีประสิทธิภาพสูงขึ้น

47. การมีกรดอมิโนสังเคราะห์เกิดขึ้น และนำมาผสมกับโปรตีน เพื่อยกระดับคุณภาพนั้น นับเป็นผลของความก้าวหน้าทางอุตสาหกรรมที่ทำให้สามารถใช้กรดอมิโนเพื่อประโยชน์ทางโภชนาการ ในราคาถูกพอสมควร จึงมีผู้พยายามที่จะนำวัตถุสังเคราะห์เหล่านี้มาใช้ผสมอาหารสำหรับมนุษย์เป็นการเพิ่มเติมจากที่เคยใช้ในอาหารสัตว์อย่างแต่ก่อน

48. โดยที่พบว่าพืชพันธุ์ประเภทแป้ง (Cereal) ส่วนใหญ่ขาดกรดอมิโนไลซีน จึงทำให้เกิดปัญหาว่าการเสริมไลซีนให้กับข้าวจะช่วยให้คุณภาพของโปรตีนของประชากรที่มีข้าวเป็นอาหารหลักดีขึ้นเพียงใด และสมควรกำหนดให้มีการเสริมคุณภาพข้าวด้วยไลซีนเป็นนโยบายหรือไม่

ปัญหาการเสริมกรดอมิโนในอาหารของมนุษย์นั้น มีความซับซ้อนยิ่งกว่าปัญหาในสัตว์ซึ่งได้รับอาหารจากการเลี้ยงที่มีส่วนประกอบที่แน่นอนเป็นประจำ ทั้งนี้เนื่องจากองค์ประกอบหลายต่อหลายอย่างได้มีผลต่อบริโภคนิสัยซึ่งทำให้ปริมาณและชนิดของอาหารที่มนุษย์บริโภคมีการเปลี่ยนแปลงได้ และไม่เป็นมาตรฐานเดียวกันเสมอไป (เช่นตามอิทธิพลของฤดูกาล ลักษณะทางเศรษฐสังคม ภูมิภาคและอื่น ๆ) จึงเป็นการยากที่จะกำหนดให้แน่ชัดว่าอาหารที่บุคคลบริโภคแต่ละคนแต่ละวันจะมีความบกพร่องในกรดอมิโนชนิดใด อย่างไร และควรจะเสริมกรดอมิโนชนิดใด เป็นปริมาณเท่าใดจึงจะเหมาะสมที่จะช่วยยกระดับคุณภาพให้ดีขึ้นโดยไม่มีการสิ้นเปลืองโดยใช่เหตุ

49. สำหรับตัวเลขเท่าที่มีอยู่ ซึ่งได้จากบัญชีดุลย์การใช้อาหารของประเทศ และการสำรวจอาหารทั่วประเทศนั้น นับว่าเป็นตัวเลขที่ให้ค่าเฉลี่ย ซึ่งจะไม่สามารถแสดงให้เห็นความแตกต่างของลักษณะ และปริมาณการบริโภคที่อาจจะผิดแผกกันไปตามท้องถิ่น ฤดูกาล เศรษฐฐานะ และอื่น ๆ ได้ แต่การใช้สถิติดังกล่าว ก็พอที่จะช่วยให้ตัดสินใจได้ว่า ควรมีนโยบายเสริมกรดอมิโนชนิดใดหรือไม่ในระดับประเทศ ส่วนการที่จะชี้บ่งให้ละเอียดลงไปว่า ควรมีการเสริมกรดอมิโนโดยเฉพาะสำหรับคนบางกลุ่มในบางเวลา อย่างไรหรือไม่นั้น จะยังไม่สามารถตัดสินได้ในระยะนี้

50. จากผลการวิเคราะห์อาหารที่มีข้าวเป็นหลัก สำหรับประเทศไทยแสดงว่า ไลซีนมิได้เป็นตัวจำกัดคุณภาพแต่อย่างใด ฉะนั้น หากจะมีนโยบายส่งเสริมการเสริมไลซีนในข้าวอย่างกว้างขวางผลที่ได้รับจากการปรับปรุงคุณภาพของโปรตีนที่ได้คืนมาจะน้อยมาก หรือไม่ได้เลย และไม่คุ้มค่าทุนที่ลงไปและหากการวิเคราะห์รายละเอียดของกรดอมิโนในอาหารไทยที่กำลังจะทำต่อไปในอนาคตแสดงให้เห็นว่า ระดับความแตกต่างระหว่างตัวจำกัดคุณภาพตัวแรกกับตัวที่ถัดไปไม่กว้างพอ เมื่อมีการเสริมกรดอมิโนเพื่อแก้ไขตัวจำกัดคุณภาพตัวแรกไปแล้ว ก็จะ

ต้องพบกับปัญหาการแก้ไขตัวจำกัดคุณภาพตัวถัดไปอีกโดยคุณภาพของโปรตีนจะยังไม่ทันดีขึ้น จนพอเหมาะสมกับทุนที่ลงไปเลย

51. ยิ่งกว่านั้น เมื่อพิจารณารบบ—การผลิตและใช้ข้าวของประเทศ โดยเฉพาะในชนบทเมื่อประชากรผลิตข้าวแล้ว ก็จะนำไปสีที่โรงสีเล็กซึ่งมีประจำอยู่เกือบทุกตำบล หมู่บ้าน หากจะจัดโครงการเสริมไลซีนในข้าวขึ้น จะต้องใช้เครื่องมือผสมไลซีนลงไปในข้าวขณะที่ออกจากเครื่องสีจึงจะได้อัตราที่แน่นอน ซึ่งหมายถึงว่า จะต้องมีการผสมไลซีนตามโรงสีเล็กต่าง ๆ ทั่วประเทศ การกระทำดังกล่าว จะทำให้เกิดปัญหาทางเทคนิคและบริหารมากจนไม่อาจเอาชนะได้ การที่ประเทศไทยไม่มีสถานีกลาง ซึ่งอาจเป็นโรงสี หรือโกดังขนาดใหญ่ จำนวนน้อยแห่งซึ่งทำหน้าที่รวมข้าวจากแหล่งต่าง ๆ เพื่อทำการสีและผสมไลซีน แล้วจึงจัดจำหน่ายอยู่สู่หมู่บ้านอีกทีหนึ่ง จะเป็นเหตุผลสำคัญที่จะทำให้โครงการเสริมไลซีนในข้าวในระดับประเทศเป็นสิ่งที่เป็นไปได้ยากหรือไม่ได้เลย

52. อย่างไรก็ดี การเสริมคุณของโปรตีนด้วยไลซีนหรือกรดอมิโนอื่นใด มิใช่ว่าจะเป็นหลักการที่ไม่มีประโยชน์เสียทีเดียว ถ้าหากสามารถจัดโครงการเพื่อใช้กรดอมิโนอย่างใดอย่างหนึ่งยกระดับคุณภาพของโปรตีนในกลุ่มใดกลุ่มหนึ่ง ที่มีปัญหาเกี่ยวกับกรดอมิโนนั้น ๆ โดยเฉพาะถ้าหากการทดลองเสริมคุณภาพโปรตีนด้วยกรดอมิโนแสดงให้เห็นผลดีอย่างเด่นชัด และการวิเคราะห์สามารถชี้บ่งให้เห็นประชากรเป้าหมายตลอดจนค้นพบวิธีเข้าถึงกลุ่มประชากรเหล่านั้นแล้ว การจัดโครงการเฉพาะแห่งเพื่อแก้ปัญหานี้ อาจเป็นวิธีที่เหมาะสมและมีทางสำเร็จได้ เพราะการเสริมอาหารด้วยกรดอมิโนไม่ต้องการเทคนิคที่ยุ่งยากซับซ้อนจนเกินไป และจะไม่มีปัญหาในเรื่องการยอมรับของประชากร เพราะกรดอมิโนที่ใช้ผสมจะมีจำนวนน้อย ซึ่งจะไม่ทำให้มีกลิ่น หรือรส อันไม่ชวนบริโภคแต่อย่างใด

53. โดยที่การเสริมคุณภาพด้วยกรดอมิโนในระดับประเทศ เป็นสิ่งที่เป็นไปได้ยาก หรือไม่ได้เลย เนื่องจากเหตุผลทางเศรษฐกิจและอื่น ๆ การใช้ประโยชน์จากหลักการนี้อาจจะทำได้โดยวิธีการเสริมกรดอมิโนให้กับอาหารโปรตีนซึ่งจะผลิตขึ้นเพื่อยกระดับคุณภาพของอาหารเหล่านั้น วิธีการนี้นับว่าควรพิจารณา เนื่องจากจะไม่ก่อให้เกิดปัญหาเช่นเดียวกับที่จะพบได้ เมื่อใช้กรดอมิโนผสมในข้าวของประชาชนโดยตรง ข้อจำกัดของวิธีการนี้จะมีอยู่ก็ในด้านเศรษฐกิจเท่านั้น เพราะการเสริมคุณภาพดังกล่าวจะทำให้ราคาของอาหกรโปรตีนนั้นสูงขึ้น

54. กล่าวโดยทั่วไป ในระยะยาวนั้น หากสามารถสร้างพันธ์ข้าวที่ผลผลิตและปริมาณโปรตีนสูงได้สำเร็จ โดยไม่จำเป็นต้องปรับปรุงปริมาณไลซีนที่มีอยู่ในข้าว ก็จะเกิดประโยชน์อันยิ่งใหญ่ และควรถือเป็นนโยบายที่สำคัญกว่าการเสริมคุณภาพด้วยกรดอมิโนในอาหาร สำหรับวิธีการอย่างหลังนั้น หานจะพิจารณาจัดทำภายในขอบเขตจำกัดโดยมีจุดมุ่งหมายและวิธีการที่แน่นอนเท่านั้น

เอกสารตอทาย

การคำณวนปริมาณโปรตีนที่เพิ่มขึ้นจากข้าว

1. ปีที่ทำการวิจัย พ.ศ. 2505
2. จำนวนประชากร 28,054,000
3. ประชากรบริโภคข้าวคนละวันละ 440 กรัม/
4. ข้าวมีโปรตีน 7 %
5. ในหนึ่งปี ประชากรได้รับโปรตีนจากข้าวที่บริโภค = 28,054,000x440x365x0.07x0.00001 = 315,383.1 ตัน
6. ถ้าประชากรเพียงครึ่งหนึ่งบริโภคข้าวที่มีโปรตีนสูงขึ้นจากเดิม 7% เป็น 11%
7. ประชากรก็ได้รับโปรตีนจากข้าว

$$= \frac{28,054,000}{2} \times 440 \times 365 \times 0.11 \times 0.000001$$

$$+ \frac{28,054,000}{2} \times 440 \times 365 \times 0.07 \times 0.000001 = 405,492.5 \text{ ตัน}$$

8. ประชากรจะได้โปรตีนเพิ่มขึ้นเป็นพิเศษอีกปีละ 405,492−315,383=90,109 ตัน
9. จำนวนโปรตีนที่ได้จากอาหารที่มีข้าวเป็นหลัก (ข้าว+กับข้าว) =46.5 กรัม/คน/วัน (ตารางที่ 1) ในจำนวนนี้เป็นโปรตีนจากข้าวประมาณ 46.5 x 0.6 =27.9 กรัม/คน/วัน* (ตารางที่ 6) และโปรตีนจากกับข้าว=46.5−27.9=18.6 กรัม/คน/วัน
10. ถ้าครึ่งหนึ่งของข้าวที่บริโภคมีโปรตีน 11% อีกครึ่งหนึ่ง 7% ตามเดิม

โปรตีนจากข้าวที่ได้ $= 27.9 \left(\frac{1}{2}+\frac{1}{2}\times\frac{11}{7}\right) = 35.9$ กรัม / คน / วัน

โปรตีนจากอาหารทั้งหมดที่จะได้ถ้าบริโภคแบบหลัง

$= 35.9 + 18.6 = 54.5$ กรัม / คน / วัน

11. ปริมาณโปรตีนที่เพิ่มขึ้นจะช่วยยกระดับการบริโภคโปรตีนของประชาชาติให้สูงขึ้น จาก 46.5 กรัม / คน / วัน เป็น 54.5 กรัม / คน / วัน

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