Nutrition Intervention in
Developing Countries

Study III
FORTIFICATION

Study IV
FORMULATED FOODS

Prepared by the Harvard Institute for International Development

Prepared for
Office of Nutrition
Development Support Bureau
U.S. Agency for International
Development

Nutrition Intervention in
Developing Countries

Study III
FORTIFICATION

James E. Austin
Thomas K. Belding
David Pyle
Florentino S. Solon
Thomas L. Fernandez
Michael C. Latham
Barry M. Popkin

Prepared by the Harvard Institute for International Development

Project Director, James E. Austin
Associate Project Director, Marian F. Zeitlin

Prepared for
Office of Nutrition
Development Support Bureau
U.S. Agency for International
Development

Oelgeschlager, Gunn & Hain,
Publishers, Inc.
Cambridge, Massachusetts

Copyright © 1981 by Oelgeschlager, Gunn & Hain, Publishers, Inc. All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means--electronic mechanical photocopy, recording or otherwise--without the prior written consent of the publisher.

International Standard Book Number: 0-89946-083-6

Library of Congress Catalog Card Number: 80-29235

Printed in the United States of America

Library of Congress Cataloging in Publication Data

Main entry under title:

Nutrition intervention in developing countries.

CONTENTS: v. 1 Study one, Supplementary feeding.--v. 2. Study two, Nutrition education.--v. 3 Study three, Fortification. Study four, Formulated foods.--(etc.)
1. Underdeveloped areas--Nutrition policy--Collected works. 2. Underdeveloped areas--Nutrition--Study and teaching--Collected works. 3. Underdeveloped areas--Food relief--Collected works. 4. Underdeveloped areas--Food supply--Collected works. I. Austin, James E. II. Zeitlin, Marian F.
TX359.N874 363.8'8 80-29235
ISBN 0-89946-083-6 (v.3)

This document has been prepared by a staff of professionals through the Harvard Institute for International Development under a contract with the Office of Nutrition, U.S. Agency for International Development. The purpose of this volume is to provide guidance to those interested in the development and implementation of programs directed at preventing malnutrition among preschool populations.

CONTENTS

Foreword..... vi

Preface.....viii

CHAPTER ONE - OVERVIEW

I. Purpose and Organization..... 1

II. The Role of Fortification..... 1

A. Key Questions..... 1
B. Summary..... 6

III. Common Forms and Usage..... 6

A. Key Questions..... 6
B. Summary..... 7

CHAPTER TWO - INTERVENTION DESIGN

I. Introduction..... 8

II. Nutrient Need..... 8

A. Key Questions..... 8
B. Summary..... 11

III. Nutrient Quantity..... 12

A. Key Questions..... 12
B. Summary..... 13

IV. Carrier and Fortificant Selection..... 13

A. Key Questions..... 13
B. Usage and Acceptability..... 13
C. Commodity-System Structure..... 14
D. Centralized and Decentralized..... 14
E. Technological Constraints..... 15
F. Summary..... 26

V. Alternative Interventions..... 26

A. Key Questions..... 26
B. Summary..... 30

CONTENTS (continued)

CHAPTER THREE - INTERVENTION EVALUATION

I. Introduction..... 31

II. Costs of Fortification..... 32

A. Key Questions..... 32
B. Summary..... 40

III. Effectiveness of Fortification and Mass Doses..... 41

A. Key Questions..... 41
B. Goiter..... 41
C. Vitamin A..... 41
D. Iron/Folate..... 42
E. Protein..... 44
F. Summary..... 45

IV. Comparison of Alternative Interventions..... 46

A. Key Questions..... 46
B. Costs..... 46
C. Personnel..... 46
D. Administration..... 48
E. Technical Feasibility..... 48
F. Beneficiary Role..... 48
G. Impact..... 48
H. Summary..... 49

CHAPTER FOUR - CASE STUDY: FORTIFICATION IN THE PHILIPPINES

I. Introduction..... 51

II. Nutritional Need..... 51

A. Clinical Assessment..... 52
B. Biochemical Assessment..... 52
C. Dietary Assessment..... 52
D. Socioeconomic Factors..... 52

III. Alternative Approaches and Research Design..... 53

A. Capsule Program..... 58
B. Public Health and Horticulture Intervention (PHI).... 58
C. MSG Fortification..... 58
D. Research Design..... 58

CONTENTS (continued)

CHAPTER FOUR (continued)

IV. Fortification Intervention Design..... 60

A. Carrier Selection..... 60
B. Technical Feasibility and Consumer Acceptability..... 63
C. Fortificant Quantity..... 63

V. Intervention Evaluation..... 63

A. Costs..... 64
1. General Costing Methodology..... 64
2. Fortification Costs..... 64
3. Mass Dose Costs..... 65
4. PHI Costs..... 65

B. Effectiveness..... 66
1. Intermediate Indicators..... 66
2. Nutritional Impact: Clinical Signs and Serum Levels..... 68
Chapter Four Footnotes..... 78

Appendix: Benefit-Cost Analysis..... 79

References..... 89

FOREWORD

How do nutrition projects begin? How are specific interventions selected? Who makes the decisions and what is the rationale behind them?

Since such decisions relate to health or food policies of countries and have important implications for budgets, personnel and other resource allocations, it would be prudent that they be made only after careful study and analysis. Regrettably, this is not usually the case. More often than not, the choice is a subjective one.

Some interventions are undertaken because they seem "obvious." Since many others are doing it, it seems like the right thing to do, and there is unquestioned faith that it works. An approach may be fashionable at a given time period. A particular activity may be promoted by an external agency. There may be very attractive offers, such as free food or technical assistance, or a start-up grant.

To the degree that costs are considered, there is usually concern only with what funds are needed to cover immediate and direct costs. The indirect or hidden costs, which may be much greater, are overlooked. Project staff time may be charged to other budgets. The implications for an increased demand on energy or scarce materials may not be considered. There is a tendency to forget overhead costs such as those for the use of buildings or for heating, cooling, and lighting.

Social costs are even more often ignored. Some projects accelerate a change away from traditional practices such as breast-feeding or using natural foods or cultivating home gardens. A project may encourage a welfare mentality, reduce incentives to work, or create lasting demands for convenience foods where packaging and processing may forever raise the price of a food. Obsessed with political needs, decision makers may not be concerned with long-term consequences, such as the problem of terminating a popular service when it is no longer needed.

Too often these kinds of questions are not addressed, resulting in only marginal effectiveness for many projects. An apparently "good project" (that is, one which is scientifically sound and well organized), will bring disappointing results if it is aimed at a problem it is not designed to deal with. This in turn can lead to a dilemma of whether to continue a project while lacking confidence in it or to terminate it and admit failure. More often, projects go on and on without bringing results but without any objective evaluation or analysis.

Avoiding these problems requires accurate identification of problems, insightful analysis of causation, and a good understanding of interventions in terms of how they work, what they cost, what they achieve, what other consequences they bring, and what preconditions should be present before a particular intervention is selected.

To help deal with the question of intervention selection, the U.S. Agency for International Development commissioned Harvard University to prepare a series of Special Studies dealing with supplementary feeding, nutrition education, formulated foods, food fortification, consumer price subsidies, agricultural production, and integrated programs. Together the separate pieces comprise a manual intended to provide guidance in selecting from alternative approaches to reach the preschool child. We hope this effort contributes to improving the process of intervention selection, and thereby, to more effective prevention of malnutrition.

Martin J. Forman
Director, Office of Nutrition
U.S. Agency for International
Development
Washington, D.C. 20523

PREFACE

This study on fortification is one of seven special studies examining the major types of nutrition programs operating in developing countries. The other studies cover supplementary feeding, nutrition education, formulated foods, consumer price subsidies, agricultural productivity, and integrated programs. Of all these interventions, fortification is perhaps the most operationally and financially feasible, and it has demonstrated effectiveness in alleviating micronutrient deficiencies. It is less suitable for tackling the problems of calorie and protein inadequacies. The reader is referred to the other studies for programs relevant to those deficiencies.

The purpose of this series is to provide guidance to planners in developing countries and international development agencies on the nature and design of these major types of nutrition interventions. The lack of knowledge about intervention design, costs, and effectiveness, was cited by the National Academy of Sciences in its 1976 World Food and Nutrition Study as a major impediment to efforts to reduce the malnutrition problem. Our work, which was carried out for the Office of Nutrition of the U.S. Agency for International Development (AID), is an attempt to help close that knowledge gap.

We have tried to make a partial assessment of the "state of the art" of nutrition interventions through a review of published and unpublished literature, a mail survey of 200 nutrition projects in 64 developing countries, interviews with professionals from many disciplines and institutions involved in nutrition programming, and direct field analyses of selected nutrition programs. From these multiple sources and voluminous data, we have attempted to present a representative picture of each nutrition intervention. A commonly cited difficulty for planners, especially in developing countries, is ascertaining what is going on elsewhere and obtaining factual information on the many facets of designing a nutrition program. We have attempted to alleviate that problem by providing fairly complete, although not exhaustive, documentation and supporting references. Such attention to detail is needed when one is actually going through the intervention design process. However, not all readers will need to immerse themselves in this detail. To facilitate their use of the studies, we have preceded each subsection with a set of Key Questions that are addressed therein. At the end of each subsection we have presented a short Summary of the major points covered. Both the Questions and Summary sections are blocked off to facilitate the reader's scanning the document and identifying those parts which are of most interest to them.

Despite our efforts for completeness and our intense desire to provide useful guidance, the relative paucity of reliable evaluative data on nutrition programs and the limitations of this work leave us far short of the ideal. It has not been possible to ascertain the quality of the data or research designs presented in most of the literature we reviewed. Our analyses and suggestions should be viewed as tentative, subject to further verification. It is hoped that these documents will facilitate such future evaluative efforts by others in the international nutrition community.

This study has benefited from the collaboration of several individuals. Dr. Martin Forman and his staff in the Office of Nutrition have provided continual support throughout the project. We appreciate the very useful comments of AID's staff members and their expert review panel. Ellen Goldberg provided editorial assistance and Melanie Mahin and Sarah and other HIID staff supplied the necessary administrative support. The case study, Chapter Four, was made possible through the collaboration of Cornell University and the Cebu Institute of Medicine, and our colleagues and coauthors Dr. Michael Latham, Dr. Barry Popkin, Dr. Florentino Solon, and Dr. Thomas Fernandez. Their studies, conducted in the Philippines, examined various approaches to alleviating vitamin A deficiencies, including fortification of MSG. Their willingness to share the results of their efforts with the rest of the international nutrition community through this forum reveals their continued commitment to the common task.

We extend our appreciation to them, and on their behalf and that of Thomas Belding and David Pyle, the other coauthors, I express our gratitude to the many individuals and institutions who made this undertaking possible.

James E. Austin
Project Director
Cambridge, Massachusetts

CHAPTER ONE

OVERVIEW*

I. PURPOSE AND ORGANIZATION

The purpose of this study is to discuss the use and design of fortification programs as they have been implemented and as they could be adapted for more effective and widespread use. Mass-dose - the administration of tablets or injections of the deficient nutrient - will also be considered inasmuch as it is often suggested as an alternative or complement to fortification. Thus, in this chapter both the role of fortification and mass doses in alleviating specific nutrient-intake deficits will be covered, as will the common forms and present uses of fortification and its alternatives in developing countries.

Chapter Two covers intervention design considerations through a review of past and current programs. In Chapter Three, the cost and effectiveness data of fortification and its alternatives will be examined. Finally, Chapter Four, a case study of vitamin A deficiency prophylaxis in the Philippines, presents a detailed comparison of a mass-dose intervention, fortification, and a public health intervention using cost-benefit methodology.

Each chapter contains an introduction and, for each subsection, a highlighting of key questions and a brief summary of the material presented.

II. THE ROLE OF FORTIFICATION

A. KEY QUESTIONS

- What is fortification?
- What is the rationale for its use as a nutrition intervention?

Fortification is defined as "the process whereby nutrients are added to foods to maintain or improve the quality of the diet of a group, a community, or a population" (Food and Agriculture Organization/World Health Organization 1971). This includes the restoration of nutrients lost during food processing, as well as the addition of nutrients beyond those present in the food's unprocessed state.

---

*This chapter was prepared by James E. Austin, Thomas K. Belding, and David Pyle.

Fortification's role is to remedy nutrient deficiencies by enriching staple foods. Its target populations are thus primarily those groups deficient in such nutrients and for whom staples represent important dietary components. Diet quality and quantity are the major causes of the deficiencies. For example, rice is devoid of carotene; and other sources of vitamin A, such as green leafy vegetables, might not be available or used to feed children. The decline in breastfeeding may also lead to xerophthalmia if not replaced by adequate quality weaning foods. (See in this series Study IV Formulated Foods.) From an implementation standpoint, the rationale for fortification is that selected nutrients can be incorporated as fortificants into existing diets without requiring major changes in people's consumption patterns. This simplifies both the delivery and the reception of the intervention. Higher incomes generally lead to more varied diets and a reduction in micronutrient deficiencies. Fortification can occur while such income generating efforts are underway. Even with higher incomes, deficiencies can still exist.

Good health, normal development, resistance to disease, and work capacity are all related to the nutritional quality of the diet, i.e., the nutrient densities of all required nutrients, not just the total amount of food consumed. The three major specific micronutrient deficiencies are those of iodine (causing goiter, cretanism, and deaf-mutism), of vitamin A (causing sight loss or impairment), and of iron or folic acid (causing anemia). Vitamin A and iron or folate deficiencies, even in their less acute forms, can exacerabate the duration and severity of other diseases even to the point of death (McLaren, Khoury, Shirajian, and Tehalian 1965; McLaren, Shirajian, Lo Shkajian, and Shadarevian 1969). Other micronutrient deficiencies exist, but appear relatively less widespread. For example, thiamin deficiency has been documented in several countries, but tremendous advances have been made in reducing beriberi (including via rice fortification with vitamin B1). Rickets, caused by vitamin D inadequacy, has been found to be particularly severe in certain areas, e.g. North Africa, while largely nonexistent in others (Food and Agricultural Organization/World Health Organization 1967). Scurvy, due to vitamin C deficiency, has been found to be even less common, affecting perhaps 5% of the population. For a review of ascorbic acid fortification technology see Johnson and Petersen (1974) and Bauernfeind and Pinkert (1970). Zinc deficiency has also been suspected of contributing to growth retardation (Mahloudji et al. 1975). Although these other deficiencies merit attention, our discussion will concentrate on the iodine, Vitamin A, and iron or folic acid deficiencies.

Although prevalence of these deficiencies is not known with precision, it is fairly certain that (a) large areas of endemic goiter exist, especially in mountainous regions; (b) at least 100,000 new cases of vitamin A-associated vision impairments occur each year (World Food Council 1977, Oomen, McLaren, and Escapini 1964; Pan American Health Organization 1970; Kamel 1973); and (c) about 25 to 80% of pregnant women in their last trimester are anemic (World Food Council 1977; World Health Organization 1975). The prevalence of these deficiency diseases, especially of goiter, has decreased in recent years because of general economic improvements and specific interventions. For example, iodization of salt has practically eliminated endemic goiter in Colombia and Guatemala

(Pan American Health Organization 1972). In Indonesia iodization in the 1930s largely eradicated goiter, but the subsequent discontinuation of fortification resulted in a major resurgence of goiter (Soekirman in Winikoff 1978). Nonetheless, the magnitude remains sufficiently large to classify these as major public health problems. Even in more developed nations, iodine, vitamin A, and iron deficiencies exist and have been addressed via fortification.

On the macronutrient side, protein deficiencies along with calorie shortages give rise to PCM (Protein-Calorie Malnutrition), the most widespread of all deficiencies. Both the quantity and quality of the diet are contributors to PCM. For instance, diets based on cereal staples and/or legumes present the problem of limited amino acids. Fortifying with appropriate synthetic amino acids or protein concentrates makes complete protein available. Calorie supplementation through the addition of calorie-dense nutrients such as oils might be desirable to address metabolic energy shortages. Both macro- and micro-nutrients can be combined as fortificants simultaneously in certain instances.

Many countries have enacted legislation requiring various types of fortification. Tables 1 and 2 show the situation for several countries. Although 18 countries had passed iodine fortification legislation, only 9 had been able to implement the program effectively (Pan American Health Organization 1972). Implementation generally entails some form of government regulatory action. The Pan American Health Organization stated in 1972 that legislation:

> Should provide a means for developing appropriate standards and controls governing the type and quantity of nutrients and foods to which nutrients can be added; this should include authority for inspection and seizure. The legislation should firmly establish the regulatory agency and should clearly define its authority and funding procedures. It should also provide for control of labelling and advertising of fortified products; allow for future change of regulations; and recognize the desirability of international coordination of national laws on food standards and fortification, particularly between countries involved in common market agreements.

TABLE 1

SALT IODIZATION: LEGISLATION ON IODINE FORTIFICATION

Country	Level of iodine compound in salt	Date of legislation
Argentina	1:30,000 K Iodide or Iodate	1967 (goitrous areas only)
Bolivia	1:20,000 K Iodate	1968
Brazil	1:100,000 K Iodate	1953
Canada	1:10,000 K Iodide or Na Iodide	1949
Chile	1:10,000 K Iodide or Iodate	1959
Colombia	1:10,000 to 1:20,000 K Iodide	1955
Costa Rica	1:36,000 K Iodate	1961
Ecuador	1:20,000 K Iodate	1968
El Salvador	1:15,000 K Iodate	1967
Guatemala	1:10,000 to 1:15,000 K Iodate	1954
Honduras	1:15,000 K Iodate	1968
Mexico	1:66,000 K Iodide or Na Iodide	1962 (goitrous areas only)
Nicaragua	-	-
Panama	1:10,000 to 1:15,000 K Iodate	1955
Paraguay	1:10,000 K Iodate	1954
Peru	1:10,000 K Iodide	1940 (goitrous areas only)
United States of America	1:10,000 K Iodide	-
Uruguay	1:30,000 K Iodide or Iodate	1963
Venezuela	1:50,000 K Iodate	1966

Source: Clements et al. 1960; Pan American Health Organization.

TABLE 2

ENRICHMENT OF WHEAT, FLOUR, AND OTHER CEREALS WITH VITAMINS AND MINERALS

(per kilogram)

Country/Item	Thiamine mg	Riboflavin mg	Niacin mg	Iron mg	Calcium* g	Remarks
1. Argentina	-	-	-	-	-	(a)
2. Brazil	-	-	-	-	-	Enrichment of wheat flour, and cassava with lysine; no enrichment program in Northeast Brazil
3. British Honduras	-	-	-	-	-	(a)
4. Bolivia	-	-	-	-	-	(a)
5. Canada						
Wheat flour	4.4-5.5	2.6-3.3	35-44	28-36	1.1-1.4	Enrichment not compulsory; labelling is compulsory when enrichment is applied
6. Chile						
Wheat flour	6.3	1.3	13	13	1.7	Enrichment compulsory; enriched wheat flour must be labelled as such
7. Colombia	-	-	-	-	-	(a)
8. Costa Rica						
Wheat flour	4.4-5.5	2.6-3.3	35-44	28-36	1.1-1.4	Enrichment compulsory; enriched wheat flour must be labelled as such (at cost of consumer)
9. Cuba	-	-	-	-	-	(a)
10. Dominican Republic						
Wheat flour	4.4-5.5	2.6-3.3	35-44	28-36	1.1-1.4	Enrichment of wheat flour and rice compulsory
Rice	4.4	2.6	35	28	-	
11. Ecuador	-	-	-	-	-	(a)
12. El Salvador						
Wheat flour	4.4	2.6	35	28	1.1	Enrichment compulsory (at cost of consumer)
13. Guatemala						
Wheat flour	4.4	2.6	35	28	1.1	Enrichment compulsory (at cost of private industry)
14. Haiti						
Wheat flour	Yes	Yes	Yes	Yes	Yes	Enrichment of wheat flour; no legislation
15. Honduras						
Wheat flour	4.4	2.6	35	28	1.1	Enrichment compulsory (80% at cost of private industry, 20% at cost of consumer)
16. Mexico						
Wheat flour	4.4-8.8	2.6-5.2	35-70	28-57	-	Enrichment compulsory
17. Nicaragua						
Wheat flour	4.4	2.6	35	28	1.1	Enrichment compulsory if used in production of bread
18. Panamá						
Wheat flour	4.4	2.6	35	28	1.1	Enrichment compulsory if used in the production of bread (at cost of consumer)
19. Paraguay	-	-	-	-	-	(a)
20. Peru	-	-	-	-	-	Only protein enrichment of food products
21. Puerto Rico						
Wheat flour	4.4-5.5	2.6-3.3	35-44	28-36	1.1-1.4	Enrichment of wheat flour and rice compulsory
Rice	4.4	0.7	35	28	-	
22. Surinam	-	-	-	-	-	(a)
23. United Kingdom						
Rice flour	2.4	-	16	16	-	Enrichment compulsory
24. United States of America						
Wheat flours	4.4-5.5	2.6-3.3	35-44	28-36	1.1-1.4	Enrichment not compulsory
Corn meals and grits	4.4-6.6	2.6-4.0	35-53	28-57	1.1-1.7	
Rice	4.4-8.8	2.6-5.3	35-70	28-57	1.1-2.2	
Macaroni and noodle products	8.8-11.0	3.8-4.9	60-75	28-36	-	Labelling is compulsory when enrichment applied
25. Uruguay						
Wheat flour	Yes	Yes	Yes	Yes	Yes	Enrichment not compulsory (at cost of private industry and consumer)
26. Venezuela						
Wheat flour	4.2	2.5	30	26	-	Enrichment not compulsory (at cost of private industry and consumer)
27. West Indies						
Wheat flour						Enrichment not compulsory
Antigua						Imported flour enriched
Barbados						Some imported flour enriched
Dominica						Imported flour enriched
Grenada						Imported flour enriched
Guyana						Imported flour enriched
Jamaica	4.4-5.5	2.6-3.3	35-46	28-36	1.1-1.4	Imported flour enriched
Monserrat						Imported flour enriched
Nevis						Imported flour enriched
St. Kitts						Imported flour enriched
St. Lucia						Imported flour enriched
St. Vincent						Imported flour enriched
Trinidad and Tobago	4.4-5.5	2.6-3.3	35-46	28-36	1.1-1.4	Enrichment compulsory

*Calcium fortification optional in all countries.

(a) No enrichment program.

Source: Pan American Health Organization, 1972.

B. SUMMARY:

ROLE OF FORTIFICATION

The rationale for the fortification of foods with specific nutrients is that by decreasing or eliminating the deficits of those nutrients through quality improvements in the common diet, nutritional deficiency diseases and their consequences can be treated and/or prevented. Implementation of the intervention is facilitated by the minimal requirements for change in the consumption patterns of the target group. Impact can be achieved in the short run, while income-increasing interventions are occurring.

Micronutrient deficiencies of iodine, vitamin A, and iron or folic acid have been the target fortification efforts as have the macronutrient deficiencies of calories and protein.

Some form of government legislation or regulation generally is a prerequisite to fortification. However, experience reveals that enacting legislation does not ensure implementation.

III. COMMON FORMS AND USAGE

A. KEY QUESTIONS

- What forms do fortification efforts take?
- What foods have been fortified throughout the world?

Fortification in developing countries has primarily addressed micronutrient deficiencies, particularly that of iodine. Salt has been the main carrier, and iodization programs exist in several Latin American and Central Asian countries. In contrast, in the low-income countries in Oceania and in most of Africa few iodization or other goiter-control programs exist. Vitamin A fortification in developing countries has been carried out using various carriers: sugar (Guatemala and Costa Rica), tea (India), monosodium glutamate - MSG (Philippines), margerine (Brazil, Chile, Colombia, Mexico, Philippines, and Turkey), and cereal products (Korea, El Salvador, Tunisia, Thailand, Guatemala, and Mexico). Fortification of various other foods with vitamin A is common in many developed countries. For a technical review see Baurnfeind and Cort (1974).

Iron fortification is the least common type of micronutrient fortification. In developing countries it has been used in bread, weaning foods, milk and tested in sugar, salt, MSG and fish sauce in various countries (India, Thailand, Venezuela, Mexico, Panama, Guatemala, and Pakistan). For a technical review see World Health Organization (1975).

Protein fortification programs (including the addition of either natural protein supplements such as soy flour or synthetic amino acids such as lysine) have not been widely implemented. Multiyear research projects were carried out in Thailand (milled rice), Tunisia (wheat flour), and Guatemala (maize dough). Protein fortification of cassava has also occured in Brazil. In several countries, imported wheat flour is supplemented with locally produced soy flour. The processed grains (corn meal, bulger, wheat flour, sorghum grits, rolled oats, and rice) shipped as food aid under Title II of the U.S. P.L. 480 program are fortified with soy flour at about a 15% level. Calcium and vitamin A are added to the all-purpose wheat flour and a multiple mineral and vitamin premix is added to the soy fortified corn meal and wheat flour. Fortified grains constituted approximately 32% of the total Title II food aid shipments in fiscal year 1978.

In many instances, multiple rather than single nutrients may be (and have been) added. Thus, the above-mentioned deficiencies and fortification forms can have a multiple-nutrient focus. The blended foods (regular and instant Corn-Soy-Milk, wheat-Soy-Blend) shipped under Title II (10% of total food shipments in 1978) are fortified with multiple nutrients (soyflour, oil, calcium, phosphorus, sodium, iron, potassium, vitamin A, thiamin, riboflavin, niacin, and ascorbic acid). However, these blends should more appropriately be considered formulated foods rather than fortified staples (see Study IV in this series, Formulated Foods).

B. SUMMARY:

COMMON FORMS AND USAGE

Fortification of foods with iodine and vitamin A has been used widely as a nutrition intervention in many developing countries in Latin America and Asia. Iron fortification has been less common but appears to be increasing. Different carriers have been chosen in different countries. Protein fortification has not had widespread implementation, although supplementation of wheat flour with local soy flour and amino acids is being practiced in several countries. Fortification is common, and often mandatory in many developed countries.

CHAPTER TWO

INTERVENTION DESIGN*

I. INTRODUCTION

This chapter will examine the main questions involved in choosing and designing a fortification intervention. The decision to implement a fortification program must be preceded by an examination of the alternative programs available for combatting the same nutritional deficiency, such as mass doses by injection or tablet, nutrition education, family gardens (or income generating programs). This chapter will concentrate on fortification and mass doses since the other interventions are covered in great detail in other studies of this series (see Study II, Nutrition Education and Study VII, Integrated Nutrition and Primary Health Care Programs).

II. NUTRIENT NEED

A. KEY QUESTIONS

- Who is the target population?
- What is the nutrient need?
- What are the methods available for identifying nutrient deficiencies?
- What regional, seasonal, or geographic differences affect nutrient intake?
- What are the interrelationships between deficiencies?

Those suffering severely from the micronutrient deficiencies can be identified by trained personnel using standard clinical and biochemical measures. See Table 3 for vitamin A deficiency classification and World Health Organization (1976) for assessment methodology; for iron and folate assessment methodology see World Health Organization (1975). Moderate deficiencies are harder to detect but dietary surveys can point out nutrient deficits relative to recommended allowances. For a manual on these surveys, see Reh (1962). Such surveys for micronutrients have been criticized as particularly misleading because some of these nutrients are stored; the prior day's consumption (using 24-hour recall) might not

*This chapter was prepared by James E. Austin, Thomas K. Belding, and David Pyle.

include the erratic consumption of a food high in this vitamin or mineral. However, low-income family diets tend to be very stable, with little variation. Nonetheless, seasonal variation in food supplies also clouds the issue since during and after the harvest micronutrients may be high but in other seasons, consumption may be low. Absorption, especially of iron, is another dimension that should be tested. Food intake will not necessarily reveal the quantity of nutrient actually metabolized.

In diagnosing need, the planner should not use national intake averages but rather should verify regional differences in consumption. These can be sizeable. For example, a preschooler dietary survey in six rural regions of Guatemala showed iron intake to vary by 72%, retinol (vitamin A) intake by 538%, calories by 34%, and protein by 22% (Snodgrass, in Austin 1977). Seasonal differences might also exist, and should be verified. Furthermore, urban and rural differences should be noted, because these can be significant, with the severity of the deficiencies often being greater among the urban poor than among their rural counterparts (Austin et al. 1976).

Also, the planner should scrutinize the full gamut of deficiencies because of their interrelationships. For example, protein malnutrition leads to a decrease in retinol-binding protein which is needed for transporting vitamin A (retinol) from the liver to the body's cells. Enzyme production also decreases, affecting beta carotene dehydrogenase which is needed for vitamin breakdown and availability. Thus, even if vitamin A is supplied through fortification (or any other method), its biological availability and utilization might be quite small in the face of significant protein inadequacy (Arroyava, Viteri, Behar, and Scrimshaw 1959; Roels and Mack 1972). Given that xerophthalmia complicates PCM (Oomen 1954) and PCM impedes adsorption of vitamin A (Reddy and Swakumar 1972), both deficiencies should be addressed simultaneously. Similarly, vitamin E has been cited as being needed for efficient vitamin A utilization and liver storage (Bauernfeind, Newmark, and Brin 1974).

Improvements in protein quality through fortification with amino acids do not meet caloric needs. Adequate caloric intake is held to be a precondition to seeing any positive impact of lysine fortification (Vaghefi, Makdani, and Michelson 1974). However, results published by Scrimshaw, Taylor and Young (1973) indicate that lysine supplementation in healthy young men have be beneficial effects despite inadequate caloric intakes. Still, the key here may be that adequacy refers to standard requirements rather than actual needs of individuals who may adapt their energy expenditure to the reduced intake and thus not actually be calorie-short. There have been many animal studies that have demonstrated that protein quality improvement increases growth and nitrogen retention even when calories are fed inadequately (Munro and Allison 1964). However, the paucity of analogous human studies confirming this phenomenon leaves in serious doubt the desirability of protein fortification in the face of caloric inadequacy (Gershoff et al. 1977).

Another problem of fortification is that the alleviation of one nutrient deficiency may exacerbate another. In India where tea appeared to be the vehicle of choice for vitamin A fortification, the question was

TABLE 3

XEROPHTHALMIA CLASSIFICATION

Classification	Signs*
	Primary:
X1A	Conjunctival xerosis
X1B	Bitot's spot with conjunctival xerosis
X2	Corneal Xerosis
X3A	Corneal ulceration with xerosis
X3B	Keratomalachia
	Secondary:
XN	Night Blindness
XF	Xeropthalmia fundus
XS	Corneal scars

* A community should be considered for intervention when X1B exists in more than 2.0% of the population at risk; or X2 + X3A + X3B in more than 0.01% , or XS in more than 0.1%; or plasma vitamin A level of less than 10 mg/100 ml in more than 5.0%.

Source: World Health Organization 1976.

raised as to whether the tea's inhibitors to iron absorption would precipitate a more severe deficiency of iron in the susceptible population. It is possible that fortification might make the perceived value of the tea greater, and therefore lead to increased tea consumption. Consequently, the incidence of poor iron absorption could rise, resulting in an increase in the incidence and severity of iron deficiency at the same time that the vitamin A deficiency is being alleviated. Of course, tea consumption can be so high anyway as to give this effect (World Food Council 1977). The expressed fears about fortification of tea or sugar enhancing their consumption may be unfounded, given the inelasticity of these staples. Nonetheless, if heavily promoted, one could see the risk of parents giving some tea instead of milk to small children. These types of interrelationships must be considered prior to implementing any intervention in order to avoid a seemingly positive action that results in a net loss.

Two final factors should be considered in assessing need. First, the nutrient losses in storage and preparation can be significant and are influenced by the form of both the fortificant and the fortification process (Bauernfeind and Cort 1974). Second, the biological availability of the nutrient may be low because of the form of the fortificant or the interactions (or lack thereof) with other nutrients. For example, the lack of meat or vitamin C may inhibit adsorption of iron (World Health Organization 1968, 1970, 1972).

B. SUMMARY:

NUTRIENT NEED

Clinical and biochemical tests can best identify severe nutrient deficiencies, while dietary surveys can be valuable for exposing moderate deficiencies and for mass screening of target groups. Interpretation of survey results must be approached cautiously, with careful attention being paid to regional, seasonal, and geographic differences.

Nutrient interrelationships can be significant for fortification in cases where intake, absorption, transport, and utilization of one nutrient is affected by another nutrient.

Interpretation of nutrient needs should also include the possible effects on nutrient losses of storage and preparation. The biological availability of the nutrient, given the other nutrients in the diet, should also be ascertained.

III. NUTRIENT QUANTITY

A. KEY QUESTIONS

- How much nutrient should be used?
- Whose nutrient deficit should the program attempt to fill?
- How mucy of the carrier is consumed by the target population?

Clinical or biochemical measures are insufficent by themselves to determine how much nutrient should be used; dietary surveys are desirable to help answer this question. There are two steps in calculating the amount of fortificant to add to the carrier (Austin 1977).

First, the planner should determine the quantity of nutrients needed to fill the nutritional deficits identified, that is, the difference between the recommended daily allowance (RDA) and the actual amount of nutrient taken in (or absorbed as in the case of iron. This will emerge from the nutritional-need analysis, but certain judgments are necessary. The degree of deficits will vary among the target-population individuals because RDAs and intakes vary, and so the planner will have to decide whose deficit to fill. One approach is to use an average deficit, and another is to use the maximum deficit; the latter improves potential impact but also increases total costs. In using the maximum approach, one should also determine the risk of toxicity.

Having calculated the nutrient need, one next verifies the daily consumption quantity of the food to be fortified. The quantity of fortifier to be added will vary depending on the carrier-consumption level. As an example, let us assume equal nutrient deficits in equal numbers of preschoolers in two different locations. In an urban slum preschoolers consume 100 grams of tortillas per day, whereas those in a rural village consume 200 grams daily. The fortification formula in the slum would have to contain twice the nutrient level of the formula in the village in order to fill the nutrient inadequacies. Thus, the calculation of the quantity of fortificant to be added must be preceded by the selection of the carrier.

Thus, "standard" quantities of a fortificant do not exist: the quantity must be determined in each case based on nutritional deficiencies and consumption patterns.

B. SUMMARY:

NUTRIENT QUANTITY

The first step in determining the amount of fortifier to be used is to identify the target group's nutrient deficit, deciding how much of the deficit the program will attempt to fill. Second, daily consumption of the carrier must be determined so that appropriate calculations for adjusting fortifier quantity, and hence intake, can be made.

IV. CARRIER AND FORTIFICANT SELECTION

A. KEY QUESTIONS

- What types of food are possible carriers and will the fortified product be acceptable to the target population?
- Does the target population participate in the carrier's commodity system structure?
- Is centralized or decentralized processing preferable for the fortification program?
- What are the technological constraints of the fortificant and fortifying process?

B. Usage and Acceptability

The carrier should be consumed on a regular, relatively constant basis by the target group. This generally eliminates carriers such as margarine or milk, the price of which is most often beyond the purchasing power of the target families. This narrows the field largely to basic, low-priced staples, such as sugar, condiments, and cereals. It is also usually asserted that the carrier must be universally consumed. In fact, this is often impossible because of regional or urban-rural differences.

Having found a carrier that fits the usage criteria, the planner should test the fortified product's acceptability to the target consumer before launching a major effort. Organoleptic suitability (taste, sight, smell, texture, that is, sensory acceptability) can be determined by three systematic, blind-triangle taste tests on a small sample of target-group recipients (Urrutia et al. in Austin 1979). It is frequently asserted

that a major advantage of fortification is that it is an "invisible" intervention, and thereby not disruptive. In most instances fortification with micronutrients is not discernible; however, taste studies have shown that consumers are sometimes able to detect fortification (Bauernfeind 1973; Austin and Snodgrass in Wilcke 1976). Detection, however, is not necessarily a negative occurence. Some respondents have even found the fortified product superior to the unfortified.

Acceptability can be affected by other factors, too, such as the effect of preparation procedures, storability, and cultural norms. The alteration of a food with a foreign substance may be culturally reprehensible. If the fortification occurs in a central mill, then this problem may be averted, if the consumer is unaware of the fortification. Ethically, however, it seems necessary to inform the consumer of such an alteration.

C. Commodity-System Structure

The structure of the commodity system chosen for fortification should be carefully examined to ensure that the target group participates in that system. For example, an examination of the wheat system in Tunisia revealed that approximately half of the production did not flow through the government's controlled procurement process and centralized mills, but rather flowed through a "parallel" black market and small village mills (Mock in Austin 1977). Fortification in the central mills would clearly not reach many rural areas. In Guatemala, approximately 15% of the families consume panela, unrefined sugar, and therefore would not receive the benefits of vitamin A refined sugar fortification (Austin and Ickis 1974). Those groups might, in fact, be the ones most in need ov vitamin A supplementation.

Of special concern also are subsistence farmers. Unless these farming families participate as buyers in the market economy, fortification will not reach them. The exception would exist if the nutrient was being added in the home. Most subsistence families do, however, enter the cash economy to buy certain basic staples, such as salt, MSG, and sugar. Furthermore, field surveys have estimated that around 90% of the rural subsistence families in Thailand, Guatemala, and Tunisia take their grain to a local mill for processing (Austin 1977). Thus, their food passes through an external processing point and can therefore be subject to fortification.

D. Centralized and Decentralized

This raises another important structural issue: centralized versus decentralized processing. Conventional wisdom about fortification has asserted that feasibility requires the carrier to be centrally processed. Centralized processing has the obvious advantage of reducing the supervisory, logistical, and control problems of the intervention. However, it also has the less obvious disadvantage of fortifying a "universal" staple that will be consumed by nutritionally non-needy segments of the society. A decentralized, regional, or village-level fortification program can be

targeted more sharply toward those in need. Where the nutritional diagnosis shows large regional differences and a relatively small afflicted portion of thepopulation, then the case for selecting a carrier with decentralized processing would be stronger.

Cost effectiveness is influenced by degree of centralization. Decentralized programs may, for example, have higher overall costs because of the need for duplication of facilities and personnel. Centralized programs may, however, result in more substantial overcoverage of the population than decentralized programs, and thus be less cost-effective on a cost-per-target-group-recipient basis. (For a complete discussion of cost-effectiveness, see Chapter 3.) However, the planner should examine each situation individually to make these comparisons. Results will depend on regional or local conditions.

E. Technological Constraints*

A final concern in selecting the carrier and fortificant is the feasibility of the fortification technology. Two aspects of the technology should be considered: the fortificants and the fortifying process. This analysis will continue to focus on iodine, vitamin A, iron and protein, rather than other nutrients.

Iodization can be achieved simply with a sodium or potassium iodide or iodate. Vitamin A is commercially available as acetate and palmitate esters, which are more stable than vitamin A alcohol (Borenstein 1975). Both the acetate and palmitate derivatives are marketed in oil solutions, emulsions, and dry encapsulated beadlets of standard potencies (see Table 4). Although the acetate form is less stable than the palmitate form, both are practically insoluble in water. The vitamin quantities needed for fortification are so small that they generally have no adverse effects on the processing and organoleptic properties of the carrier, but vitamin fortification is not without its problems. Added vitamin A and thiamine reportedly cause undesirable odors when broken down by heat in toasted cereals (Aylward and Morton 1970, Borenstein 1975).

Iron is absorbed poorly from diets rich in bulky carbohydrates, phosphates, oxalates, and carbonates because of the formation of precipitates and polymers excreted in the feces (Harris 1970). Certain forms of iron are more readily absorbed than others. In general, biological availability parallels solubility under conditions resembling those in the digestive system (Harris 1970). Solubility of elemental iron powders is not necessarily a function of particle size, however. High surface area and porosity may compensate for large particle size (Ranum 1978). Food manufacturers prefer forms of iron and calcium with low solubility, because they are less liable to cause flavor and taste problems by themselves

*This section is based primarily on the work of Dr. Samuel Yong (Yong in Austin 1977); for a more complete review of cereal fortification technology see Yong in Austin (1979).

TABLE 4

FOOD APPLICATION FORMS OF VITAMIN A

Type and Name	Potency (IU/g)	Other Ingredients	Usage
A. Liquid products			
1. Vitamin A Palmitate	1,650,000 to 1,800,000	Edible antioxidant such as butylated hydroxyanisole and butylated hydroxytoluene; no oil diluent	Where maximum concentration is required
2. Vitamin A Palmitate Type PIMO	1,000,000	Edible oil only for potency standardization	For general use without stabilizers
3. Vitamin A Palmitate Type PIMO/BH	1,000,000	Edible oil plus butylated hydroxyanisole and butylated hydroxytoluene as antioxidants	Recommended for general use
4. Vitamin A Palmitate Emulsion	500,000	Acacia, butylated hydroxyanisole and butylated hydroxytoluene as emulsifier and antioxidants; sodium benzoate as preservative	Fortification of cereal and dairy products, potato flakes, and other food products that require special processing techniques
5. Vitamin A Acetate Type AIMO	1,000,000	Edible oil only for potency standardization	For general use without stabilizers such as oil solutions and gelatin capsules
B. Dry products			
6. Dry vitamin A Palmitate beadlets Type 500	500,000	Gelatin, carbohydrate and tri-calcium phosphate; and butylated hydroxytoluene as antioxidants and sodium benzoate and sorbic acid as preservatives	For products which are not dispersed in cold water; for example, extruded foods, candies, compressed bars and similar forms where high resistance to moisture and heat is required
7. Dry vitamin A Palmitate beadlets Type 250 CWS	250,000	Gum acacia, carbohydrates, food starch-modified; butylated hydroxyanisole, butylated hydroxytoluene and dl-alpha tocopherol as antioxidants	Water-dispersible, for dry products to be reconstituted before use
8. Dry vitamin A Palmitate beadlets Type 250-S	250,000	Gelatin, dextrose, modified food starch, coconut oil, sorbitol, sodium citrate, with ascorbic acid, butylated hydroxytoluene and dl-alpha tocopherol as antioxidants	Water-dispersible, free-flowing beadlets to help meet the stringent flavor needs of milk-base products and other beverages
9. Dry vitamin A Palmitate-SD Type 250-SD	250,000	Acacia, lactose, coconut oil; butylated hydroxytoluene, sodium benzoate and sorbic acid as preservatives	For product use wherever fine particle size is desirable, i.e., flour, corn meal, vitamin premixes, dry milk, sugar, beverages

Source: Bauernfeind and Cort (1974).

or in combination with other substances. For instance, iron is a well-known catalyst in the oxidative degradation of unsaturated fats which may yield off-flavor compounds.

Although electrolytically and chemically reduced iron powders are the most widely used sources of iron in cereal fortification, their biological availability is low compared to some other sources. Reduced iron has less than 50% of the biological availability of ferrous sulfate or ferfous fumarate, but sodium iron pyrophosphate and ferric orthophosphate are even less available biologically and are generally not recommended for fortification because they are extremely expensive. A grayish powder with high bulk density, reduced iron presents off-color problems and is difficult to incorporate uniformly in a dry mix. Furthermore, the magnets used to remove trap iron from cereal products will also entrap the iron powder which, unlike iron salts, is magnetic (unless the fortification takes place after the magnets are used).

Ferrous sulfate, a low-cost, fine, white powder, is therefore the iron source of choice whenever it can be used without adverse organoleptic effects. Problems of black spots on the crust of rolls and bread resulting apparently from surface oxidation have been resolved by reducing particle size (Ranum 1978). In those cases where organoleptic stability is a problem, previously mentioned iron sources of low solubility and low biological availability must be used (Anderson, Bookwalter, and Vojnovich 1976). However, the quantity biologically available must be high enough to contribute significantly to the nutrient deficiency identified to justify the fortificant's use. Stability problems have been reported when ferrous sulfate is added to wheat flour. The higher biological availability of ferrous sulfate is associated with a more reactive molecule which can also oxidize the lipids in wheat flour during storage; this might cause off-odors or flavors. To avoid this problem, scientists are developing a "stabilized" form of ferrous sulfate. This research is particularly important because ferrous sulfate is otherwise a very attractive fortificant. It has a higher biological availability than reduced iron, is cheaper, and has a lower bulk density and is thus less likely to settle out in transport. However, as a salt it is soluble and could dissolve in the humid environment of flour; this could oxidize the lipids in the wheat flour and cause off-flavor. Thus, the research aims to find a means of preventing the ferrous irons from interacting with the flour while still retaining their high biological availability.

Many cereals contain low quality proteins that are limiting in one or more essential amino acids. L-lysine is the most important limiting acid in all cereals, and L-tryptophan and L-threonine are also limiting in corn and rice respectively (Senti and Pence 1971). It is possible to add these limiting amino acids to basic cereals with natural protein such as soy flour. Researchers found no difference in L-lysine use between supplements in the form of L-lysine and HCl and as natural protein (Longenecker and Hause 1959, Schwartz, Fisher and Taylor 1959). It is also important to keep in mind the earlier point that protein fortification generally would not be advisable without also filling caloric gaps, since the protein would otherwise be metabolized for energy rather than for

growth purposes. Protein fortification might be appropriate for low-protein, high-calorie, tuber-based diets. It should also be noted again, however, that calorie needs may be less than stated calorie requirements due to physiological adaptation; thus, a nominal calorie deficit may not be an actual physiological one (Durwin 1979). Finally, in animal studies the quantity and quality of protein in the diet have strong effects on voluntary energy intakes; this may also be applicable to children, but conclusive evidence does not exist.

For economic and technical reasons, methionine is currently the only essential amino acid manufactured by chemical synthesis from pretoleum-based raw materials (Kacem 1976 and Reisman 1977). Consequently the others, L-lysine, L-threonine, and L-tryptophan, are all manufactured by fermentation. This process requires molasses, starch hydrolysates, sugars, and similar substances for energy and carbon sources, but all fermentation methods are patented. Almost all of the world's L-lysine, L-threonine, and L-tryptophan are manufactured by the Kyowa Hakko Kogyo Company and Ajinomoto Company of Japan (Reisman 1977). Production capacity for L-lysine is estimated at 55 million pounds per year (Austin and Snodgross in Wilcke 1976), with the demand for 1980 projected at 143 million pounds (Reisman 1977). At this moment, L-tryptophan and L-threonine production is limited to pharmaceutical uses (Reisman 1977). Markets for these human-grade amino acids will probably not develop until a major market for L-lysine as a protein fortificant emerges. Production of DL-methionine and methionine hydroxy analogue is estimated at 205.5 million pounds, of which 64% is made in Europe, 22% in Japan, and 11% in the United States (Austin and Snodgrass in Wilcke 1976). Almost all (approximately 98% of the methionine and 90% of the lysine) of this output is used for animal-feed supplements (Japan Chemical Annual 1974).

Of the protein sources that have been considered for cereal fortification in different parts of the world (Bauernfeind 1970), soybean, fish, milk, sunflower and other oilseeds, and microorganisms are rich in L-lysine (Milner 1969 and Jansen 1974). Cereal supplementation with these proteins raises the quantity as well as the quality of proteins in the final mixture. On the other hand, L-lysine levels, in groundnuts and cottonseed, are not too much greater than in cereal proteins; for example, in terms of mg/g of total nitrogen the lysine level in corn meal is 167, in wheat flour 159, and in polished rice 226, while the level in groundnuts is 221 and in cottonseed cake 259 (Food and Agricultural Organization 1970; Hegsted 1969; and Jansen 1974). Accordingly, these proteins have only limited value for cereal fortification unless synthetic L-lysine or lysine-rich proteins are added to them. Cottonseed flour has been degossypolized by extraction and heating, and then used in Incaparina and other protein-enriched cereal foods (Shaw 1969 and Bauernfeind 1970). Cottonseed protein, in addition to its inferior nutritive value per unit cost, has been known to impart a strong yellow-green color to food in some applications.

Regarding the fortifying process, the following general technological considerations apply:

(1) a systematic method of adding the nutrient and the availability of reliable equipment;
(2) uniformity of distribution of added nutrients at the mill and during the transportation, storage, and preparation of of the food;
(3) precise quality-control procedures and a rapid and reliable assay procedure to determine the level and the distribution of nutrients in the fortification premix and in the fortified cereal;
(4) evaluation of the nutritional gains brought about by the addition of certain nutrients to cereals against their potential adverse effects.

The form of the nutrients and the point and manner of their addition must be treated individually, because so many factors related to them can affect the nutrient levels of the final products. The process for adding vitamin A to sugar or protein-vitamin mixes to cereal flour employs a premix. This is prepared centrally and then added to the carrier by automatic or mechanical feeders. To minimize errors in feed rates, the premix should be free-flowing and consistent in bulk density. Also, to avoid separation and settling during transportation and storage, the premix particle size should mesh with the carrier.

Settling as well as stability should be carefully pretested. Vitamin A and its precursor, beta-carotene, are sensitive to air, oxidizing agents, and ultraviolet light. Their decomposition is catalyzed by metal ions and accelerated by increasing temperatures. Vitamin A losses in fortified food during storage and processing can be reduced by (1) use of food-approved antioxidants (for example, BHT, BHA, propyl gallate), and (2) protective coatings, and (3) minimizing exposure to high temperatures and acidity.

Minerals, unlike vitamins, amino acids, or proteins, are rarely destroyed through chemical reactions in food. Rather, the problem is one of inadequate absorption; oxalates and phytates inhibit iron absorption by forming insoluble salts that pass through the digestive track.

Stability depends on processing and storage conditions as well as on the physical and chemical form of the fortificant and fortification process (see Table 5). The institution of these processes in sugar mills (Instituto de Nutricion de Centro America y Panama 1974) and wheat mills (Austin 1977) has proven to be minimally disruptive and relatively non-demanding. Similarly, iodization of salts has been easily accomplished.

The feasibility of village-level fortification has also been documented (Austin 1977), but here the intervention is highly visible and requires the cooperation of millers and consumers. Alternative technologies are available to adapt to the village situation. At the village level, there are three possible methods of fortifying semolina and flour:

TABLE 5

STABILITY OF FORTIFICATION NUTRIENTS UNDER SPECIFIC PROCESSING AND STORAGE CONDITIONS

Fortificant	Processing/storage conditions	Percentage loss	Reference
Vitamin A (as acetate oil) added to simulated kernel	Extrusion cooking to prepare simulated kernel and storage for three months at 86°F	45-50 (combined processing storage loss)	Gershoff et al. (1975)
Vitamin A (as palmitate beadlets containing antioxidant) added to dry mix products	Storage at room temperature	0.5/month	Borenstein (1975)
Vitamin A (as palmitate beadlets) added to wheat or maize flour	Baking of bread (Western-type, chapatis, tortillas)	0-10	Borenstein (1975)
	Five days storage at room temperature after baking	5-15	
Vitamin A (as palmitate beadlets) added to wheat flour	Three month storage at 45°C		
	9 percent moisture level	13-20	
	13.5 percent moisture level	50-90	
	Four month storage at room temperature		
	9 percent moisture level	0-2	Rubin and Cort (1969)
	13.5 percent moisture level	8-27	
Vitamin A (as palmitate beadlet) added to flour	Baking of (Western-type bread, chappatis, tortillas)	10-13 8 0	Rubin and Cort (1969)

TABLE 5 (continued)

Fortificant	Processing/storage conditions	Percentage loss	Reference
Vitamin A added to nonfat dry milk	Storage at 23°C for twelve months	11-31	Bauernfeind and Parman (1964)
	Storage at 37°C for three months	0-6	
Vitamin A sprayed on ready-to-eat cereal	Storage at 23°C for six months	17	De Ritter (1976)
Thiamine added to corn grit	Extrusion cooking at 300°F	39	
	13 percent moisture level	39	
	16 percent moisture level	10	Beetner, Tsao, Frey, and Harper (1974)
	Extrusion cooking at 380°F		
	13 percent moisture level	52	
	16 percent moisture level	81	
Thiamine (encapsulated) added to protein-rich mixture	Extrusion cooking	10	Smith (1969)
Thiamine added to ready-to-eat cereal	Heating to prepare toasted cereal products	15	Borenstein (1975)
	Storage at 23°C for twelve months	0	De Ritter (1976)
Thiamine added to wheat flour	Commercial baking	21-26	Schultz, Atkin, and Frey (1942)
	Baking of Devil's food cake (alkaline)	93-100	De Ritter (1976)
Thiamine added to pasta products	Cooking and draining	50	Rubin and Cort (1969)

TABLE 5 (continued)

Fortificant	Processing/storage conditions	Percentage loss	Reference
Thiamine added to dry products (e.g., cocoa)	Twelve month storage at 75°F	13	Borenstein (1975)
	at 98°F	21	
Thiamine (as thiamine naphthalene disulfate) added to simulated rice kernel	Washing, soaking for six hours and slow cooking for two hours (combined loss)	24	Gershoff et al. (1975)
Thiamine added to bulghur	Steamed for table use	Negligible	Pence et al. (1964)
	Canned at 55 percent moisture, retorting	72	
Thiamine added to premix rice kernels by infusion method (with steaming of rice surface)	Washing	7	Kondo (1951)
	Washing and cooking	12	
Riboflavin added to pasta	Cooking and draining	30	Rubin and Cort (1969)
Riboflavin added to corn grits	Extrusion cooking at 300°F		
	13 percent moisture level	0	
	16 percent moisture level	13	Beetner, Tsao, Frey, and Harper (1974)
	Extrusion cooking at 380°F		
	13 percent moisture level	0	
	16 percent moisture level	46	
Riboflavin added to bulghur	Cooking and draining	40	Rubin and Cort (1969)
Niacin added to pasta products	Steamed for table use	10	Pence, Fenels, and Robertson (1964)
	Canned at 55 percent moisture retorting	30	

TABLE 5 (continued)

Fortificant	Processing/storage conditions	Percentage loss	Reference
L-lysine added to wheat flour	Baking of white bread with 4-6 percent nonfat milk powder (ordinary use)	5-25	Matthews, Richardson, and Lichtenstein (19690 Jansen and Ehle (1965b). Gates and Kennedy (1964)
	Baking of white bread with 25 percent nonfat milk powder (high content of reducing sugars)	40	Ehle and Jansen (1965)
	Baking of sweet bread (high content of reducing sugars)	30	Ericson and Larson (1962)
	Baking of unleavened bread (chappatis, poories, parathas)	0-4	Matthews, Richardson, and Lichtenstein (1969) Bains and Tara (1970)
	Boiling and draining of noodles	50-60	Akino (1971)
	Boiling or frying	33	Pereira, Bergum, Jesudian, and Sundarary (1969)
	Storage for 51 and 83 days at room temperature	Negligible	
	Steaming to prepare couscous	Negligible	Tunisia Report (1977)
	Baking of bread	9-17	
L-lysine added to Incaparina	Boiling of Incaparina with nonreducing sugar for 24 minutes	Negligible	Bressani, Elias, Jarquin, and Braham (1964)
L-lysine added to whole wheat by the infusion method	Twelve month storage at 100°F		Ferrel, Sheperd, and Guadagni (1970)
	13 percent moisture level	Less than 10	

TABLE 5 (continued)

Fortificant	Processing/storage conditions	Percentage loss	Reference
L-lysine added to simulated rice kernels	Washing, soaking in water for six hours, and cooking for two hours	18	Gershoff et al. (1975)
L-lysine added to fortified rice premix by the infusion method (with and without steaming of fortified rice surface to form α-starch layer)	Washing for ten minutes (no steaming)	40	Mitsuda and Yasumata (1974)
	3 minute steaming	20	
	10 minute steaming	10	
L-lysine added to parboiled rice	Cooking without draining the gruel	Negligible	Bains and Tara (1970)
L-threonine added to parboiled rice	Cooking without draining the gruel	Negligible	Bains and Tara (1970)
DL-threonine added to animal feeds	One year storage at 50°C	Negligible	Rohdenburg and Rosenberg (1956)

(1) At a central location, prepare two premixes differing only in particle size, one at the mesh range of semolina, and the other at the mesh range of flour. Each premix can be mixed with sifted semolina or flour at the village mill with a simple mixing bucket agitated by hand-rotated paddles. The mixing bucket and the measuring cups used to scoop the premixes can be standardized so that the semolina and flour will be fortified at the proper level.
(2) Prepare a powder premix which the village miller can add to the attrition mill at controlled rates by slightly modifying the milling machine and attaching a simple volumetric feeder. (Tablets if used would be added per standard weight of the milled product.) The premix tablets will be added to the wheat stream just before it enters the attrition rollers, and mixing will take place during milling. Tablets or pellets can also be mixed with wheat by hand before the mixture is added to the milling machine.
(3) Prepare a premix in the form of heavily fortified whole wheat kernels, which can be added to wheat as in the second method above.

Each of these methods has advantages and shortcomings. The first method is by far the most efficient in terms of premix and equipment costs, but to be effective it requires extensive cooperation from the mill operator and his customers. Powdered premixes cannot be added accurately because the outcoming stream of milled wheat is small and always changing. To avoid the separation in the feeder unit of premixes with different bulk densities, one feeder must be installed for each premix. Furthermore, because there is no built-in mixing step, fortified semolina and flour must be mixed, possibly by hand.

Both the second and third methods require much less cooperation from the miller, especially if he can attach an inexpensive feeder to his milling machine. The reliability and accuracy of such feeders (1 = 0.03%) is demonstrated in the Thailand rice fortification study (Gershoff et al. 1975). Nevertheless, the pellet form of the second method of premix costs more to make. Another disadvantage is the uncertain distribution of the added nutrients between semolina and flour after sifting. Unless the pellet or tablet is physically similar to the whole wheat kernel, a greater portion of the added nutrients may end up in either the semolina or the flour. Unfortunately, no experimental data are presently available to pursue this discussion further. Unlike the second method, the third assures the uniform distribution of fortifiers between semolina and flour and provokes the least customer resistance.

Although technically feasible, village-level fortification has to be designed to enlist the support of the miller. This support may be achieved either through legislation mandating fortification accompanied by adequate surveillance and/or through economic incentives.

F. SUMMARY:

CARRIER AND FORTIFICANT SELECTION

Any food that is being considered as a possible carrier should be consumed by the target group on a regular basis. Thus, basic low-cost staples are generally the carriers of choice. To maximize consumption the fortified product must be culturally acceptable to the target group with respect to its taste, sight, and smell.

The carrier must be distributed within a commodity system that reaches the target population to ensure a point of access for the fortification process. If the carrier is not part of a commodity system, but is brought to a local mill for processing, the latter point will serve satisfactorily as the point of access for fortification.

Despite the conventional approach for centralized processing - with its obvious case of control and management - there are instances where decentralized processing is more appropriate. Regional differences in need and targeting capabilities require individualized cost-effectiveness evaluations before one approach is chosen above another.

The fortificant chosen must be in a form that can easily be incorporated into the carrier and then be biologically active and available once consumed. Care should be taken that equal distribution of the nutrient in the carrier is possible. Reliable equipment and adequate transportation, storage, and preparation procedures are necessary to minimize settling and decomposition.

Methods for fortifying foods at the village level require the cooperation of the miller as well as serious consideration of fortificant costs and consumer resistance to the process of adding exogenous material to food by virtue of the high visibility of local fortification.

V. ALTERNATIVE INTERVENTIONS

A. KEY QUESTIONS

- What are the alternative interventions to fortification?
- What alternative programs have been implemented so far?

- What are the program-design issues raised by these experiences?
- What is the relationship between fortification and its alternatives?

The most commonly used alternatives are injections, tablets, family gardens, nutrition education, and plant breeding. The various alternatives are not mutually exclusive and can be used to complement each other as required by target group needs, cost, equipment, and personnel constraints. It is beyond the scope of this study to deal in depth with each of these, but salient aspects will be described.

Direct dosage programs provide large doses of a nutrient parenterally (by injection) or orally (in tablets or capsules) to entire populations or large target groups. The rationale behind administering mass doses of a nutrient is based on the body's ability to store fat-soluble vitamins in the liver and circulating minerals that are bound to certain proteins and fat-soluble compounds. These can be mobilized and utilized by the body weeks, months, sometimes even years later when intakes of these nutrients are low. Conclusions regarding the usefulness of this type of intervention vary, specifically because of the technical problems of delivery, absorption, and biological availability.

Iodinated oil has been administered intramuscularly on a large scale in Irian Jaya, New Guinea, to pregnant women. Since initiation of the program ten years ago, no cretins have been born in the area. Intramuscular iodine preparation consists of ethylene esters of fatty acids of poppyseed oil, 37% iodine by weight. Although a large proportion of the iodine is excreted shortly after injection, enough of the mineral is retained to keep stores high and prevent goiter, cretinism, and deaf-mutism from iodine deficiency for three to five years. The World Food Council (WFC), in a report on policies and programs to improve nutrition, recommended that mass doses of iodine be administered in countries where iodization programs are not feasible due to inaccessible populations, lack of a distribution network for a centralized carrier, or local resistance to the fortified carrier (such as the refinement of salt necessary for fortification) (World Food Council 1977).

The first use of periodic vitamin A distribution was part of the xerophthalmia project in Jordan, 1965-1966 (McLaren, Khoury, Shirajian, and Tehalian 1965). Subsequent programs have been and continue to be conducted in India (Srikantia and Reddy 1970), (Swaminathan, Susheela, and Thimmayama 1970, and World Health Organization 1976), El Salvador (Sommer, Faich, and Quesada 1975; Sommer, Quesada, Doty, and Faich 1975), Bangladesh (Kamel 1973, 1974), West Bengal (Sinha and Bang 1973), the Philippines (Cash 1976 and Solon, Fernandez, Latham, and Popkin 1979), Sri Lanka and Brazil. The national Vitamin A Prophylaxis Program was initiated in 1970, and by 1974 reached three million children in ninety-seven districts in fourteen states (World Health Organization 1976). The main problems

encountered in India were associated with the delivery of the vitamin. Lack of personnel, poor coordination, and inadequacy of record-keeping made it increasingly difficult to ensure high levels of coverage while maintaining repeat doses to the recipients. The progressive decline in motivation of the staff resulted in decreasing success on subsequent rounds of distribution (success being measured by percent of target group covered). Additionally, a well-developed infrastructure was found to be crucial to facilitate delivery to and adequate coverage of both the urban and rural populations.

The feasibility of mass dose programs rests first on these two aspects of delivery - personnel and structure. Should any external or internal stress such as political or social unrest develop to interfere with either of these, the program is immediately jeopardized. For example, famine and epidemic in Bangladesh caused a breakdown in both elements and thus this program reached fewer people than on previous rounds, particularily among the high risk group. A further disadvantage is that once a person is missed in a nationwide periodic program, he or she must often wait until the next administration, four or six months later.

Schedule of administration must next be considered. Vitamin A can be prepared as water miscible or oil soluble (U.S. Agency for International Development 1973) and has been administered in 200,000 - 300,000 IU doses at various intervals during the year. Because of the large storage capacity for vitamin A, it was imperative to find the level and frequency that could be safely administered without producing toxicity. Hypervitaminosis A is characterized by projectile vomiting, headache, fever, and abdominal pain. These reactions were observed within twenty-four hours after ingestion in 4% of the capsule recipients in India (Swaminathan, Susheela, and Thimmayama 1970), the Philippines (Solon, Fernandez, Latham, and Popkin 1979) and West Bengal (Sinha and Bawg 1973). Although transitory, these reactions greatly decreased the willingness of recipients to participate in subsequent vitamin administrations. Most recently, recommendations have been made to reduce the dose and to conduct the program at more frequent intervals, that is, every four months rather than every six or twelve (Solon, Fernandez, Latham, and Popkin 1979).

Iron/folate supplementation has been administered in Balwadis (through the rural Maternal and Child Health Services) in India (Sarma, Damodaraw, and Naidu 1977). Children ages two to six years were given daily supplements with 50 to 60% showing beneficial effects. However, 30% of the target group was not reached at all, while the daily delivery was disrupted easily by attendance changes and teacher turnover. In rural Tanzania, iron supplements given to five-to-fourteen year-olds did not significantly change hemoglobin levels. Upon further investigation, it was discovered that malaria was a more potent cause of anemia, and was thus in greater need of treatment than the iron deficiency (Vaughan et al. 1976). This study demonstrates the need to investigate the cause and effect of nutrition/health problems to ensure that the appropriate preventive and curative measures for the disease in question are being used.

The last problem with iron supplementation or injection is that of biological availability. The same considerations that are part of choosing a fortificant apply with iron supplementation; these are covered in the section entitled Technological Constraints.

A program that administers large doses of a nutrient to individuals identified as having biochemical deficiency and/or clinical signs of deficiency syndromes can be vital in the short run to stabilize an acute condition, reverse a deterioration process, or prevent death.

The World Food Council (1977) emphasizes the point that fortification and other alternatives take time to implement and that direct dosage is a good interim solution until the fortification system is established. This combination of approaches is being uitilized in N.W. Zaire and Peru for iodization and in El Salvador for vitamin A. Anemia, the target of iron/folate supplementation, is a deficiency prevalent in several different target groups (pregnant and lactating women, parasitically infested children) and hence may require multiple vehicles for effective fortification. The combination of interventions might therefore reflect therapeutic supplementation as appropriate for one group and fortification for the other, again depending on the health system infrastructure and suitable fortification conditions.

Nutrition education and family gardens can be simultaneously launched as longer-run, permanent solutions aimed at behavior change. Other public health measures aimed at reducing multiple deficiencies, infections, or intestinal parasites that interfere with absorption and biological availability of certain nutrients might also be desirable to include in a government's health/nutrition program. These alternative interventions utilize a different approach than fortification, that is, they do not directly supply quantities of nutrients to the deficient population. The design questions for such interventions are thus quite different from those for fortification and are covered in great detail in Studies II and VII of this series, Nutrition Education and Integrated Nutrition and Primary Health Care Programs, respectively.

A final alternative to fortification is plant breeding. Efforts in this area have focused on increasing the protein quality and quantity. The advantages cited are that wide coverage of the population can be reached by the improved staple, if adopted by farmers, without significantly altering the processing or distribution aspects of the commodity system and that the benefits are self-perpetuating (if not a hybrid); the disadvantages are seen as farmer resistance to adoption, the need to buy new seeds each year (if a hybrid), the changed farming practices and cropping patterns which might adversely affect some needy groups, and breeding research which is long and costly (Wilcke 1976).

High lysine corn has been developed but its yield appears about 10% less than hybrid's. High protein strains of wheat have been developed which are not incompatible with higher yields and milling quality. Rice breeding has concentrated on increasing yields with little success in simultaneously increasing protein levels.

B. SUMMARY:

ALTERNATIVE INTERVENTIONS

Injections, tablets, family gardens, and nutrition education are the most common alternatives to fortification being used for combating deficiency disease. Nutrition education and family gardens are discussed in Studies II and VII of this series, respectively. Fat soluble preparations of vitamin A have been used extensively to decrease the incidence and prevalence of xerophthalmia, while iodinated oils have been administered to prevent goiter, cretinism, and deaf-mutism. Trained and motivated personnel and delivery system infrastructure are the two factors identified as being crucial to successful implementation.

Adverse effects of large nutrient doses must be included in the determination of preparation quantities to minimize toxic reactions. By reducing dosage and increasing the frequency of administration, this can be accomplished.

Iron/folate supplementation has shown to be beneficial in raising serum levels. However, this effect is limited where the deficiency was caused by an external factor such as hookworm infestation or malarial disease.

Mass doses can be an effective short-term approach implementable simultaneously with a fortification program. Investigation, however, may reveal advantages of conducting both types of programs for different target groups depending upon local and regional infrastructures and conditions.

Plant breeding can produce varieties with increased protein quality and quantity which, if adopted, can benefit large population groups. However, research costs, adoption resistance, and changed farming practices may present problems. Higher protein content has been achieved in corn, but yields have been hurt. Wheat yields and quality have been increased. Rice yields have been increased but without accompanying improvements in protein levels.

CHAPTER THREE

INTERVENTION EVALUATION

I. INTRODUCTION

A planner must consider the costs of various alternatives before one program or a combination of programs can be chosen as the most desirable solution. Thus, when choosing between fortification, mass doses, nutrition education, family gardens, or plant breeding as methods of filling the nutrient gap of a target population in question, the costs of each program at every stage of implementation must be studied and then balanced with the desired outcomes. Only at this point can an informed decision be made so that scarce financial resources can be allocated in such a way that maximum cost-effectiveness is obtained.

Costeffectiveness can be defined in different ways depending on objectives. With respect to a specific nutrient deficiency, the objective might be to fill each person's nutrient deficit partially, or to fill severe deficits completely. In order to decide which program can best be aimed at which outcome, a review of the effectiveness of each alternative is necessary.

Evaluation methodologies use both cost and effectiveness measures to provide planners with the information necessary to make program choices and answer certain implementation questions. The Overview in this series of studies discusses nutrition evaluation methodology and elucidates two types of indicators: outcome and operating. Outcome indicators relate costs of a program to its effectiveness in altering nutritional and health status, for example, cost per closing the vitamin A deficit or cost per change in the prevalence of xerophthalmia.

Another useful evaluation methodology is cost/benefit analysis, for which both costs and benefits are quantified in monetary terms. Because of the difficulty in projecting the monetary value of present and future benefits resulting from a nutrition intervention, cost-effectiveness analysis is often the only feasible methodology. However, attempts have been made to apply the former methodology. The case study on vitamin A deficiency in the Philippines, presented in the following chapter, is an attempt to make cost/benefit calculations for the comparison of fortification with its alternative interventions.

Operating indicators cover aspects of delivery-system functioning, exposing points at which improvements should and can be made. These indicators are especially useful when evaluating approaches to the same nutrient deficiency, or when adjusting the design of a particular approach. Percent of target group reached, cost per target group recipient, dropout rate, and nutrient leakage are good measures of whether or not a program is reaching its target group and at what cost. Because of the spe-

cific nature of fortification and mass dose programs, the cost per change in incidence of the target deficiency and cost per change in disease-specific mortality rates are two other possible indicators for cost-effectiveness evaluation.

Evaluation of past or pilot programs is an indispensable tool for planners and for village-level personnel in guiding future decision-making and implementation. To facilitate evaluation, data gathering must be worked into the intervention design so that information is organized and available when needed. The services of a data expert should be obtained at the program's start to help decide what statistics are necessary, and the appropriate methodology for their collection.

An essential component of a fortification evaluation schema is a monitoring system. Such a system contains procedures to verify the operating integrity of the intervention as well as its impact. In-plant tests should be carried out periodically to ensure that the appropriate quantities of the nutrients are being added and that the equipment is functioning correctly to ensure uniformity of distribution of the premix throughout the carrier. Verification should also occur outside the plant. Random analyses of the fortified product should be carried out periodically. Inexpensive spot tests exist for several nutrients consisting of adding a few drops of certain reagents to the food and examining the resultant color which verifies the existence of the fortificants. The impact monitoring should involve baseline data, control groups, periodic dietary, clinical, and biochemical measurements. To reduce costs while preserving validity, stratified, multi-stage probability samples can be used.

II. COSTS OF FORTIFICATION

A. KEY QUESTIONS

- What are the costs of the fortificant?
- What are the equipment costs?

The costs of fortificants are the primary ones in fortification (Austin 1977). Tables 6 through 9 present the prices of vitamin A, iodine, iron, and synthetic and natural protein sources. Vitamin and mineral prices are relatively stable, but prices of protein sources have fluctuated considerably. In costing out projects, planners should of course take care to incorporate the inflation effect into budget projections. Care should also be taken to include the costs of any donated materials as well as the marginal costs of shared facilities and/or personnel; however, in most fortification programs these costs do not represent significant quantities.

The cost of any fortification program will depend on the price of the fortificants and the quantity added, the cost of adding it, and any costs of distribution, control, and evaluation. The main cost will generally be that of the fortificant. The reader can use the fortificant prices in Tables 6 - 9 as a starting point in the calculation. The other variables will be country-specific and depend on the size of the nutrient deficit existing and the prevailing logistical and factor costs.

As an illustration of fortificant costs see Table 10 which presents the quantities and costs of the protein, vitamin, and mineral premixes used in experimental cereal fortification projects in Guatemala, Tunesia, and Thailand. Prefeasibility analyses for national or regional fortification in each of these countries determined that fortificant costs would constitute about 90% of total intervention costs (for a full analysis see chapters 7 through 9 in Austin 1979). Among the nutrients, protein is, of course, many more times expensive than the vitamins and minerals. The financial feasibility of micronutrient fortification is much greater than macronutrient fortification.

Equipment costs for adding the fortificant are not exceptionally great, although they vary considerably depending on the needed capacity. Volumetric dry feeders supply a constant preset volume of premix and have been used in wheat flour fortification at large mills. Prices range from $1300 to $2200 (see Table 11). Premixed vitamins and minerals can be blended with protein of L-lysine with a spiral ribbon mixer. Prices range from $4500 to $8500 (see Table 12). At the village level mill the equipment is rudimentary (mixing cups or simple feeders) and very inexpensive ($10 - $100).

Few detailed program-cost data are available, but various estimates exist. It would cost $0.03 per capita per year to provide 80% of all Guatemalans with 75% of their daily vitamin A allowance via sugar fortification (Instituto de Nutricion de Centro America y Panama 1974). However, not all need such supplementation. The needy groups really are the 203,000 children with blood-serum levels below 20 mcg/100 ml. The annual cost of the national program in Guatemala is $450,000, and therefore it would require $2.20 per year to move each of these children to an adequate serum level (Arroyava, Aguilar and Portela 1976). The annual cost per child reached by the MSG-vitamin A fortification pilot project in the Philippines is estimated at $0.19 (Solon, Fernandez, Latham, and Popkin 1979). Only half of the children there had low or deficient vitamin A serum levels, so the annual cost per needy child was approximately $0.38; approximately 14% of the children moved out of the deficiency category after fortification, yielding an annual cost per child improved of $1.64 (Solon, Fernandez, Latham, and Popkin 1977).

Iodization costs have been estimated at $0.002 per capita (World Food Council 1977). Goiter prevalence varies greatly, but where it exists as a significant problem, perhaps 25% of the population is affected. Thus,

TABLE 6

1977 PRICES OF VITAMIN A AND IODINE

Vitamin A	$/kg
Palmitate beadlet (250,000 IU/g)	15.00
Palmitate in oil (106 IU/g)	30.00
Acetate beadlet (500,000 IU/g)	23.00
Iodine	
Potassium iodate	2.65

Source: Adapted from figures provided by Hoffman-La Roche, 1977.

TABLE 7

1976 PRICES OF COMMERCIALLY AVAILABLE IRON SOURCES

Iron Source	Cost Per Kg (U.S. $)	Percentage of Contained Iron	Cost Per Kg Iron (U.S. $)
Ferrous sulfate, anhydrous	0.66	32.1	2.05
Ferrous sulfate, heptahydrate	0.84	20.1	4.16
Chemically reduced iron	1.56	96.0	1.63
Electrolytically reduced iron	2.55	97.0	2.64
Ferrous fumarate	2.24	32.9	6.82
Ferric orthophosphate	1.63	28.6	5.70
Sodium iron pyrophosphate	1.80	14.5	12.45

Source: Adapted from J.T. Davidson and M.E. Russo, "Iron Fortification in Breakfast Cereal," Cereal Foods World, 21:534, 1976.

TABLE 8

CURRENT AND HISTORICAL PRICES OF SYNTHETIC AMINO ACIDS FOR CEREAL FORTIFICATION

	U.S. $/kg			
	L-lysine · HCl	L-threonine	L-tryptophan	DL-methionine
1972	3.80	-	-	4.20
1973	3.80	-	-	4.20
1974	7.30	57.70	86.80	4.20
1975	5.60	57.70	86.80	5.30
1976	5.60	57.70	86.80	5.30
1977	5.60	57.70	86.80	5.30

Prices are quoted for food-grade L-lysine and DL-methionine in bulk quantities (a ton or more); for L-tryptophan and L-threonine, prices are quoted for pharmaceutical-grade in quantities greater than 50 kg. Except for DL-methionine prices, which are obtained from Chemical Marketing Reporter, amino-acid TOB Japan prices are estimated from the "delivered prices" given by Ajinomoto Co., U.S.A., using the following formula:

$$\text{estimated price} = \frac{\text{delivered price}}{(100\% + \text{handling and transportation charge and customs duty})}$$

where customs duty is 6% for L-lysine · HCl and L-threonine, 12.5% for L-tryptophan, and transportation and handling charge is estimated at 6%.

Source: Austin 1977.

TABLE 9

CURRENT PRICES AND NUTRITIVE VALUE OF DIFFERENT PROTEIN SOURCES

Protein Source	Percentage of Protein*	Percentage of L-lysine**	U.S. $/kg	U.S. $/kg Protein	U.S. $/kg L-lysine	P.E.R.***
Spray-dried whole milk	26.4	2.3	1.89	7.14	82.17	3
Spray-dried skim milk	35.9	3.1	1.35	3.75	43.55	3
Defatted soy flour	50	3.6	0.35	0.70	9.72	2-2.5
Soy protein concentrate	70	4.2	0.77	1.10	18.33	2-2.5
Soy protein isolate	95	5.7	1.46	1.54	25.61	1.1-1.6
Fish protein concentrate	80	7.2	1.50	1.88	20.83	3
Full-fat soy flour	42	3	0.40	0.95	13.33	2-2.5

*Percentage of protein values are obtained from the manufacturers.

**Percentage of L-lysine values are obtained from Ehle and Jansen (1965), Wolf and Cowan (1971), and Astra Nutrition U.S.A., Inc. (1977).

***Protein Efficiency Ratio: these ratings were provided by the manufacturers and are expressed relative to cassein at 2.5.

Prices of milk products and soy products are FOB bulk rates quoted by Borden, Inc., and Central Soya (1977), respectively. Price for fish protein concentrate is estimated from FOB Sweden prices quoted by Astra Nutrition U.S.A., Inc. (1977) for bulk quantities at $0.235 = 1 Swedish Krona. Price of full-fat soy flour quoted by ADM, Borden, Inc. (1977), Decatur, Illinois.

Source: Adapted from Austin 1977.

TABLE 10

Fortificant Quantities and Costs for Cereal Fortification

Country	Nutrient	Quantity per Kg of Grain	$/kg of Nutrient	$/kg of Grain
Guatemala[a]	Thiamine	21.4 mg	25.00	0.000535
	Riboflavin	13.0 mg	42.00	0.000546
	Niacin	154.4 mg	5.00	0.000772
	Vitamin A	6250 IU	30.00	0.00001875
	Iron	480 mg	5.70	0.002736
	Soy flour	78 gms	0.35	0.0273
	L-lysine-HCl	1.2 gms	5.60	0.00672
				0.0386277
Tunisia[b]	Thiamine	8.5 mg	25.00	0.00021
	Riboflavin	5.4 mg	42.00	0.00023
	Niacin	63.8 mg	5.00	0.00032
	Vitamin A	10,000 IU	30.00	0.00003
	Vitamin D_2	2,000 IU	30.00	0.000006
	Iron	55.9 mg	2.05	0.00011
	Tricalcium Phosphate	50.0 mg	2.04	0.0001
	L-lysine-HCl	2.0 gms	5.60	0.0112
				0.012206
Thailand[c]	Thiamine	5 mg	25.00	0.000125
	Riboflavin	4 mg	42.00	0.000168
	Vitamin A	23,700 IU	30.00	0.00007
	Iron	80 mg	2.05	0.000164
	L-lysine	2 gms	5.60	0.0112
	L-threonine	1 gm	57.70	0.0577
				0.069427

Sources: a - Juan Jose Urrutia 1977; b - George Kerr 1977; c - Stanley Gershoff 1977.

TABLE 11

PRICES OF VOLUMETRIC FEEDERS

Type	Feed Rates Ft^3/hr	Kg/hr	Price (FOB Belleville, N.J.)
Roll	0.000167-0.16	0.00277-2.176	$1300
Screw	0.001 - 11.40	0.0136 - 155.04	$1800
Screw	0.001 - 18.50	0.0136 - 251.60	$2200

Source: Wallace and Tirnan, suppliers.

TABLE 12

PRICE OF RIBBON MIXERS

Capacity Ft^3	Kg	Price (FOB York, PA)
5	68	$ 8,500
50	680	$17,000
125	1700	$32,000
260	3536	$45,000

Source: READCO, suppliers (1977).

cost per target person would be $0.008. Near elimination is possible; the cost per cured individual would approach $0.20 per year.

Iron fortification of sugar has been estimated to cost $0.03 per capita per year in Guatemala. Using the average Latin American percentage of the population that is anemic (27%), the cost per target person would be $0.11.

Protein fortification costs are orders of magnitude greater than micronutrient fortification costs. Even assuming that targeting would minimize overcoverage, the cost to reach, for example, each of the 1.4 million preschoolers in the northeastern region of Thailand would be $2.50. Protein fortification can represent as much as $25% of the cost of grain. An exception occurs when natural protein supplements such as soy flour displace the grain flour. In some instances the fortifier costs almost the same as the flour it displaces, thus causing no net cost increase and creating a "free fortifier." Wheat-flour fortification with soy was one such example (Hoover 1976). However, fluctuations in soyflour prices are common (e.g. $2.25/10 kg in 1972 and $3.50 in 1977) and can increase the fortification costs.

The cost of fortification should be low enough not to cause a significant increase in the price of the staple, thereby reducing consumption. The cost of fortification in the case of micronutrients in general presents no great burden, and may be borne by the processor. With macronutrients, the nutrition planner is faced with the alternatives of user fees (increased prices), general taxation, or a combination of the two to defray fortification costs. User fees would be inequitable to the poor because of the substantial share of their budgets that go to basic foodstuffs, relative to the share so allocated by the wealthy, and would probably reduce consumption. A more complete discussion of the economic aspects of fortification is provided elsewhere (Snodgrass in Austin 1979).

B. SUMMARY:

COSTS OF FORTIFICATION

The main financial burden in a fortification program is the cost of the fortificant. Although vitamin and mineral costs have remained relatively stable, the costs of protein sources have varied widely.

Equipment costs vary depending upon the process used for fortification. Initial costs can be quite high when high-technology, large-capacity machinery is needed. Protein fortification costs generally exceed those of micronutrients, except in cases where the fortificant displaces part of the carrier (for example, when soy flour is substituted for grain flour). When the fortifier costs about the same as the substance it displaces, a "free fortificant" is cre-

ated. Possible implementation of user fees or taxation to assist in supporting the program may be appropriate, but only when the burden is not placed on the poor.

III. EFFECTIVENESS OF FORTIFICATION AND MASS DOSES

A. KEY QUESTIONS

- Can fortification and mass doses alleviate or prevent specific nutrient deficiencies and contribute to improved health status?
- What other factors may inhibit the effectiveness of fortification?

With an understanding of the costs involved in the implementation of a fortification program, we turn to effectiveness issues and examine current available data focusing again on goiter, vitamin A, iron folate, and protein. The impact data for fortification programs are scarce. More findings are available for direct dose interventions. We will present both. It is not unreasonable to assume that if the fortification system was successful in delivering to the target group an equivalent quantity of nutrients over a year's period, then the biological impact would be similar to the mass dose. In this sense the mass dose results may be indicative of the potential impact of fortification.

B. Goiter

Iodization of salt has shown the most dramatic results. Iodization in Hamachal Pradesh, India, reduced the incidence of goiter in children from 38% in 1956 to 3% in 1973 (Bauernfeind 1973). Similar eradication has been achieved in other areas, such as Central America and Columbia. Whenever iodization of salt has been implemented its impact has generally been very effective. It is relatively inexpensive, technically simple, socially acceptable, and politically feasible. Of all the fortification programs, this appears to present the fewest problems and to have clearest impact. Where goiter is actually or potentially present, iodization is highly recommended.

C. Vitamin A

Failure to treat vitamin A deficiency signs can lead to night blindness, drying and degeneration of the cornea (xerophthalmia), and even to total blindness. Furthermore, vitamin A deficiency is a contributing factor to mortality, and infection, and poor appetite. Vitamin A fortification has been successful in raising blood serum levels and in reducing clinical signs of deficiency. Preliminary results of the sugar fortification in Guatemala have revealed shifts in the distribution curve of serum

vitamin A to higher levels. The MSG fortification project in the Philippines succeeded in raising the mean serum vitamin A levels from 21.3 mcg per 100 ml to 28.5 mcg (Solon, Fernandez, Latham, and Popkin 1977). Those very deficient (below 10 mcg) quadrupled their average level, from 6.4 mcg to 25.4 mcg. Those in the 10 to 19 mcg category doubled their level, from 14.4 mcg to 28.8 mcg. The 4.2% of the children showing clinical signs of xerophthalmia were reduced to 1.0% after fortification. In the evaluation of alternative vitamin interventions in the Philippines project, MSG fortification was shown to have the most attractive benefit-cost ratio relative to mass dosage, gardens, and public health measures mentioned previously. It must be kept in mind that individual conditions influence benefit-cost and cost-effectiveness outcomes, making generalization of results difficult.

The reported results of mass doses of vitamin A are more numerous. Table 13 presents a sample of such findings. In general, they reveal that doses of about 200,000 IUs every six months can rapidly increase the blood serum levels of vitamin A and decrease the incidence of xerophthalmia. For severe deficiency cases water-based vitamin A injections of 50,000-100,000 IUs seem appropriate. For prophylactic purposes 200,000 IU oil based oral doses seem effective. It also seems desirable to administer vitamin E with A to enhance the utilization of the A, to contribute to alleviating any vitamin E deficiency, and to lessen any transient toxic effects of the mass doses.

D. Iron/Folate

The effectiveness of iron fortification has been difficult to document. Anemia is a complex and tenacious problem that will not lend itself to ready, short-term solutions. Iron fortification appears to be an effective long-term means of alleviating iron deficiency anemia. However, its use is indicated only where iron deficiency can be established as the primary causative factor. Demonstrated response to oral iron treatment is necessary before fortification can be justified.

In Thailand a widely used fish sauce has been fortified with iron salts with reported beneficial effects (Garby and Areekul 1974). Skimmed milk has also been successfully fortified with readily absorbed iron glycerophosphate (Layrisse et al. 1973). This method may be acceptable if it is part of a subsidized milk or supplementary feeding program; otherwise the accessibility of the lower income groups could be difficult (see Studies I and V of this series: Supplementary Feeding and Consumer Food Price Subsidies). Many countries fortify wheat flour with reduced iron or iron sulfate (including that shipped as food aid). The nutritional value of this is not known; the impact may be severely limited in developing countries due to poor iron absorption (Elwood 1968 and World Health Organization 1975). The consumption of folate fortified corn (300-500 mg) by five lactating women suffering megaloblastic anemia produced optimal hematological responses (Colman et al. 1974). Finally, salt fortified with 35-100 mg of ascorbic acid when added to rice and corn increased two to four times the absorption of the intrinsic iron found in these cereals (Sayers et al. 1974a, 1974b).

TABLE 13

RESULTS OF SELECTED VITAMIN A MASS DOSE PROGRAMS

Dose Form	Dose Quantity	Results	Reference
Oral, Water Dispersible	50,000 IU/kg body weight, daily for 5 days to children	Decrease in eye symptoms, increase in serum vitamin A	McLaren, Khoury, Shirajian, and Tehalian (1965)
Oral, Water Dispersible	600,000 IU to pregnant women shortly prior to delivery	Increased vitamin A levels in breast milk for 30 days	Ajans, Sarrif, and Husbands (1965)
Oral, Oil Solution	100,000 IU to preschoolers	Serum levels of healthy, greater than control for 13 weeks; 15 weeks for vitamin deficient	Pereira and Begum (1969) Pereira, Begum, Jesudian, and Sundarary (1969)
Oral, Oil Solution	100,000 IU to 2-6 year olds	Elevated serum levels at four months	Susheela (1969)
Oral, Oil Solution	300,000 IU to preschoolers	Significant serum levels at 6 months and, for some, 12 months	Srikantia and Reddy (1970)
Oral, Oil Solution	200,000 IU every 6 months to 400,000 1-4 year olds	Incidence of xerophthalmia decreased 75%	Gopalan (1960 and 1970)
Oral, Aqueous Emulsion	200,000 IU to 473 preschoolers	Prevalence of ocular manifestations cut by 75%	United Nations International Childrens Emergency Fund (UNICEF) (1972)
Injection, Oil Solution	10,000 IU/kg body weight of child	No significant increase in serum levels	Cienfuegos (1946)
Injection, Oil Solution	100,000 to 300,000 IU in preschoolers	Serum values not maintained	Pereira and Begum (1968)
Oral, Oil Solution	200,000 IU to preschoolers every 6 months	At 6 months significantly less night blindness, conjunctival xerosis, and Bitot's spot than in control group	World Health Organization (1976)
Oral, Oil Solution	200,000 IU to preschoolers	Incidence of eye lesions and corneal xerosis dropped markedly but Bitot's spot and keralomalachia incidence unchanged.	World Health Organization (1976)
Oral, Oil Solution	200,000 IU plus 40 IU of vitamin E	No influence on occurrence of xerophthalmia	Sommer, Faich, and Quesada (1975); Sommer, Quesada, Doty, and Faich (1975)

As with vitamin A, impact data for iron mass doses are more plentiful than for fortification. For example, in India iron supplementation of pregnant women beginning in their 22nd week resulted in a significant rise in the mean hemoglobin concentration after 12 weeks; it decreased in the unsupplemented control group (Sood et al. 1975). In Israel supplementation of pregnant women from the second trimester until term with 100 mg of iron and 300 mg of folate decreased the prevalence of anemia of pregnancy from 50% to 6% (Izak et al. 1973). Combining iron and folate was found superior to iron alone.

Iron supplementation has reportedly been effective in improving physical endurance and work capacity in anemic laborers in Western Java. Hemoglobin and hematocrit levels and iron stores rose after twenty-eight days of delivering ferrous sulphate tablets, and remained high up to forty days after cessation of therapy. As a result of the increased iron stores, morbidity decreased and higher scores of the Harvard step test were achieved (Basta 1979). Improvements in work performance due to iron supplementation have also been reported by Viteri and Torun (1974 and 1975) and Viteri (1974). This endurance test and these productivity measures demonstrate the potential economic benefits of adequate iron nutriture.

Other deficiencies, intenstinal parasites (such as hookworms), and bilharzia may limit the effectiveness of fortification or supplementation. For example, folate deficiency may accompany iron deficiency, calling for a combined fortification of iron with folic acid.

E. Protein

Protein fortification under field conditions has been evaluated longitudinally in three countries: Guatemala, Tunisia, and Thailand. The basic objective of these studies was to determine whether protein fortification (using natural protein supplements or amino acids) would produce under field conditions a positive impact on the nutritional or health status of children. The projects used control groups and periodic impact assessment (anthropometric, clinical, biochemical). The composition of the fortificants (protein, vitamins, and minerals) is shown in Table 9. Despite reasonably careful research design, field administration, and data analysis, none of the interventions was able to demonstrate significant anthropometric or biochemical effects. Guatemala reported significant differences in morbidity and mortality (Urrutia, Garcia, Bressani, and Mata in Wilcke 1976); however, limitations in the research design do not permit conclusive attribution of these effects to the fortification intervention.

Several possible explanations for the negligible results exist. A primary explanation postulated is that the children were not meeting their caloric needs and thus were metabolizing the added protein for energy rather than growth purposes (Gershoff et al. 1977, el Lozy and Kerr 1976). Although adequate quantities of food were available, the nutrient density or palatability of the staple may have restricted nutrient intake among preschoolers. This would suggest the need for a formulated food intervention (see Study IV, Formulated Foods). Protein quality may not have been the limiting factor in the diet (Jansen 1977). Some have felt that zinc deficiencies may have hindered results. The high prevalence of infectious disease, however, was not found to be accountable for the lack of intervention effect (Gershoff et al. 1977).

These results would suggest that protein fortification should not be undertaken in the face of significant calorie deficits. However, further research is needed to ascertain the impact of protein fortification and calorie supplementation. Previous studies show positive impact under conditions of caloric adequacy (e.g., see Graham et al. 1969; Pereira, Begum, Jesudian, and Sundarary 1969; Hedayat et al. 1973). Also, research is needed on the physiological versus the nominal calorie requirements and the functional significance of calorie and protein deficits of varying levels.

A final, and very important, conclusion that can be drawn from the longitudinal studies is that field level cereal fortification is operationally feasible. Both centralized fortification (Tunisia) and decentralized village-level fortification (Guatemala and Thailand) have been proven possible.

F. SUMMARY:

FORTIFICATION EFFECTIVENESS

Iodization and vitamin A fortification have resulted in increased serum levels of the nutrient and in reduced clinical signs of goiter and xerophthalmia, respectively. Mass doses of vitamin A have also demonstrated positive impact.

The effectiveness of iron fortification has not been widely documented, but raised iron stores, as well as raised hemoglobin and hematocrit levels, have been recorded. Mass dose has also shown positive impact in reducing anemia and in improving endurance and productivity.

Effectiveness of fortification can be inhibited by deficiencies or parasites accompanying the target deficiency, in which case the source of the problem should be identified and treated. Protein fortification has not produced conclusive impact, particularly in the face of calorie deficits. The operational feasibility of village-level fortification has been demonstrated.

IV. COMPARISON OF ALTERNATIVE INTERVENTIONS

A. KEY QUESTIONS

- What criteria are useful for comparing fortification with mass dose (tablets and injections), nutrition education, home gardens, and plant breeding?
- What are the initial and continuing investments of money, personnel, and technology required for each intervention?

Each alternative intervention - fortification, tablets, injections, nutrition education, gardens, plant breeding - has inherent advantages and disadvantages with respect to certain criteria, some of which can only be weighed subjectively in importance. These criteria include costs, skill and number of personnel, delivery system infrastructure, technical feasibility, role of the beneficiary, and impact. To illustrate this methodology, Table 14 ranks each of the approaches against this set of criteria. In this manner, a general comparison of the alternative interventions can be made; however, each country's situation must be examined individually before actual rankings are made and a decision is taken as to which approach or combination is most appropriate.

B. Costs

Fortification entails initial investment in equipment while the continuing costs in terms of personnel and materials are small once the program is set up. On the other hand, both tablets and injections require minimal initial financial support, although high costs for personnel to administer and record each dose are incurred each time the program is repeated. Injection materials are somewhat more expensive than the tablets (vitamin A capsules are only a penny-a-piece, and are often supplied free of charge by the United Nations International Childrens Emergency Fund (UNICEF) (Jones 1977) and require higher pay for more highly trained personnel. Nutrition education and home gardens require minimal capital outlays. Nutrition education is an on-going process, so personnel needs are continuing. Home gardens become self-sufficient more quickly, although periodic advice from extensionists would be desirable. Conversely, nutrition education has less of a need for new materials; home gardens will require seeds and possibly agrochemicals on an annual basis. Plant breeding operations are capital-, people-, and material-intensive.

C. Personnel

The number of personnel required to administer tablets or injections to each member of the target group is high compared to the few central personnel needed to oversee centralized fortification. However, many of these people could be part of the existing health system. A high level of skill is also necessary for giving injections, while moderate

TABLE 14 - COMPARISON OF ALTERNATIVE INTERVENTIONS

Criteria	Fortification	Tablets	Injections	Nutrition Education	Home Gardens	Plant Breeding
Costs						
Initial capital investments	Moderate	Low	Low	Low	Low	High
Continuing personnel	Low	High	High	High	Low	High
Continuing materials	Low*	Low	Moderate	Low	Moderate	High
Personnel Requirements						
Skill level	Moderate	Moderate	High	Low	Moderate	High
Numbers	Low	High	High	Moderate	High	Low
Administrative Requirements						
Supervision	Moderate	High	High	Moderate	Moderate	High
Health system organization	Low	High	High	Moderate	Low	Low
Technical Feasibility						
Technology dependability	High**	High	Moderate	Moderate	High	Moderate
Side effects risk	Low	Moderate	High	Low	Low	Moderate
Beneficiary Rule						
Acceptability	High	Moderate	Moderate	Moderate	Moderate	Moderate
Community involvement	Low***	Moderate	Moderate	High	High	Low
Impact						
Population coverage	High	Moderate#	Moderate#	Moderate	Moderate	Moderate
Time needed to show benefit	Moderate	Low	Low	Moderate	Low	High
Permanency of benefit	High	Low	Low	Moderate	High	High

*An exception is protein fortification, which is expensive relative to micronutrient fortification.
**Iron fortification has encountered technical difficulties, but recent improvements appear to have resolved these.
***In contrast to a central processing plan, village-level fortification could have high community participation.
#Direct-dosage coverage is a function of the outreach capacity of the delivery system, but coverage is constrained by the one-to-one system.
Source: Adapted from World Food Council 1977.

skill is adequate for the other two interventions. Nutrition education can be carried out by low-skilled village personnel; agricultural extension requires a somewhat higher skill level. Coverage requires large numbers, although mass media can reduce this need. Plant breeding needs few, but highly skilled, personnel.

D. Administration

Because of the large nutrient doses involved with tablets and injections, an existing health system is important for monitoring these programs, while the large numbers which must be reached necessitate supervision and a developed infrastructure for delivery. Fortification, however, is often accomplished centrally and thus diminishes the need for complex admnistration. Supervision is important to nutrition education, home gardens, and plant breeding. Nutrition education tends to be tied into the health system; agricultural production is independent of it.

E. Technical Feasibility

Technologically, successful preparations have been developed that can be useful for fortification, tablets, or injections. When toxicity is a potential risk, fortification is the least dangerous method, tablets the next, and injections the most dangerous form of administration since the relative quantity of nutrients administered increases in that order. Nutrition education and home gardens carry few risks of perverse effects. Plant breeding could cause unintended negative effects through crop displacement or income effects.

F. Beneficiary Role

Fortification has been considered the easiest intervention to implement since it requires little if any community participation and is hardly detectable and thus highly acceptable to the population. Tablets and injections, however, require some active cooperation on the part of those receiving the nutrient. Nutrition education, home gardens and new seeds have generally been accepted by the community, but the behavioral modification meets some resistance. Community involvement is high for the first two and low for breeding activities.

G. Impact

Because fortification is accomplished centrally, it covers a large portion of the population at large. Mass doses reach those within the outreach of existing health/delivery systems and thus can be targeted more closely to those at risk. Finally, since fortification is continuous, the permanancy of benefit is high, although the effects take a moderate amount of time to appear. In contrast, any impact that is to be observed after administering tablets or injections occurs immediately but the impact decreases over time.

The coverage of the education, gardens, and plant breeding (new seed dissemination) is a function largely of the delivery system. Broad coverage is possible if a large extension and promotion network is es-

tablished. Impact from nutrition education is generally slow in coming but depends on the type of behavioral change sought. Permanent change is possible but not often achieved without periodic reinforcement. Home gardens can produce quick results in terms of intake and can readily become a sustaining process if the benefits are sufficient. Plant breeding is a slow process, but once new varieties are successfully developed and adopted they can become a permanent part of the food production system.

With the information presented here regarding the various aspects of the alternative programs, the question arises regarding how one is to decide among the alternatives. One program may appear more cost-effective as demonstrated by its operating indicators and another may come out ahead in outcome cost-effectiveness. The first tool is to balance the indicators with the specific objectives set for attacking the deficiency problem. Thus, discrepancies in timing and coverage can be weighted in accordance with the aims of the original planners. Next, the lack of a delivery system infrastructure may preclude the implementation of one program. If the management capacity is insufficient, a program may vanish as a possibility. The point is that each case and country must be studied individually so that program decisions based both on this information and cost-effectiveness indicators can be made. Again the interventions are not mutually exclusive and complementarities should be sought.

H. SUMMARY:

COMPARISON OF ALTERNATIVE INTERVENTIONS

Costs, personnel, administration, technology, beneficiary role, and impact are the important elements in comparing alternative interventions. Each country's situation will require varying investments depending upon the existing infrastructures for delivery and the level of technology chosen. Beneficiary involvement and impact is different for each intervention. These factors are important for cost-effectiveness calculations which are useful indicators of appropriate program choice.

Fortification and plant breeding will usually involve high initial investments in equipment; mass doses and breeding require highly trained personnel and hence continuing costs in salaries and administration. Side effects are most likely to occur in mass dose programs. Community involvement is greatest with nutrition education and home gardens. Fortification tends to have the greatest propulation coverage. Mass doses can produce the quickest results. Plant breeding is the slowest process. Permanent benefit is usually higher for fortification than for other programs, although home gardens and breeding can also have lasting effects.

An evaluation of the outcome must be made in light of program goals as an aid in deciding among interventions. The individual assessment of existing conditions often reduces the number of appropriate choices and thus simplifies the planner's decision-making. Reinforcing combinations of interventions should be sought.

CHAPTER FOUR

CASE STUDY: FORTIFICATION IN THE PHILIPPINES

I. INTRODUCTION

This case study is based on the work of Solon, Fernandez, Latham, and Popkin, who attempted to determine the most appropriate means of reducing vitamin A deficiency in the Philippines. It will demonstrate how a vitamin A fortification program was planned, implemented, and evaluated. The evaluation will compare the fortification approach with mass dose and public health/horticulture programs. Their relative cost and effectiveness will be discussed. Relatively few nutrition programs have been thoroughly evaluated with either cost-effectiveness or cost-benefit methodology. One of the reasons for selecting this case study was this evaluation focus. Although somewhat more technical, this approach will provide readers with a detailed example of how such techniques can be used in program evaluation. (For case studies on cereal fortification, the reader is referred to Austin 1979).

The case study is organized in four sections. The first documents the extent and nature of the vitamin A deficiency. This documentation is the logical starting point in the design of any intervention. The second part briefly describes three alternative approaches and the research design. The third part discusses in more detail how the fortification intervention was designed. The final section evaluates the three approaches in terms of cost and nutritional impact.

II. NUTRITIONAL NEED

To assess the nutritional needs of the population, the Cebu Institute of Medicine and Cornell University conducted in mid-1973 an epidemiological, clinical, and biochemical study of 1,715 children aged one to 16 who came from 626 families living on the densely populated, poor island of Cebu in the Philippines. The per capita income in Cebu was reported as US $84, with half of those surveyed earning below $50 per annum. The staple food of most of the island's inhabitants is white flint corn.

Cebu was divided into four groups (urban slums or squatter areas, periurban barrios, rural coastal barrios, and semimountainous hinterland barrios) to represent its major ecological zones, where differences in diet, market accessibility, sanitary conditions, and occupations occur. These differences can be expected potentially to affect the planning and effectiveness of any nutritional or health program. Three separate communities within each zone were then selected for the three intervention programs (see Section III), so that alternative programs could run concurrently in each zone during the implementation phase of the project. A baseline survey was conducted in these areas, and a stratified random sample of approximately 100 children aged 1 to 6 and 50 children aged 7 to 16 was selected for each.

A. Clinical Assessment

The presence of xerophthalmia (X) was established by recognition of clinical signs as well as by biochemical determiniations of serum vitamin A levels. Children who had conjunctival xerosis were classified as having no clinical signs of X. Clinical diagnosis of (X) used the system developed by the World Health Organization (1976). As seen in Table 15, 4.4% of the children displayed clinical signs, with 4.1% having active signs. Bitot's signs with conjunctival xerosis and night blindness were the most prevalent. The incidence of clinical signs of X was higher in urban than in other areas (Table 16).

B. Biochemical Assessment

Biochemical determinations of serum vitamin A levels were performed at the Cebu Institute of Medicine using the Carr-Price method (Neeld and Pearson 1963). These analyses showed that 40% of the children tested had low (10-19 mc/100 ml) and 17% had deficient (0-9 mc/100 ml) serum levels (Table 17). The prevalence of low and deficient serum levels was highest in the rural coastal barrios (62%) and lowest in the urban squatter areas (54%).

Since X was defined so strigently, the figures arrived at in this study must be considered conservative. Two and nine-tenths percent of the sample were classified as having xerophthalmia (Table 16). The presence was lowest among the one-to-three-year-olds (1.4%) and highest in the four-to-six-year-olds (4.7%).

C. Dietary Assessment

Twenty-four-hour dietary recalls were collected from 130 randomly chosen sample children. This was done during November through January. Possible seasonal variation in diet and carotene intake should be considered; in the case of the Philippines, however, there is no evidence to suggest significant seasonal variation in factors responsible for xerophthalmia.

Table 18 indicates that people in the rural areas consumed considerably more vitamin A via vegetables and fruits than did those in the urban or semi-uran areas. This was explained by their more direct access to vegetables and the larger number of home gardens in these areas. Overall, 91% of the vitamin was consumed in the form of carotene and nonanimal sources. Fish, the main animal component of the diet, contributed 5.5% of the calories and 25.1% of the protein, but only 3% of the vitamin A. Interestingly, females and younger children tended to consume more vitamin A relative to their Recommended Daily Allowances than males - males were found to consume 36% less than females, for largely unexplained reasons. Males were fed more key foods such as fish and rice, and females were fed more soup (Popkin and Solon 1976).

D. Socio-Economic Factors

Income did not appear to be an important factor, mainly because the samples were predominantly from poor communities. The household con-

TABLE 15

CLINICAL SIGNS OF XEROPHTHALMIA BEFORE ALL INTERVENTIONS

	Before Intervention
Inactive Signs*	
XS Corneal scars	0.3%
Active Signs	
XN Night blindness	2.2
X1B Bitot's spots with xerosis	1.4
X2 Corneal xerosis	0.5
X3B Keratomalacia	-
Total active signs (%)	4.1
Total clinical signs	4.4
Total number of children	1,407

*All signs from World Health Organization (1976) classification.

TABLE 16

PREVALENCE OF VITAMIN A DEFICIENCY ESTABLISHED BY CLINICAL SIGNS (XEROPHTHALMIA), BIOCHEMICAL EVIDENCE (SERUM VITAMIN A LESS THAN 20 MC/ML), OR BOTH

Ecological Zone	Number Examined	Evidence of Vitamin A Deficiency* Clinical %	Biochemical %	Both %
Urban				
Squatter	435	5.7	54**	3.2
Barrio	423	5.4	59	3.3
Rural				
Coastal	415	3.1	62***	2.4
Hinterland	442	3.6	56	2.7
All areas	1,715	4.5	57	2.9

*All estimates varied significantly ($p < .01$) as a function of ecological zone.

**T-test between squatter and coastal areas shows significant difference at 1% level.

***T-test between rural coastal and hinterland areas shows significant difference at 10% level.

TABLE 17

SERUM VITAMIN A LEVELS IN CEBU CHILDREN*

Ecological Zone	Serum Vitamin A (UG/100 ML) 0-9 (Deficient) %	10-19 (Low) %	20-49 (Acceptable) %	50+ (High) %	Total %
Urban					
Squatter	17	37	43	3	100
Barrio	15	44	39	2	100
Rural					
Coastal	20	42	36	2	100
Hinterland	18	38	43	1	100
All areas	17	40	40	3	100

*Interdepartmental Committee on Nutrition for the National Defense (ICNND) Standards.

Number of cases: 1,715.

TABLE 18

FOOD SOURCES OF VITAMIN A FOR CHILDREN IN CEBU BY ZONE*

	Urban				Rural					
	Squatter		Barrio		Coastal		Hinterland		Total	
Food Source	(IU)	(%)	(IU)	(%)	(IU)	(%)	(IU)	(%)	(IU)	(%)
Vegetables and fruits	303	60	445	76	461	77	1453	93	662	81
Animal*	80	16	72	13	80	13	34	2	68	9
Cereals	123	24	36	6	57	10	77	5	73	9
Miscellaneous	0	0	30	5	0	0	0	0	8	1
Total	506	100	583	100	598	100	1564	100	771	100
Standard deviation	(488)		(1062)		(981)		(2580)		(1453)	
Number of children	34		34		35		27		130	

*Includes meat, eggs, fish, poultry, milk.

sumption and expenditure patterns for 60 persons (measured for three days) showed that one dollar would purchase 200,000 International Units of vitamin A in vegetables, 4,333 IU in fruit, and 1,566 IU in all other items. The high carotene contents of vegetables and their relatively low prices made them particularly efficient sources of vitamin A. Drumstick, malabar, nightshade, and water convolvulus leaves were the main vegetable selections. The sample families spent less than 5% of their total income on fruits and vegetables, for a weekly total of about $0.38. A $1 (1.4%) rise in per capita income resulted in an increase of 80 IU per individual. However, in the squatter zones, each child received only an additional 25 IU, demonstrating inequality in intrafamilial distribution.

Regression analysis further indicated that a 1% increase in food expenditure led to an increase of 95 IU of vitamin A for children in the urban squatter areas and of over 500 IU for those in the periurban barrios. However, the effect of income changes in the rural areas was minimal. These differences may reflect the buying habits of the parents, their food beliefs and food practices based on their environment, and the relative prices of vegetables in each zone.

Close to 70% of the families had home gardens. The sales value of the average garden output was $14.50 per annum, or 39% of the household's income. For the poorest 25% of the families, home gardens contributed 8% of their incomes. The assessment survey and analysis revealed that in the area with the highest vitamin A consumption (hinterland barrios), a 1% enlargement of the home garden was associated with a 192 IU increase in each child's vitamin A intake. Elsewhere, however, this enlargement resulted in a decline of 30 IU in each child's consumption, since the additional produce yield was taken to market instead of being consumed at home.

A higher incidence of xerophthalmia was noted among children of working mothers. Although the annual per capita income in families with both parents employed was $92, as compared with $78 when only the father worked, the study found vitamin A intakes declined in the children of workin mothers by 839 IU This phenomenon can be explained by such factors as the absence of breast-feeding, the prevalence of improper weaning, and poor supervision and feeding of the young child if the mother is not present at mealtimes. The children's tendency was to ignore vegetables unless their mothers were there to feed them, and basic soup dishes containing green leafy vegetables were seldom prepared in the mother's absence.

Finally, as might be expected, increases in the size of the family were associated with decreases in each child's vitamin A intake.

III. ALTERNATIVE APPROACHES AND RESEARCH DESIGN

To address the documented deficiencies of vitamin A three different intervention approaches were designed and implemented on a pilot basis.

A. Capsule Program

As with programs in India, Bangladesh, Indonesia, and El Salvador, periodic massive doses of vitamin A were distributed in the area where xerophthalmia was endemic. Every six months the selected children received through community organizations 200,000 IU of vitamin A with 40 IU of vitamin E (to improve the storage of retinol in the liver and reduce the possible toxic symptoms). In determining the quantity, the excretion rate of vitamin A was not considered. For the younger child who was unable to swallow the capsule, the end of the capsule was cut off and the almost tasteless solution was squeezed into the child's mouth.

B. Public Health and Horticulture Intervention (PHI)

This intervention (which resembles in some ways the integrated approach discussed in Study VII, Integrated Nutrition and Primary Health Care Programs) included medical treatment, environmental sanitation (improved water and sanitation facilities), deworming, immunization (DPT, typhoid, cholera), nutrition and health education, and home gardening (provision of seeds, seedlings, and extension services aimed at increasing the family's supply of vitamin A foods). The average size of the home garden which used throughout most of the year was 14.7 square meters. Commonly consumed carotene-rich vegetables such as drumstick, malabar, nightshades, and water convolvulus leaves could be grown in the garden plots owned by most Cebu residents. However, it was calculated that a plot of 18.5 square meters would only yield one third of an average family's vitamin A needs (including a 20% food wastage amount).

C. MSG Fortification

The intervention on which we will focus in this case study is the fortification of monosodium glutamate (MSG) with vitamin A. MSG is almost universally used in the Philippines in the soups, stews, and many other dishes served to young children. The vitamin was added to regular packets of MSG and then distributed by program personnel to the selected families.

As was noted in the previous chapter, several of the above alternatives could be implemented simultaneously. For example, direct dosage could be used as a short-term measure for the severely malnourished while education and garden intervention are designed for long-run behavioral diet changes.

D. Research Design

To compare the three approaches, each was mounted in different barrios. The 1973 baseline deficiency indicators (clinical signs and serum vitamin A levels) were compared in each group to the same indicators collected in 1975 after completion of the interventions. Multivariate analysis was used to control for socio-economic differences among the three intervention groups. The total sample included 1,407 children between one and six years of age divided approximately equally among the three intervention categories. Table 19 presents this sample according to clinical signs of xerophthalmia and Table 20 does the same for serum vitamin A levels.

TABLE 19

CLINICAL SIGNS OF XEROPHTHALMIA BY INTERVENTION GROUP

	PHI		Capsule		Fortification	
	%	No.	%	No.	%	No.
Active	4.9	23	3.1	15	4.2	28
Inactive	0	0	0.4	2	0.4	2
Normal	95.1	439	96.5	454	95.4	452
		462		471		474

TABLE 20

SERUM VITAMIN A LEVELS BY INTERVENTION GROUP

	PHI		Capsule		Fortification	
	%	No.	%	No.	%	No.
Deficient* (< 10 mcg)	19.3	75	17.5	59	16.4	62
Low (10-19 mcg)	42.7	166	41.1	139	35.7	135
Acceptable (20-49 mcg)	35.9	140	38.7	131	45.3	171
Normal (> 50 mcg)	2.1	8	2.7	9	2.6	10
Total **		389		338		378

*Interdepartmental Committee on Nutrition for the National Defense (ICNND) Classification.
**Individuals with outlier values were excluded.

IV. FORTIFICATION INTERVENTION DESIGN

The initial needs assessment surveys provided the nutritional information base for locating the target group. To design the fortification intervention, the researches (1) carried out consumption and processing surveys to identify the appropriate carrier, (2) examined technical feasibility and consumer acceptability, and (3) determined the quantity of vitamin A to be added.

A. Carrier Selection

In a survey, the pattern of consumption of potential carriers for vitamin A such as rice, corn grits, refined white sugar, brown centrifugal sugar, salt, chocolate, coffee, margarine, soft drinks, MSG, and flour products (biscuits and breads) was determined for each child. The mother was asked how often each child consumed each item, in order to clarify intrahousehold food distribution. The results showed that table salt, MSG, and flour-based products were the most frequently consumed items. Much of the salt was purchased from producers who had evaporated it from saltwater. Because of the dozens of small producers involved, it did not appear feasible to fortify salt. Flour was also processed and distributed by a large number of firms. In contrast, all of the MSG in the Philippines was produced by two manufacturers, one of which dominated the market. For this reason, MSG was selected for fortification.

In the 12 areas studied, 94% of the children consumed MSG at least once a week. The children in the younger age groups (Table 21) had the lowest rate of consumption, at 91.5 to 93.2%, whereas in other ages at least 98% consumed MSG at least once a week. Low intakes also occurred more often in poorer families.

While over 90% of the children in the urban barrio, coastal, and hinterland samples consumed MSG daily, only 79% of the urban squatter children did so (Table 22). Reasons for the lower consumption of MSG by the urban squatter children were sought. Being urban dwellers, their families were expected to participate in the commercial food-market economy more than their rural counterparts. The squatter's household income per capita was $82, which was only $2 less than that of the urban fringe barrio household. Also, the squatter families had higher total food expenditures than any of the other families. However, the lower MSG consumption among this group was found to be caused by their unusual household feeding patterns. These differences reflected the distinctive food habits of the areas from which the squatters had originally migrated. Over 36% of the fathers in the squatter areas had migrated from other provinces, and only about 10% were born in the area. The pattern was similar for the mothers.

Four months after the baseline survey was made, a detailed survey of 227 families was conducted to determine the marketing and consumption patterns of MSG in the sample population. It was ascertained that 98% of the MSG consumed in the area was from one MSG processor. Females consumed an average of 2.2 gram packets of MSG per day, while the most MSG consumed was three packets per day (by 19% of the families). Each packet sold for less than $0.01.

TABLE 21

POTENTIAL COVERAGE OF MSG FORTIFICATION IN TOTAL SAMPLE BY AGE IN CEBU

Age	Reach %	Miss %	Total %
1-3	91.5	8.5	100
4-6	93.2	6.8	100
7-9	98.0	2.0	100
10-13	98.7	1.3	100
14-16	98.3	1.7	100

*Consume MSG once or more per week.
Number of cases = 1,779.

TABLE 22

POTENTIAL COVERAGE OF MSG FORTIFICATION IN TOTAL SAMPLE BY ZONE IN CEBU
(%)

	Urban Squatter	Urban Barrio	Coastal	Hinterland
Miss	17	1.6	1.7	2.3
Reach				
Daily	78.6	93.9	90.8	92.8
3-6 times weekly	2.1	3.1	3.9	3.8
Less often	2.3	1.4	3.6	1.1

N - 1,779.

B. Technical Feasibility and Consumer Acceptability

Based on existing vitamin A deficiency and MSG consumption patterns in Cebu, and in consultation with scientists at the Hoffman-La Roche Company, planners decided to include 15,000 IU of vitamin A in each MSG packet, and with the technical assistance of Hoffman-La Roche, a suitable product was developed and tested for its stability and organoleptic qualities. The basic process for vitamin A fortification of MSG in the Philippines used a Nauta mixer to combine the MSG with Roche palmitate 250-SD A flow enhancing agent, silicic acid (silicon dioxide), was added to the vitamin A and MSG during the mixing process. The mixer could handle 11,000 pounds per shift, producing 4,545,000 units of 2.2-gram MSG packets, each containing 0.1 gram of fortificant in a two-shift day. The MSG was tested in the field in Cebu and no problems of palatability were encountered.

MSG is a crystalline substance which is difficult to fortify because of moisture retention and coloration problems. Another, more general problem associated with the fortification of vitamin A is the instability of the vitamin under warm and humid conditions. Extensive tests were conducted to determine the loss rates of vitamin A in the fortified Filipino MSG when stored at different temperatures. The average initial vitamin A content per packet was 15,300 IU. After six months' storage at 36°C, which is 5° to 10° warmer than the average temperature in Cebu, the average content per packet was 11,600 IU, which indicated an average loss rate of about 3% per month. Considerable variations existed among the packets. There was a marked decline in loss rates after the initial six months of storage.

C. Fortificant Quantity

Each family in the pilot project was given a weekly supply of the fortified MSG at the rate of two packets (2.2 grams each) per family per day. Empty packets were collected and replaced each week. Taking storage losses into consideration, approximately 4,000 IU of vitamin A per day were given to each family member. This is equivalent to 100% to 200% of the recommended daily allowances (RDA) for target-group individuals. In comparison, slightly less than 1,100 IU (200,000 IU divided by 183 days) per day were given to each beneficiary of the direct massive dose, and a possible 2,300 IU per day were given in an effectively implemented PHI program. The quantity of the MSG fortificant's being higher than the RDA implies excess vitamin A and higher cost, but was used in the trial to insure maximum biological impact.

After a careful review of the literature and a number of consultations with authorities, the study group was satisfied that the danger of toxicity from MSG was negligible and that the fortification of MSG with 15,000 IU of vitamin A was safe under existing consumption pattersns.

V. INTERVENTION EVALUATION

The evaluation of the fortification intervention relative to the other approaches basically involves an examination of costs, both private and social, and nutritional impact, i.e., effectiveness. Thus, costs and

effectiveness will be examined in this final section. A further important refinement in the evaluation is a social-cost benefit analysis. This approach is demonstrated in the Appendix.

A. Costs

1. General Costing Methodology

Both private costs and the broader category of social costs must be considered in calculating the total costs of a program. The former are borne by the individual households that participate in the program, and can be split into direct and indirect costs. Direct costs consist of the money required for materials such as seeds, fertilizers, medical supplies, etc. The subsidized portion of each item is excluded. Indirect costs represent economic opportunities missed because of participation - additional commitment of money or time to home gardening or to nutrition or health education - in the project.

Social costs are the sum of private costs and all other costs, which in this case are fixed investments (in training and facilities), operating and maintenance costs, and the market value of any food aid or other program components, whether purchased outright or received in the form of assistance. This would also include the cost of the subsidy. Societal costs, or, more appropriately, social opportunity costs, are independent of whoever pays for the program.

For this cost analysis we will compare the costs of MSG fortification with those of the alternative mass dosage and public health/gardening interventions, thus giving a richer illustration of the costing methodology.

In computing the specific costs of each program, several assumptions are made. First, the target population of 300 households in each barrio includes three children per household. Second, the cost calculations include economies of scale, as would any national health or nutrition program. For example, the cost of the mass-dosage capsules is based on a large purchase. Third, an estimation of the value of time required for participation must be included. Thus, time for gardening is excluded, as households are not asked to spend any more time on gardening than they did before the PHI project was introduced. Fourth, the costs are based on the current salary structure and medical technology available in the Philippines. For example, new TB chemotherapy used in other countries, which is more cost-effective but unused at present in the Philippines, was excluded.

2. Fortification Costs

Costs for a micronutrient fortification program are low, especially when there is only one central processor and distributor. Calculations are based on a large program covering over two million persons daily. Costs are then scaled down and compared to the benefits of a program for one barrio, in order to make the costs comparable on a per capita basis with other national health, nutrition, or development projects. Clearly,

expenditures per capita are lower with large programs than small ones, and the costing of a project on the basis of a small pilot study unfairly increases the average costs of certain types of programs.

The MSG fortification costs include the mixer ($22,000), Roche palmitate ($12/kg), and silicic acid at $0.65 per pound. In addition, three full-time employees were needed.

For one barrio of 300 households, the total cost of processing for a fifteen-year program in present (1977) value terms with a 15% interest or discount rate, was estimated to be $1134. Costs for the first year would be $173, including the pro-rated share of cost of the mixer. The cost of the second year of the fortification program should decrease slightly, to $168 (because the mixer was purchased in the first year). These cost calculations do not include the storage loss costs, which would have to be covered by an increase in the vitamin A placed in each packet. On the assumption that there is an average of three children aged one to sixteen in each of the barrio households, the cost per potential beneficiary child for the first year of the program would be $0.19. Considering that only a little more than half of the children exhibit low serum vitamin A levels, the cost per needy beneficiary approaches $0.38.

An MSG fortification program on a national scale could be very inexpensive for the government since the only real costs would be in monitoring the program and its effectiveness. As planned, there would be no price increases to the consumer. The leading manufacturer of MSG, Union Chemicals, Ltd., agreed that approximately 0.1 gram of MSG in each 2.2-gram packet could be replaced by vitamin A and the flow-enhancing agent at no extra cost. This was possibly because the cost of the vitamin A-agent mixture does not significantly differ from that of the MSG. The result would be that the public would consume marginally less MSG per packet, while receiving a valuable nutrient in its place.

3. Mass Dose Costs

On the other hand, the mass-dosage was provided twice a year to each child. The social costs included only the costs of the capsules and the delivery system, which was found to be the principal cost. This was the least expensive of the three programs, costing about $62 each year per barrio. There is a possibility, however, that the costs have been underestimated, because no user's time was included in the calculation. One significant problem is that in this program, the probability that children of mothers engaged in market work would miss at least one of the capsule deliveries was 8% greater than that children of mothers engaged only in home production would do so. As noted already, program dropout rates and administrative burdens have significantly decreased the effectiveness of mass-dosage interventions in many countries.

4. PHI Costs

The public health intervention required both time and monetary investments of each household, and as such was the only one of the three interventions to show private costs. Construction of the toilets and toilet housing, the establishment of a small pharmacy in each barrio, and

time needed to attend nutrition education classes and to implement the new ideas are all private costs. These were estimated to be $6.12 per capita for the first year, but zero for the second year of the project.

The social costs of the PHI programs included the costs of a physician and auxiliaries who visit each barrio one day per week, a part-time horticulture consultant, tuberculosis and antihelminthic drugs, seeds and cuttings, and various educational and medical supplies. The costs for volunteer assistants in each area were also included. Such volunteers were essential, their cost was reflected by the much greater difficulty in getting volunteer assistance in the coastal areas, where the market value of time for women is much higher. The mean market or real value of time was used for all time costs, even when the time was donated. The total social costs per barrio, over 65% of which were private household costs, were $2840 for the first year. The social costs dropped to $947 during the second year of the program, when no private costs were incurred.

Table 23 provides a summary of the present value of private and societal costs for each program calculated annually for five-year and for fifteen-year programs. Note the smaller differentials between each program's costs over the 15-year period. As the PHI program operates for a longer period, fewer training and educational expenses are required. Similarly, the costs of equipment for the fortification program and for the training of persons to deliver the mass-dosage capsules are lower with each year. Equal costs are assumed for each ecological zone. The 15-year costs are used in the determination of the benefit/cost ratios.

B. Effectiveness

It was realized that the provision of the capsule or the fortified MSG was not likely to result in any benefits other than improved vitamin A nutritional status because of the nature of the interventions. Therefore, the results were judged on the basis of clinical signs of vitamin A deficiency and serum vitamin A levels. On the other hand, the public health and horticulture intervention was expected to possibly result in benefits other than its effect on vitamin A nutritional status.

1. Intermediate Indicators

In achieving the goal of decreasing xerophthalmia through planned interventions, planners may use intermediate indicators of effectiveness - for instance, the acceptability of the program - to gain an idea of whether the intervention will have an impact. In the capsule program, 3.4% of the recipients reported reactions such as vomiting, headaches, and fevers up to 24 hours after receiving the dose. This may have contributed to the refusal rate of 3.3% for the second capsule delivery. It is not known how many would have reported similar symptoms after receiving a placebo. Without this information, and given the estimate that only a third to half the vitamin A dosage is stored in the body, a dose every 3 or 4 months of 100,000 IU for the younger and 200,000 IU for the older children is suggested for future capsule programs.

TABLE 23

ANNUAL COSTS AND PRESENT VALUE OF THESE COSTS FOR EACH PROGRAM
(in dollars)*

Program	Private Costs Per Household (Annual Basis Only)		Social Costs Per Barrio					
			Annual Basis		Present Value of			
					5 Years		15 Years	
	Year 1	Year 2	Year 1	Year 2	8%**	15%**	8%	15%
Capsule	-	-	$ 62	$ 62	$ 267	$ 239	$ 572	$ 416
Fortification of MSG	-	-	173	168	728	652	1,556	1,134
Public Health Intervention	$6.12	-	2,840	947	8,636	8,203	13,344	10,945

*7.35 Philippine Peso = U.S.$1.

**Discount rates.

Another intermediate indicator, delivery, was not a problem in the fortification intervention because the MSG packets were delivered by program personnel directly to the family each week, at no charge. As a result, the study only tested the effectiveness of the MSG fortification and did not adequately test the delivery system. Realistically, a planner should take delivery factors into account; however, a later phase of this project is testing MSG delivery systems.

In contrast, delivery was a problem in the capsule program. Over 90% of the children between one and six years of age were reached the first time capsules were distributed. Thirteen percent of these children were not reached on the second delivery, and an even higher dropout rate was reported the third time around. The delivery system used local community organizations so that the results might approximate those that could be achieved nationally. A partial explanation of the problems can be derived from the finding of an inverse relationship between the income of the child's family and the rate of taking the capsule. Furthermore, it was observed that a child will probably receive less vitamin A if its mother works away from home (in this case, since the child would miss the capsule distribution).

The disadvantages of fortification as an intervention that were previously discussed were corroborated by the Philippine MSG fortification data. These include start-up costs for equipment, excess coverage, lack of involvement by the community, and the inability to eliminate the cause of the deficiency itself. Nonetheless, fortification of a carrier such as MSG makes it possible to attain a high rate of coverage through a simple and inexpensive delivery system.

The problems encountered in implementing the integrated PHI program make it difficult to consider a large-scale implementation for the sole purpose of eradicating xerophthalmia. As stated before, public health and horticulture interventions are expected to have some positive benefits beyond those related to vitamin A nutritional status. The children in some of the areas in which the PHI was implemented exhibited (a) a significant increase in vitamin A intake, (b) a significant improvement in their expected weight (Harvard weight-for-height standard) and (c) a significant reduction in the total number of children with third-degree malnutrition (Gomez classification), compared to the baseline study. However, there was no significant change in the prevalence of severe diseases or heavy parasite loads.

2. Nutritional Impact: Clinical Signs and Serum Levels

The prevalence of active clinical eye signs of xerophthalmia before and after interventions is presented in Table 24. These are the results for the 1407 children who were examined during the baseline study in 1973 and after completion of the interventions in 1975. Of the children, 4.1% had active clinical signs at the beginning of the intervention, and 1.7% had such signs at the end. The change in the distribution of xerophthalmia is significant at the .001 level using a chi-square test.

TABLE 24

CHANGES IN CLINICAL SIGNS OF XEROPHTHALMIA - ALL CHILDREN

	Before Intervention (%)	After Intervention (%)	Change (%)
Inactive Signs			
XS Corneal scars	0.3	0.5	+67
Active Signs			
XN Night Blindness	2.2	0.6	-73
X1B Bitot's spot with xerosis	1.4	0.9	-36
X2 Corneal xerosis	0.5	0.1	-80
X3B Keratomalachia	-	0.1	-
Total Active signs	4.1*	1.7*	-59
Total Chemical signs	4.4	2.2	-50
Total number of children	1,407	1,407	

* Paired t-test significant at 0.001 level.

Table 25 breaks the figures of Table 24 into groups according to intervention category. The groups receiving capsules and fortified MSG had statistically significant reductions in the prevalence of active signs. A nonsignificant reduction was observed in the public health and horticulture group.

One important consideration in studying these figures is to remember that the actual number of clinically diagnosed cases is quite small. While statistically significant results are noted, it is desirable to have larger numbers of cases, since "marginal" changes in prevalence in the aggregate could be strongly influenced by factors such as seasonal fluctuations or inconsistency in diagnosing xerophthalmia. Reliable data on these factors were unavailable for the Philippine interventions.

The mean serum vitamin A levels for the three groups before and after intervention are shown in Table 26. About 20% of the sample children did not provide final blood or the blood was hemolyzed and thus useless for analysis. A statistically significant rise in serum vitamin A levels occurred with MSG fortification. No other significant changes were noted.

The decrease in the public health intervention group can be logically explained only by factors unrelated to the intervention itself, since there is no reason to expect this change. Economic factors may be responsible. As shown in Table 27, the recipients in barrios where the public health intervention was carried out had lower per capita incomes than the other groups and may therefore have been more apt to change their consumption because of increasing food prices. This explanation was investigated and found to be plausible, as is discussed below concerning inflation. The importance of controlling for socio-economic similarity among experimental groups is critical and is also discussed subsequently.

In Table 28, serum vitamin A levels from before and after intervention for the three sample groups, PHI, capsule and MSG fortification, are presented. All individuals have been classified into deficient, low, acceptable, and normal categories. Indicated here are significant changes in the proportions of individuals in the four categories for each intervention. Notable results from the MSG fortification are consistent with those noted previously; there are fewer individuals in both the low and deficient categories after intervention than before. Similarly, there are more individuals in the normal and acceptable categories after intervention. However, changes found for the PHI and capsule programs are not as would have been expected based on the hypothesis that the intervention should have either a positive or a neutral influence. In both PHI and capsule groups, the number of individuals in the deficient category more than doubles following intervention. Equal numbers of individuals would have been expected in these groups if the intervention had a neutral effect. There is no reason a priori to expect the number of individuals in the deficient category to increase as observed. One explanation is that in Cebu between the base line period prior to intervention and the follow-up period after intervention the situation got worse because of inflation, because of agricultural events and because of other economic and related conditions. In fact, real incomes during the period declined. The Public

TABLE 25

CLINICAL SIGNS OF XEROPHTHALMIA BEFORE AND AFTER INTERVENTION

	Before		After	
	%	#	%	#
PHI				
Active	4.9	(23)	3.4	(16)
Inactive	0	(0)	0.2	(1)
Normal	95.1	(439)	96.4	(445)
Capsule*				
Active	3.1	(15)	0.6	(3)
Inactive	0.4	(2)	0.8	(4)
Normal	96.5	(454)	93.6	(464)
MSG Fortification				
Active	4.2	(20)	1.0	(5)
Inactive	0.4	(2)	0.4	(2)
Normal	95.4	(452)	98.6	(467)
Total		1,407		1,407

*There is a significant reduction in the prevalence of active signs at the 0.01 level using a paired t-test.

TABLE 26

MEAN SERUM VITAMIN A LEVELS BEFORE AND AFTER EACH INTERVENTION

	N	Before mcg/100 ml		N	After mcg/100 ml	
PHI	391	19.0	(11.9)*	391	16.4	(11.9)*
Capsule	343	19.6	(11.5)	343	19.6	(13.4)
MSG Fortification	387	21.0**	(12.4)	387	28.5**	(14.8)
Total	1,121***	19.9	(11.9)	1,121***	21.5	(14.1)

*Numbers in parentheses are standard errors.

**These differences are significant at 0.01 level using paired t-test.

***A second blood sample was not obtained from 286 children who were seen at the second examination. Hence the N = 1,121 here and 1,407 in Table 15.

TABLE 27

COMPARISON OF THE SOCIOECONOMIC BACKGROUND OF SAMPLE CHILDREN BY TREATMENT GROUP

	Household Income Per Capita 1973*	Household Wealth 1975	Mothers' Education Level	Weekly Food Expenditures Before	Weekly Food Expenditures After
Public health and horticulture fortification	$ 77	$218	2.6	$8.16	$8.03
MSG fortification	83	393	3.3	8.71	9.39
Mass dose capsule	110	558	2.8	8.57	8.16
Overall average	90[2]	391[2]	2.9[2]	8.57	8.44**

*7.35 Philippine pesos equals U.S.$1. The figures are presented for 1975 values.
**F-statistic significant analysis of variable at 1% level.

Number of cases = 1,407.

TABLE 28

SERUM VITAMIN A LEVELS BEFORE AND AFTER INTERVENTION ACCORDING TO THE INTERDEPARTMENTAL COMMITTEE ON NUTRITION FOR THE NATIONAL DEFENSE (ICNND) CLASSIFICATION

ICNND Classification	PHI		Capsule		MSG Fortification	
	Number	mcg/100 ml	Number	mcg/100 ml	Number	mcg/100 ml
Deficient (below 10 mcg)						
Before	(75)	6.6	(59)	6.4	(62)	6.4
After	(183)	5.6	(126)	5.4	(47)	6.8
Low (10-19 mcg)						
Before	(166)	14.0	(139)	14.4	(135)	14.3
After	(113)	14.5	(90)	15.0	(94)	15.0
Acceptable (20-49 mcg)						
Before	(140)	29.2	(131)	28.7	(171)	29.0
After	(86)	28.1	(108)	28.4	(216)	30.1
Normal (above 50 mcg)						
Before	(8)	60.6	(9)	54.4	(10)	54.3
After	(7)	66.4	(14)	56.6	(21)	60.4
n*	(389)		(338)		(378)	
X^2 significance	0.01		0.5		0.01	

*Individuals with outlier values have been excluded.

Health Intervention group during this period showed a decline in mean serum vitamin A levels from 19.0 to 16.4 mcg/100 ml which was not statistically significant (see table 28). Perhaps this is what happened in most of the population, and possibly this intervention had no positive effects except when eye lesions occurred. Then one could say if the PHI is the control group, that the capsule group having a mean of 19.6 mcg/100 ml before and 19.6 mcg/100 ml after benefitted slightly from the intervention in that their mean serum vitamin A levels did not deteriorate like the PHI group. It should also be stated that the blood in the capsule group was taken six months after the last capsule was consumed. Our evidence, and that of others, suggests that serum vitamin A levels following a high dose of vitamin A remain elevated for much less than six months (perhaps only three months). If we suggest that the situation got worse in Cebu in the period under study, then the rises in serum vitamin A levels in the MSG group became even more impressive. That is, serum vitamin A was a mean of 28.5 mcg/100 ml after intervention which is 12.1 mcg/100 ml higher than the PHI group after intervention.

Analyses are carried out to ensure that various socio-economic factors such as inflation, household per capita income, and education were not influencing the outcomes. As can be seen from Table 27, differences in these factors existed in the three intervention groups. In the 1973-1975 period during which the program experienced price inflation over 35 percent, real food expenditures in sample households declined. Another confounding issue was that income per capita and education levels were not equal in the barangays randomly selected for each of the three interventions. The barrios with the public health and horticulture intervention program had the lowest mean household wealth and per capita income, while the barrios receiving the capsule intervention program had the highest. In terms of educational level, the mothers in the PHI barrios had a mean of 2.6, the capsule barrios of 2.8, and the MSG barrios of 3.3 years of education.

A multiple regression analysis was performed to assess the extent to which these economical and educational differences contributed to final serum vitamin A levels (Table 29). The analysis determined the relative importance of the type of intervention program in predicting serum levels at the end of the study while controlling for education, household and per capita incomes, and initial serum levels. The result showed that the MSG intervention and initial serum vitamin A levels were significant independent variables. This implies that the MSG fortification intervention was associated with a significant rise in serum vitamin A levels when controlling for socio-economic variables. The low R^2 (.04), however, indicates substantial unexplained variation in results, reflecting in part the difficulty of explaining biological variation in human nutrition studies. On the basis of this information, planners should be aware that interpretation of such results is not completely certain but that the signficance of MSG fortification cannot be challanged.

The vitamin A fortification program has moved through three stages: a determination of the epidemiology and prevalence of the vitamin

TABLE 29

REGRESSION ANALYSIS: RELATIVE IMPACT OF EACH INTERVENTION ON SERUM A LEVELS
Dependent Variable: Serum A level (mcg/100 ml) at end of study

Independent Variables	Equation 1		Equation 2	
	B Coefficient	(t-value)	B Coefficient	(t-value)
Coefficient constant	11.5		11.7	
Education of the mother (levels)	.58	(.96)	.65	(1.06)
Household income per capita ($)	.0006	(1.51)	-	-
Change in income from 1973-1975	-	-	.0001	(0.31)
Initial serum A level of child in 1973	0.15	(2.04)*	0.15	(2.1)*
MSG fortification (0-1 variable)	11.5	(5.33)*	11.4	(5.3)*
Capsule program (0-1 variable)	2.7	(1.22)	2.9	(1.33)
R^2	.04		.04	
F-statistic	8.8		8.3	
Number of cases	1,118		1,118	

*$P < .05$.

A problem, an evaluation of the relative effectiveness and cost of the three intervention programs, and finally, the initiation of three fortification programs in three provinces (Cebu, Marinduque, and Nueva Viscaya) to test the feasibility of a national program. The fourth and final stage will likely be the implementation of such a program, which will cover the entire population (42 million) of the Philippines.

CHAPTER FOUR FOOTNOTES

[1] $B/C \gtrless 1$. An alternative measure is net benefit = $N = B - C \underset{F}{\overset{J}{\lessgtr}} 0$. Net benefit has the disadvantage of not indicating the size of the net benefit in relation to either benefits or costs.

[2] Transfer payments may, however, influence the distribution of wealth in society, an issue of equity. This is not dealt with in either classical cost-benefit analysis or this study. Such factors would have been difficult to consider in any event, since no blind people received welfare assistance.

APPENDIX A

BENEFIT COST ANALYSIS OF PHILIPPINES VITAMIN A INTERVENTIONS

VIII. BENEFIT-COST ANALYSIS

In addition to knowing how effective a proposed intervention is, policymakers often want to know the economic benefits of alternative programs. Benefit-cost analysis is one of the tools used by public officials to determine how major resources are to be allocated. Under this method, the ratio of social benefits to social costs is the illustrative indicator. It determines simply whether benefits outweigh costs.[1] Benefit-cost analysis is closely related to cost-effectiveness analysis, but goes one step further in quantifying benefits and costs in comparable terms. Because benefits could be quantified with these interventions, benefit-cost analysis was chosen. It should be noted, however, that the assumption that a monetary value can be placed on benefits excludes those real social benefits which are not easily monetarized. The method also requires estimation of changes in productivity and future income flows. This is a difficult issue to consider in evaluating social programs.

The primary element of benefits is the expected additional income earned over the lifetime of an individual because xerophthalmia is eliminated in that individual. There are four mutually exclusive groups that are affected by this benefit: those sick from xerophthalmia; those blind from xerophthalmia; those dying from xerophthalmia; and those not showing signs of xerophthalmia, but suffering from a higher incidence of communicable diseases as a result of being exposed to xerophthalmia. Estimations have been made of the probability of a child's being in one of these groups and of that child's potential income over an average lifetime, assuming all individuals are fully employed and taking into consideration sex, educational attainment, and place of residence.

According to the World Health Organization, fatality rates associated with xerophthalmia vary from 24% to 60%. The conservative estimate of 20% is used for the study. The present benefits of not dying are simply the present value of future earnings.

The probability of blindness due to xerophthalmia was set at one out of 662 children aged one to six and one out of 2765 children aged 7 to 16. The income value of blind persons was estimated by taking a survey of 48 blind persons living in the research area. The age-earning profiles for blind males were compared with those of one cohort of healthy males. The difference in the earnings of the young and healthy persons aged 17 and older were used to calculate the economic gains of preventing blindness.

Persons who have xerophthalmia and who do not die or become blind are expected to have much higher morbidity levels than those who do not have xerophthalmia. Xerophthalmia lowers the integrity of epithelial

tissues and disease resistance, resulting in an increased incidence of upper respiratory tract infections, tuberculosis, whooping cough, and several other diseases. Protein utilization is also lowered. Recent studies have indicated that sick children appear less able to concentrate, have poorer judgment, are absent from school more often, learn less, and have a lower level of cognitive ability (Cravioto, J. and DeLicardie 1971). Although it is difficult to quantify the effects of poor health and nutritional status on cognitive ability and school performance, it was estimated that the sick child would later earn 5% less than the average healthy child. Some would dispute this estimate in view of the labor suplus situation in most developing countries.

Some potential private monetary benefits to the nonxerophthalmic group from the elimination of xerophthalmia also exist. The probability of the nonxerophthalmic group contracting communicable diseases from among the xerophthalmic group increases. By eliminating xerophthalmia, it is estimated that a 1% increase in lifetime productivity of the nonxerophthalmic groups will occur because of decreased morbidity.

Detailed clinical and biochemical measures were developed to determine the rate of failure of protection in each program. Changes in the probability of ocular signs of severe xerophthalmia were used to determine the programs' effectiveness against blindness. Changes in the blood levels were used to analyze their effectiveness against death and morbidity.

All programs were assumed to give complete protection against death. However, none of them completely prevented morbidity-related xerophthalmia. Although the fortification program was most successful in raising serum vitamin A levels in the children, its effectiveness in preventing morbidity was conservatively estimated at 83% and 85% in the two ecological zones. The overall effectiveness parameter given in Table 30 is the average of the effectiveness of each program weighted against each type of problem.

Estimates of effective expected net private benefits are given by intervention type in Table 31. This table is simplified by only calculating benefits for cohorts of boys and girls in urban squatter areas and rural coastal barrios who have three to seven years of education. This is the largest educational group. An example calculation is provided in Table 32.

Social benefits are the sum of all expected private benefits, savings of public resources used in treatment which are no longer needed, and technological changes resulting from improvements in the health and education of recipients. The latter could not be easily measured and thus are not included in this analysis. Likewise, no effort was made to estimate opportunity costs. Possible changes in revenues and/or welfare payments resulting from reduction of vitamin A-associated problems also are not included, as they are transfer payments and thus do not represent net changes in overall social benefits.[2] These benefits were calculated for 900 children in each barrio.

TABLE 30

THE EFFECTIVENESS PARAMETER: EFFECTIVENESS PROBABILITY FOR EACH PROBLEM BY AREA AND PROGRAM

Ecological Zone, Nutrition Program	Morbidity	Blindness	Death	External Benefits	Overall Effectiveness
Squatter Areas					
PHI	.50	.97	1.00	.50	.59
MSG Fortification	.85	1.00	1.00	.85	.97
Capsule	.75	1.00	1.00	.75	.82
Coastal Barrios					
PHI	.50	.98	1.00	.50	.58
MSG Fortification	.83	1.00	1.00	.83	.99
Capsule	.75	1.00	1.00	.75	.79

TABLE 31

PRESENT VALUE OF EFFECTIVE EXPECTED NET PRIVATE BENEFITS
(in dollars)*

	Public Health Intervention		MSG Fortification		Mass Dosage Capsule	
	8%	15%	8%	15%	8%	15%
Urban Squatter						
age 1-6						
boys	9.01	1.68	12.58	2.37	11.57	2.17
girls	2.76	0.46	4.30	0.72	3.87	0.65
age 7-16						
boys	9.93	3.23	16.26	5.34	14.46	4.74
girls	4.54	1.29	7.48	2.13	6.65	1.89
Rural Coastal						
age 1-6						
boys	8.99	1.93	12.80	2.77	11.88	2.57
girls	5.19	1.06	7.48	1.53	6.93	1.41
age 7-16						
boys	15.92	5.95	23.09	8.65	21.35	8.00
girls	6.30	2.21	10.46	3.67	9.45	3.32

*For persons with an expected education level of three to seven years. These calculations are made using the same method given in Table 27.

TABLE 32

EXAMPLE OF CALCULATION OF EFFECTIVE EXPECTED NET PRIVATE ECONOMIC BENEFITS FOR THE FORTIFICATION PROGRAM IN THE SQUATTER AREA

Benefit Group (k)	Probability Squatter Age 1-6		Net Present Value (Dollars) of Future Earnings Educ. 3-7 Yrs Cohort Males Age 1-6*		Effectiveness Fortification Program		Present Value (dollars)
Expected value of the sum of:	P_k		$W_t - W_{kt}$		M_{kj}		
A. $Pa\ (W_t - W_{at})M_{aj}$ morbidity	= (.0173)	x	(47.75)		(.85)	=	0.702
B. $Pb\ (W_t - W_{bt})M_{bj}$ blindness	= (.0015)	x	(405)	x	(1.0)	=	.6075
C. $Pd\ Wt\ M_{dj}$ death	= (.0035)	x	(955)	x	(1.0)	=	3.34
D. $Pnox\ (Wt - Wnoxt)M_{noxj}$ externalities	= (.9777)	x	(9.55)	x	(.85)	=	7.93
Effective expected value of private economic benefits							$12.58

P_a, P_b, P_d, P_{nox} = probability of belonging to groups A, B, C, D respectively.

P_k = probability of belonging to group with problem k where k = a, b, d and nox problems.

$W_t - W_{kt}$ = net future earnings accruing as a result of fortification.

M_{kj} = effectiveness parameter of program j for type of problem k.

*Calculated by discounting to the present the expected value of future income or additions to future income resulting from fortification. For example, based on the estimated future income flow, a one-year-old boy whose death is prevented and who is fully employed from ages 14-60 has a net present value of future earnings of

$$PV(W_t) = \sum_{14}^{60} \frac{E(W_t)}{(1+r)^{t-1}}$$

The average value for the one- to six-year-old cohort is $955.

Treatment benefits consist of the amount of savings gained from the reduced treatment for children both in rural and urban health centers (outpatient care) and in hospital or other inpatient centers (for example, malnutrition rehabilitation wards). It was estimated that only 4% of the chilfren with xerophthalmia would be treated in outpatient clinics. The total cost for four outpatient visits was conservatively estimated to be $0.61. Only 0.25% of the children (1 in 400) would be placed in a hospital at an average cost of $68 (based on a 12-day stay). The prevalence of xerophthalmia in each barrio was then used to determine treatment costs for each year. By eliminating xerophthalmia, total treatment benefits in a squatter barrio, over a 15-year period in current value terms, were $200 and $95 at discount rates of 8% and 15% respectively. Each program would effectively eliminate all hospital costs related to the treatment of xerophthalmia. Morbidity costs are covered by the PHI program; the other programs eliminate all of these treatment costs. Therefore, 100% effectiveness in eliminating all treatment costs would result. Table 33 presents the present values of total social benefits, using 8% and 15% discount rates.

The social benefit-cost ratios calculated for the three programs are presented in Tables 34 and 35. The project costs for fifteen years were compared with social benefits for an entire (age one to sixteen) cohort. In other words, it was assumed that the benefits of coverage provided for four years to a 12-year-old plus coverage for eleven years to a child who enters the program during its fifth year and remains in the program are equivalent to benefits of coverage provided for 15 years to one child. The resulting benefit-cost ratios show that both the capsule and fortification programs produce significant net benefits, while the PHI's costs are greater than its benefits.

In many ways, it is inappropriate to compare the three programs, because the benefits of the PHI program are different from those of the others. The MSG fortification and capsule programs provide benefits only while they are operating. In contrast, the education, sanitation, horticulture, and other aspects of the PHI program could produce benefits for a much longer period. A consideration of longer-term benefits, even intergenerational ones, could significantly enhance the economic benefits attributed to PHIs. One reason to select such a program is that it breaks away from a supply orientation. Of course, the lack of consumer involvement may be the reason why the PHI program's effectiveness was lower.

Additional health and nutritional benefits unaccounted for in this analysis accrue to children covered by the PHI program. For instance, hemoglobin levels (indicators of anemia) of PHI children increased significantly, while those of MSG and capsule children decreased during the intervention period. Furthermore, the overall current nutritional status of PHI children (measured as percent weight for height on an international standard) increased significantly relative to the other children's nutritional status. Other benefits of the PHI are the elimination of tuberculosis and the immunization of most of the children. An intangible benefit important to the Filipino government was the development of a community infrastructure composed of both volunteer and paid para-professional health

TABLE 33

PRESENT VALUE OF SOCIAL BENEFITS FOR EACH PROGRAM BY ZONE AND DISCOUNT RATE (in dollars)*

	Discount Rate				Total	
	Private Benefits		Treatment Benefits		Social Benefit	
	8%	15%	8%	15%	8%	15%
Urban Squatter						
Public health intervention	$ 5,987	$1,609	200	95	$ 6,187	$1,704
MSG fortification	9,417	2,583	200	95	9,617	2,678
Mass dosage capsule	8,444	2,306	200	95	8,644	2,401
Rural Coastal						
Public health intervention	8,542	2,758	225	120	8,767	2,878
MSG fortification	12,788	4,159	225	120	13,031	4,279
Mass dosage capsule	11,771	3,825	225	120	11,996	3,945

*For 900 children in both ecological zone and program. The age and sex distributions of these 900 children were based on the 1970 Philippines Census distribution of children for the Province of Cebu. Of the 900 children, 167, 175, 272, and 286 were males age 1-6, females age 1-6, males age 7-16, and females age 7-16, respectively. These calculations are made using the same method given in Table 14.

TABLE 34

BENEFIT - COST RATIOS*

Treatment Group	Social Benefits 8%	Social Benefits 15%	Social Costs 8%	Social Costs 15%	Benefit/Cost Ratio 8%	Benefit/Cost Ratio 15%
Urban Squatter						
Public health intervention	$ 6,187	$1,704	$13,344	$10,945	0.7	0.2
MSG fortification	9,617	2,678	1,556	1,134	6.2	2.4
Mass dosage capsule	8,644	2,401	572	416	15.2	5.8
Rural Coastal						
Public health intervention	8,767	2,878	13,344	10,945	0.7	0.3
MSG fortification	13,031	4,279	1,554	1,134	8.4	3.8
Mass dosage capsule	11,996	3,945	572	416	21.0	9.5

*Fifteen-year project.

TABLE 35

SENSITIVITY ANALYSIS: EXCLUSION OF EXTERNALITIES

Urban Squatter Area	Social Benefits 8%*	Social Benefits 15%*	Benefit/Cost Ratio 8%	Benefit/Cost Ratio 15%
With Externalities				
PHI	$6,187	$1,704	0.7	0.2
MSG	9,617	2,678	6.2	2.4
Capsule	8,644	2,401	15.1	5.8
Without Externalities				
PHI	1,444	340	0.1	0.03
MSG	1,274	507	0.8	0.4
Capsule	1,456	352	2.5	0.8

*Discount rates.

Certain externalities were also included in the benefit-cost analysis. For example, the largest proportion of private benefits was attributed to the group that did not have xerophthalmia. Although the benefits per child were small, close to 98% of the sample children fell into this category. If this group had been smaller (as was the case when an earlier and much less stringent definition of xerophthalmia was used), these external benefits would have been more plausible. To understand the relevance of this category, the benefits for the squatter-area children were calculated while excluding the private benefits of the group without xerophthalmia. Table 22 demonstrates that the elmination of these benefits lowers the benefit-cost ratios significantly. The only program where the benefits remained greater than the costs is the capsule program, using an 8% discount rate. The income levels in the squatter areas are lower than in the coastal areas. Therefore, the coastal barrios' benefit-cost ratio for MSG fortification, calculated at a discount rate of 8%, was also above 1.0.

The private economic benefits of these programs may have been significantly understated. The probability of the prevalence of xerophthalmia was conservatively estimated, and a much higher level of xerophthalmia is possible. In fact, if deficient and low serum vitamin A levels had been used to measure xerophthalmia, 57% of the sample children would have been classified as having the disease. Also, children's earnings and the value of women's time were significantly underestimated. Consequently, we expect a relatively greater underestimation of the economic benefits to women.

REFERENCES

Ajans, Z. A., Sarrif, A., and Husbands, M. Influence of vitamin A on human colostrum and early milk. Am. J. Clin. Nutr. 17:139, 1965.

Akino, K. Recent developments in amino acid fortification in Japan. In Amino acid fortification of protein foods, eds. N. S. Scrimshaw and A. M. Althschul. Cambridge, Massachusetts: MIT, 1971.

Anderson, R.A., Bookwalter, G. N., and Vojnovich, C. Iron enrichment of dry-milled corn products. Cereal Chemistry 53:937, 1976.

Arroyave, G., Aguilar, J., and Portela, E. Undated. Improving sugar for better nutrition. Fortification with vitamin A at a national scale. Mimeographed. Guaetmala: INCAP and El Salto, S.A., 1976.

Arroyave, G., Viteri, F., Behar, M., and Scrimshaw, N. S. Impairment of intestinal absorption of vitamin A palmitate in severe protein malnutrition (kwashiorkor). Am. J. Clin. Nutr. 7:185, 1959.

Austin, J. E., ed. Global malnutrition and cereal fortification. Harvard University report to AID, June, 1977.

Austin, J. E., ed. Global malnutrition and cereal fortification. Cambridge, Massachusetts: Ballinger Publishing Company, 1979.

Austin, J. E., et al. Urban malnutrition: problem assessment and intervention guidelines. Harvard University report to the World Bank. September, 1976.

Austin, J. E., and Ickis, J. Sugar fortification in Guatemala. Boston, Massachusetts: Harvard Business School. Case 4-374-297, 1974.

Austin, J. E., and Snodgrass, D. R. Cereal Fortification: barriers to implementation. In Improving the nutrient quality of cereals, ed. H. L. Wilcke. Washington, D. C.: USAID, 1976.

Aylward, F., and Morton, I. D. Vitamin fortification of foods. In Third international congress, food science and technology. Chicago: IFT, 1970.

Bains, G. S., and Tara, K. A. Progress report of studies of lysine fortification of cereals. Mysore, India: CFTRI, 1970.

Basta, S. et al. Iron deficiency anemia and the productivity of adult males in Indonesia. Am. J. Clin. Nutr. 32:916-925 (April) 1979.

Bauernfeind, J. C. Vitamin fortification and nutrified foods. In Third international congress, food science and technology. Chicago: IFT, 1970.

Bauernfeind, J. C. Vitamin A technology. In Vitamin A, xerophthalmia, and blindness. Vol. 3. Washington, D. C.: Technical Assistance Bureau, AID, 1973.

Bauernfeind, J. C., and Cort, W. M. Nutrification of foods with added vitamin A. Pp. 337-375 in CRC critical reviews in food technology (January) 1974.

Bauernfeind, J. C., Newmark, H., and Brin, M. Vitamin A and E nutrition via intramuscular or oral route. Am. J. Clin. Nutr. 27:234-253 (March) 1974.

Bauernfeind, J. C., and Parman, G. K. Restoration of nonfat dry milk with vitamins A and D. Food Technology 18:174-179, 1964.

Bauernfeind, J. C., and Pinkert, D. M. Food processing with ascorbic acid. Advances in food research 18:219-313, 1970.

Beetner, G., Tsao, T., Frey, A., and Harper, J. Degradation of thiamine and riboflavin during extrusion processing. Journal of Food Science 39:207-208, 1974.

Borenstein, B. Vitamins and amino acids. P. 85 in Handbook of food additives, ed. T. E. Furia. Cleveland: CRC, 1975.

Bressani, R., Elias, L. G., Jarquin, R., and Braham, J. E. All-vegetable protein mixtures for human feeding. XIII. Effect of cooking mixtures containing cottonseed flour on free gossypol content. Food Technology 18(10):1599-1603, 1964.

Brooke, C. L. Fortification of food products with vitamin A, with special reference to fortification of cereals and cereal products in India. In Proceedings western hemisphere nutrition conference II. San Juan, Puerto Rico: American Medical Association, 1968.

Cash, R. Xerophthalmia prevention in the Philippines: report on a system for delivering high dose vitamin A capsules through a food distribution program for malnourished children. New York: American Foundation for Overseas Blind, Inc. (November) 1976.

Cienfuegos, G. Comparison of absorption of vitamin A after oral and intramuscular administration in normal children. J. Pediatr. 28:191, 1946.

Clements, F. W., et al. Endemic goiter. World Health Organization Monograph Series No. 44. Geneva: World Health Organization, 1960.

Colman, N. et al. Prevention of folate deficiency by food fortification VI. The antimegaloblastic effect of folic acid-fortified maize meal. S. Afr. Med. J. 48:1795-1798, 1974.

Cravioto, J., and DeLicardie, E. R. The long-term consequences of protein-calorie malnutrition. Nutrition Reviews 29:107-111, 1971.

Davidson, J. T., and Russo, M. E. Iron fortification in breakfast cereal. Cereal Foods World 21:534, 1976.

De Ritter, E. Stability characteristics of vitamins in processed foods. Food Technology 30:48, 1976.

Durwin, P. Nutritional aspects of physical performance. Bibl. Nutr. Dieta No. 27, 1979.

Ehle, S. R., and Jansen, G. R. Studies on breads supplemented with soy, nonfat dry milk, and lysine. I. Physical and organoleptic properties. Food Technology 19:1435-1439, 1965.

el Lozy, M., and Kerr, G. R. Results of lysine fortification of wheat products in Southern Tunisia. P. 113 in Improving the nutrient quality of cereals, ed. H. L. Wilcke. Washington, D. C., U.S. Agency for International Development, 1976.

Elwood, P. Iron in flour. London: HAMSO, 1968.

Ericson, L. E., and Larson, S. The loss of added lysine during baking of a soft bread with exceptionally high content of reducing sugar. Acta Physiol. Scand. 55(1):64, 1962.

Ferrel, R. E., Sheperd, A. D., and Guadagni, D. G. Storage stability of lysine in lysine-fortified wheat. Cereal Chemistry 47:33-37, 1970.

Food and Agricultural Organization. Amino acid content of foods. Rome: United Nations, 1970.

Food and Agricultural Organization/World Health Organization (FAO/WHO). Report of joint FAO/WHO ad hoc expert committee. Rome: FAO, 1971.

Food and Agricultural Organization/World Health Organization (FAO/WHO) Joint Expert Committee on Nutrition. Seventh report. WHO Technical Series No. 377. Geneva: World Health Organization, 1967.

Garby, L., and Areekul, S. Iron supplementation in Thai fish-sauce. Ann. trop. Med. Parasitol. 68:467-476, 1974.

Gates, J. C. and Kennedy, B. M. Protein quality of bread and bread ingredients. Effect of using nonfat dry milk and lysine. J. Am. Diet. Assoc. 44:374, 1964.

Gershoff, S. N. Personal communication, Boston, 1977.

Gershoff, S. N., et al. Amino acid fortification of rice studies in Thailand. I. Background and baseline data. Am. J. Clin. Nutr. 28(2): 170-182, 1975.

Gershoff, S. N., et al. Nutrition studies in Thailand. II. Effects of fortification of rice with lysine, thionine, thiamin, riboflavin, vitamin A, and iron on preshool children. Am. J. Clin. Nutr. 30: 1185-1195 (July) 1977.

Gopalan, C. Studies of vitamin A deficiency in children. Am. J. Clin. Nutr. 8:833, 1960.

Gopalan, C. Some recent studies in the nutrition research laboratories, Hyderabad. Am. J. Clin. Nutr. 23:35-51, 1970.

Graham, G. G., et al. Lysine enrichment of wheat flour: evaluation in infants, Am. J. Clin. Nutr. 22:1459, 1969.

Harris, R. S. Mineral fortification of foods and food products. In Third international congress of food science and technology. Washington, D. C.: IFT, 1970.

Hedayat, H. H., et al. The effect of lysine fortification of Iranian bread on the nutritional status of school children. Acta Paediat. Scand. 62:297, 1973.

Hegsted, D. M. Nutritional value of cereal proteins in relation to human needs. In Protein enriched cereal foods for world needs, ed. M. Milner. St. Paul, Minnesota: American Association of Cereal Chemists, 1969.

Hoffman-La Roche. Personal communication, Hoffman-La Roche, Inc. Nutley, New Jersey, 1977.

Hoover, W. J. A case study: Ecuador. In Improving the nutrient quality of cereals, ed. H. L. Wilcke. Washington, D. C.: AID, 1976.

International Nutritional Anemia Consultative Group (INACG). Guidelines for the eradication of iron deficiency anemia. New York: The Nutrition Foundation, 1977.

Instituto de Nutricion de Centro America y Panama (INCAP). Fortification of sugar with vitamin A in Central America and Panama. Guatemala, 1974.

Izak, G. et al. The effect of iron and folic acid therapy on combined iron and folate deficiency anaemia: the results of a clinical trial. Scand. J. Haematol. 11:236-240, 1973.

Jansen, G. R. The amino acid fortification of cereals. P. 39 in New protein foods, vol. 1A. Technology, ed. A. M. Altochul. New York: Academic Press, 1974.

Jansen, G. R. Amino acid fortification. P. 177 in Evaluation of proteins for humans, ed. C. E. Bodwell. Westport, Connecticut: AVI Publishing Co., 1977.

Jansen, G. R. and Ehle, S. R. Studies on breads supplemented with soy, nonfat dry milk, and lysine. Food Technology 19:1439-1442, 1965.

Japan Chemical Annual. 1974. Tokyo, Japan.

Johnson, A. H. and Petersen, M. S., eds. Pp. 67-75 in Encyclopedia of food technology. Westport: AVI Publishing, 1974.

Jones, S. The mass administration of vitamin A: how effective a remedy for xerophthalmia? Mimeographed. Boston: Harvard School of Public Health, 1977.

Kacem, B. Amino acid fortification. Mimeographed. Boston: Harvard School of Public Health, 1976.

Kamel, W. W. A global survey of mass vitamin A programs. Vitamin A, xerophthalmia and blindness, vol. 1. Washington, D.C.: U.S. Agency for International Development, 1973.

Kamel, W. W. Assignment reports on blindness prevention programme in Bangladesh. WHO. SEA/NUT/41, 45, 47, 1973, 1974.

Kerr, G. Personal communication, Boston, 1977.

Kondo, K. Nutritional enrichment of white rice. IV. Preparation of vitamin B_1-enriched rice. Bulletin of Research Institute of Food Science (Kyoto University). 6:57, 1951.

Kramer, A., and Twigg, B. A. Fundamentals of quality control for the food industry. Westport, Connecticut: The Avi Publishing Co., Inc., 1966.

Layrisse, M., et al. Iron absorption from skim milk enriched with rion glycerophosphate. Arch. Latimoam. Nutr. 23:145-150, 1973.

Longenecker, J. B., and Hause, N. L. Relationship between plasma amino acids and composition of the ingested protein. Arch. Biochem. Biophy. 84:46, 1959.

McLaren, D. S., Khoury, G., Shirajian, E., and Tchalian, M. Xerophthamlia in Jordan. Am. J. Clin. Nutr. 17:117-130, 1965.

McLaren, D. S., Shirajian, E., Lo Shkajian, H., and Shadarevian, S. Short term prognosis in protein-calorie malnutrition. Am. J. Clin. Nutr. 22:863-870, 1969.

Mahloudji, M. et al. Combined zinc and iron compared with iron supplementation of diets of 6- to 12-year old village schoolchildren in southern Iran. Am. J. Clin. Nutr. 28:721-725, 1975.

Matthews, R. H., Richardson, G., and Lichtenstein, H. Effect of lysine fortification on quality of chappatties and yeast bread. Cereal Chemistry 46:14-21, 1969.

Milner, M. ed. Status of development and use of some unconventional proteins. In Protein enriched foods for world needs. St. Paul, Minnesota: American Association of Cereal Chemists, 1969.

Mitsuda, H. and Yasumato, K. The amino acid fortification of intact cereal grains. P. 121 in New protein foods, vol. 1A: Technology, ed. A. M. Althschul. New York: Academic Press, 1974.

Mock, C. Tunisian case study. In Global malnutrition and cereal fortification, ed. J. E. Austin. Report submitted by Harvard University to USAID under contract AID Ita-c-1172 (June) 1977.

Munro, H. N. and Allison, J. B., eds. Mammalian protein metabolism, vol. 2. New York: Academic Press, 1964.

Neeld, J. B. and Pearson, W. N. Macro- and micromethods for the determination of serum vitamin A using Triflouroacetic acid. J. Nutr. 79: 454-462, 1963.

Oomen, H. A. P. C. Xerophthalmia in the presence of kwashiorkor. Br. J. Nutr. 8:307-318, 1954.

Oomen, H. A. P. C., McLaren, D. S., and Escapini, H. A global survey on xerophthalmia: epidemiology and public-health aspects of hypovitaminosis. A. Trop. geogr. Med. 16:271-315, 1964.

Pan American Health Organization. Guidelines for food fortification in Latin America and the Caribbean. Scientific publication no. 240. Washington, D. C.: Pan American Health Organization, 1972.

Pan American Health Organization. Hypovitaminosis A in the Americas. Scientific publication no. 198. Washington, D. C.: Pan American Health Organization, 1970.

Pence, J. W., Fenel, R. E., and Robertson, J. A. Effects of processing on B-vitamin and mineral contents of bulgur. Food Technology 18: 765-768, 1964.

Pereira, S. M. and Begum, A. Studies in the prevention of vitamin A deficiency, part I. Indian J. Med. Res. 56:362, 1968.

Pereira, S. M. and Begum, A. Prevention of vitamin A deficiency. Am. J. Clin. Nutr. 22:858, 1969.

Pereira, S. M., Begum, A. Jesudian, G., and Sundarary, R. Lysine supplemented wheat and growth of pre-school children. Am. J. Clin. Nutr. 22:606, 1969.

Popkin, B. M. An evaluation of alternative vitamin A interventions in the Philippines. Ph.D. dissertation, Cornell University, 1974.

Popkin, B. and Solon, F. S. Income, time, and the working mother and child nutriture. J. Trop. Pediatr. Environ. Child Health 22(4): 156-166 (August) 1976.

Ranum, P. M. Value of iron enrichment emphasized. Milling and Baking News (30 May) 1978.

Reddy, V. and Swakumar, B. Studies on vitamin A absorption in children. Indian Pediatr. 9:307-310, 1972.

Reh, E. Manual on household food consumption surveys. Food and Agriculture Organization, Nutritional Studies No. 18. Rome: FAO, 1962.

Reisman, H. Amino acids. P. 197 in Encyclopedia of clinical processing and design, vol. 3, ed. J. J. McKetta and W. A. Cunningham. New York: Marcel Dekker, 1977.

Roels, O. A. and Mack, J. P. Vitamin A and protein metabolism. J. Agr. Food Chem. 20:1133, 1972.

Rohdenburg, E. L. and Rosenberg, H. R. Estimation and stability of added DL-methionine in mixed feeds. J. Agr. Food Chem. 4:872-875, 1956.

Rubin, S. H. and Cort, W. M. Aspects of vitamin and mineral enrichment. P. 220 in Protein enriched cereal foods for world needs, ed. M. Milner. St. Paul, Minnesota: American Association of Cereal Chemists, 1969.

Sarma, K. V. R., Damodaran, M., and Naidu, A. N. The Balwadi as an outlet for anemia prophylaxis programme. Indian J. Med. Res. 65:839-844, 1977.

Sayers, M. H., et al. Iron absorption from rice meals cooked with fortified salt containing ferrous sulfate and ascorbic acid. Br. J. Nutr. 31:367-375, 1974a.

Sayer, M. H., et al. The fortification of common salt with ascorbic acid and iron. Br. J. Haematol. 28:483-495, 1974b.

Schultz, A. S., Atkin, L., and Frey, C. N. The stability of vitamin B_1 in the manufacture of bread. Cereal Chemistry 19:532-538, 1942.

Schwartz, H. G., Fisher, H, and M. W. Taylor. The utilization by the chick of protein-bound as compared to free dietary lysine. Poult. Sci. 38:316 (July) 1959.

Schrimshaw, N., Taylor, Y., and Young, V. Lysine supplementation of wheat gluten at adequate and restricted energy intakes in young men. Am. J. Clin. Nutr. 26:965, 1973.

Senti, F. R. and Pence, J. W. Technological aspects of adding amino acids to foods. In Amino acid fortification of protein foods, ed. N. S. Scrimshaw and A. M. Altschul. Cambridge, Massachusetts: MIT Press, 1971.

Shaw, R. L. Incaparina in Central America. In History and status of specific protein-enriched cereal foods for world needs, ed. M. Milner. St. Paul, Minnesota: American Association of Cereal Chemists, 1969.

Sinha, D. P. and Bang, F. B. Seasonal variation in signs of vitamin A deficiency in rural West Bengal children. Lancet 2:228-231, 1973.

Smith, O. B. History and status of specific protein-rich foods: Extrusion-processed cereal foods. P. 140 in Protein enriched cereal foods for world needs, ed. M. Milner. St. Paul, Minnesota: American Association of Cereal Chemists, 1969.

Snodgrass, D. R. Economic aspects. Pp. 123-168 in Global malnutrition and cereal fortification, ed. J. A. Austin. Report submitted by Harvard University to USAID under contract AID Ita-c-1172 (June) 1977.

Snodgrass, D. R. Economic aspects. Pp. 97-128 in Global malnutrition and Cereal fortification, ed. J. E. Austin. Cambridge, Massachusetts: Ballinger Publishing Company, 1979.

Soekirmin. Indonesia. Pp. 129-168 in Nutrition and national policy, ed. B. Winikoff. Cambridge, Massachusetts: The MIT Press, 1978.

Solon, F. S., Fernandez, T. L., Latham. M. C., and Popkin, B. M. Research to determine the cost and effectiveness of alternative means of controlling vitamin A deficiency (xerophthalmia). Final report, Project No. NDSB-CIT 7305 FN, Cebu Institute of Medicine and Cornell University 1977.

Solon, F. S., Fernandez, T. L., Latham, M. C., and Popkin, B. M. Control of vitamin A deficiency in the Philippines. Planning, implementation and evaluation of a fortification program. J. Amer. Diet. Assn. 74:112-118, 1979.

Sommer, A., Faich, G., and Quesada, J. Mass distribution of vitamin A and the prevention of keratomalachia. Am. J. Ophthalmol. 80:1073-1080, 1975.

Sommer, A., Quesada, J., Doty, M. and Faich, G. Zerophthalmia and anterior-segment blindness among preschool age children in El Salvador. Am. J. Ophthalmol. 80:1066-1072, 1975.

Sood, S. K., et al. WHO sponsored collaborative studies on nutritional anaemia in India: I. The effects of supplemental oral iron administration to pregnant women. Quart. J. Med. 44:241-258, 1975.

Srikantia, S. G. and Reddy, V. Effect of a single massive dose of vitamin A on serum and liver levels of the vitamin. Am. J. Clin. Nutr. 23: 114-118, 1970.

Susheela, T. P. Studies on serum vitamin A levels after a single massive oral meal. Indian J. Med. Res. 57:2147, 1969.

Swaminathan, M. C., Susheela, T. P., and Thimmayamma. Field prophylactic trial with a single annual oral massive dose of vitamin A. Am. J. Clin. Nutr. 23:119-121, 1970.

Tunisia Report. Final report of Tunisian wheat fortification study. Boston: Harvard School of Public Health, 1977.

United Nations International Childrens Emergency Fund (UNICEF). World Health Organization Meeting on Prevention of Xerophthalmia. Reports of UNICEF, E/ICEF/NGO/132; E/ICEF/CRP/72-73, Hyderabad: (April) 1972.

U. S. Agency for International Development (USAID). Vitamin A, xerophthalmia, and blindness. Vol. I, II, III. Office of Nutrition (July) 1973.

Urrutia, J. J. Personal Communication, Boston, 1977.

Urrutia, J. J., et al. Case study: Guatemala. Pp. 165-166 in Global malnutrition and cereal fortification, ed. J. E. Austin. Cambridge, Massachusetts: Ballinger Publishing Company, 1979.

Urrutia, J. J., Garcia, B., Bressani, R., and Matta, L. J. Report of the maise fortification project in Guatemala. P. 28 in Improving the nutrient quality of cereals, ed. H. L. Wilcke. Washington, D. C.: U.S. Agency for International Development, 1976.

Vaghefi, S. B., Makdani, D. D., and Michelson, O. Lysine supplementation of wheat proteins. A review. Am. J. Clin. Nutr. 27:1231, 1974.

Vaughan, J. P., et al. Anemia treatment trials in a rural population of Tanzania. Trop. Geogr. Med. 29:369-373, 1976.

Viteri, F. E. Physical fitness and anaemia. Pp. 559-583 in Japanese malnutrition panel of the US-Japan cooperative medical science program, eds. N. Shimazono and T. Arakaiua. Tokyo: The National Institute of Nutrition, 1974.

Viteri, F. E. and Torun, B. Anaemia and physical work capacity. Clin. Haematol. 3:609-626, 1974.

Viteri, F. E. and Torun, B. Ingestion calorica y trabajo fisico de obreros agricolas en Guatemala. Bol. Of. Sanit. Panam. 78:58-74, 1975.

Wilcke, H. L., ed. Improving the nutrition quality of cereals. Washington, D. C.: Agency for International Development, 1976.

Winikoff, B., ed. Nutrition and national policy. Cambridge, Massachusetts: The MIT Press, 1978.

Wolf, W. J. and Cowan, J. C. P. 47 in Soybeans as a food source. Cleveland: CRC, 1971.

World Food Council (WFC). Report by WHO on possible programmes to combat endemic goitre, vitamin A deficiency and xerophthalmia, and nutritional anaemia. WFC/45. New York: United Nations (2 May) 1977.

World Health Organization (WHO). Nutrition Anaemias. Report of a WHO Scientific Group, WHO technical report series, no. 405. Geneva: WHO, 1968.

World Health Organization (WHO). Requirements of ascorbic acid, vitamin D, vitamin B_{12}, folate and iron. Report of a Joint FAO/WHO expert group, WHO technical report series, no. 452. Geneva: WHO, 1970.

World Health Organization (WHO). Nutritional anaemias. Report of a WHO Group of Experts, WHO Technical Report Series, No. 503. Geneva: WHO, 1972.

World Health Organization (WHO). Control of nutritional anaemia with special reference to iron deficiency. WHO technical report series, no. 580. Geneva: WHO, 1975.

World Health Organization (WHO. Vitamin A deficiency and xerophthalmia. Report of a joint WHO/USAID meeting. WHO technical report series, no. 590. Geneva: WHO, 1976.

Yong, S. H. Fortification technology. Pp. 45-100 in Global malnutrition and cereal fortification, ed. J. E. Austin. Report submitted by Harvard University to USAID under contract AID Ita-C-1172 (June) 1977.

Yong, S. H. Fortification technology. Pp. 43-73 in Global malnutrition and cereal fortification, ed. J. E. Austin. Cambridge, Massachusetts: Ballinger Publishing Company, 1979.

Nutrition Intervention in
Developing Countries

Study IV
FORMULATED FOODS

Jerianne Heimendinger
Marian F. Zeitlin
James E. Austin

Prepared by the Harvard Institute for International Development

Project Director, James E. Austin
Associate Project Director, Marian F. Zeitlin

Prepared for
Office of Nutrition
Development Support Bureau
U.S. Agency for International
Development

Oelgeschlager, Gunn & Hain,
Publishers, Inc.
Cambridge, Massachusetts

Copyright © 1981 by Oelgeschlager, Gunn & Hain, Publishers, Inc. All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means--electronic mechanical photocopy, recording or otherwise--without the prior written consent of the publisher.

International Standard Book Number: 0-89946-083-6

Library of Congress Catalog Card Number: 80-29235

Printed in the United States of America

Library of Congress Cataloging in Publication Data

Main entry under title:

Nutrition intervention in developing countries.

CONTENTS: v. 1 Study one, Supplementary feeding.--v. 2. Study two, Nutrition education.--v. 3 Study three, Fortification. Study four, Formulated foods.--(etc.)
1. Underdeveloped areas--Nutrition policy--Collected works. 2. Underdeveloped areas--Nutrition--Study and teaching--Collected works. 3. Underdeveloped areas--Food relief--Collected works. 4. Underdeveloped areas--Food supply--Collected works. I. Austin, James E. II. Zeitlin, Marian F.
TX359.N874 363.8'8 80-29235
ISBN 0-89946-083-6 (v.3)

This document has been prepared by a staff of professionals through the Harvard Institute for International Development under a contract with the Office of Nutrition, U.S. Agency for International Development. The purpose of this volume is to provide guidance to those interested in the development and implementation of programs directed at preventing malnutrition among preschool populations.

CONTENTS

Foreword..... viii

Preface..... x

CHAPTER ONE - OVERVIEW

I. Purpose and Organization..... 1

II. The Role of Formulated Foods..... 1

A. Key Questions..... 1
B. Summary..... 6

III. Forms and Usage..... 7

A. Key Questions..... 7
B. Forms and Nutritional Characteristics..... 7
C. Home and Village Production..... 8
D. Industrial Production..... 9
E. Summary..... 12

CHAPTER TWO - INTERVENTION DESIGN

I. Introduction..... 13

II. Nutritional Design..... 13

A. Key Questions..... 13
B. Calories..... 16
C. Protein..... 18
D. Essential Fatty Acids..... 19
E. Vitamins and Minerals..... 20
F. Nutritional Quality Control..... 20
1. Toxicity..... 22
2. Measures of Protein Quality..... 23
3. Tests of Tolerance, Acceptability, and Supplementation..... 23
4. The Quality Testing of Laubina..... 23
G. Summary..... 26

III. Raw Material Supply..... 26

A. Key Questions..... 26

CONTENTS (continued)

CHAPTER TWO (continued)

B. Sources 27
1. Oilseeds 27
a. Soy 27
b. Groundnuts 27
c. Cottonseed 28
d. Sunflower 28
e. Sesame 29
f. Coconut 29
2. Protein Concentrates 29
a. Wheat Protein Concentrate 29
b. Fish Protein Concentrate 30
c. Leaf Protein Concentrate 30
3. Other Fabricated Protein Sources 31
4. Legumes 31
5. Oil 31
6. Sugar 31
7. Dry Skim Milk 32

C. Supply Availability 32
D. Summary 33

IV. Processing 34

A. Key Questions 34

B. Home Processing 34
1. A Homemade Weaning Food in India 35
2. Homemade Recipes in Ethiopia and Sudan 35
3. Homemade Foods in Malawi, Sierra Leone, and Upper Volta 37

C. Village Processing 38
1. Hyderabad Mix 38
2. Nutripak 39
3. Poshak 40

D. Industrial Processing 41
1. The Technicalities 41
a. CSM 42
b. Superamine 42
2. Producers 43

E. Choosing the Appropriate Level of Processing 43
F. Summary 44

CONTENTS (continued)

CHAPTER TWO (continued)

V. Consumer Acceptability..... 46

A. Key Questions..... 46
B. Laubina..... 48
C. Poshak..... 48
D. Summary..... 49

VI. Distribution and Pricing..... 49

A. Key Questions..... 49
B. Transportation..... 51
C. Storage..... 51
D. Promotion..... 52
E. The Influence of Price..... 58
F. Summary..... 59

CHAPTER THREE - INTERVENTION EVALUATION

I. Introduction..... 60

II. Costs..... 61

A. Key Questions..... 61
B. Home Processing..... 61
C. Village Processing..... 62
D. Industrial Processing..... 62
E. Price..... 67
F. Summary..... 74

III. Effectiveness..... 75

A. Key Questions..... 75
B. Summary..... 78

CHAPTER FOUR - UPPER VOLTA CASE STUDY OF HOME-BASED COMMUNITY-LEVEL WEANING FOOD DEVELOPMENT

I. Introduction..... 79

II. Goals of the Case Study..... 79

CONTENTS (continued)

CHAPTER FOUR (continued)

III. The Upper Volta Setting 80

A. Nutritional Conditions 80
B. Health and Nutrition Services for Preschool Children . . 81
C. The Extension of Services by Village-Level Workers . . . 82

IV. The Case Study Survey 83

A. Survey Procedure and Sampling 83
B. The Data and Their Limitations 84
C. Survey Results 84
1. Sociodemographic and Dietary Information 85
2. Family Meals 85
3. Nutrition and Health Status of the Sample Infants . . 87
4. Differences in Intervention Design Characteristics Between the Yako and Koupele Programs 91
5. Measuring Intervention Effects 96
6. Knowledge of Bouillie 96
7. The Recipes 96
8. Attitudes, Perceptions, and Other Factors Affecting the Use of Weaning Food 97
9. Practices Regarding the Preparation and Consumption of Bouillie 98
10. Factors Significantly Related to Nutritional Status 99

V. Cost-Effectiveness Analysis 99

A. Marginal Costs 100
B. Cost Effectiveness 100
C. Malnutrition Averted 103

VI. Conclusions 106

A. Village-Level Services Cost Effectiveness 106
B. Teaching Weaning Food Development Through Village-Level Workers 107
C. Integrated Village-Level Health and Rural Development . 107
D. Message Content and Method of Presentation 108
E. Constraints to Effectiveness 109
F. Further Research Required to Solve Basic Problems . . . 109
G. Policy Guidelines for Weaning Food Development and Nutrition Education 110

CONTENTS (continued)

Appendix A: Formulated Weaning Foods..... 113

Appendix B: PAG Statements and Guidelines..... 127

Appendix C: Sociodemographic Data on Yako and Koupele..... 130

Appendix D: Yako and Koupele Survey Results..... 134

Appendix E: Analysis of Factors Significantly Related to Nutritional Status..... 148

Appendix F: Technical Appendix on Cost-Effectiveness Evaluation..... 161

References..... 168

FOREWORD

How do nutrition projects begin? How are specific interventions selected? Who makes the decisions and what is the rationale behind them?

Since such decisions relate to health or food policies of countries and have important implications for budgets, personnel and other resource allocations, it would be prudent that they be made only after careful study and analysis. Regrettably, this is not usually the case. More often than not, the choice is a subjective one.

Some interventions are undertaken because they seem "obvious." Since many others are doing it, it seems like the right thing to do, and there is unquestioned faith that it works. An approach may be fashionable at a given time period. A particular activity may be promoted by an external agency. There may be very attractive offers, such as free food or technical assistance, or a start-up grant.

To the degree that costs are considered, there is usually concern only with what funds are needed to cover immediate and direct costs. The indirect or hidden costs, which may be much greater, are overlooked. Project staff time may be charged to other budgets. The implications for an increased demand on energy or scarce materials may not be considered. There is a tendency to forget overhead costs such as those for the use of buildings or for heating, cooling, and lighting.

Social costs are even more often ignored. Some projects accelerate a change away from traditional practices such as breast-feeding or using natural foods or cultivating home gardens. A project may encourage a welfare mentality, reduce incentives to work, or create lasting demands for convenience foods where packaging and processing may forever raise the price of a food. Obsessed with political needs, decision makers may not be concerned with long-term consequences, such as the problem of terminating a popular service when it is no longer needed.

Too often these kinds of questions are not addressed, resulting in only marginal effectiveness for many projects. An apparently "good project" (that is, one which is scientifically sound, well organized, etc.), will bring disappointing results if it is aimed at a problem it is not designed to deal with. This in turn can lead to a dilemma of whether to continue a project while lacking confidence in it or to terminate it and admit failure. More often, projects go on and on without bringing results but without any objective evaluation or analysis.

Avoiding these problems requires accurate identification of problems, insightful analysis of causation, and a good understanding of interventions in terms of how they work, what they cost, what they achieve, what other consequences they bring, and what preconditions should be present before a particular intervention is selected.

To help deal with the question of intervention selection, the U.S. Agency for International Development commissioned Harvard University to prepare a series of Special Studies dealing with supplementary feeding, nutrition education, formulated foods, food fortification, consumer price subsidies, agricultural production, and integrated programs. Together the separate pieces comprise a manual intended to provide guidance on selecting from alternative approaches to reach the preschool child. We hope this effort contributes to improving the process of intervention selection, and thereby, to more effective prevention of malnutrition.

Martin J. Forman
Director, Office of Nutrition
U.S. Agency for International
Development
Washington, D.C. 20523

PREFACE

This study on formulated foods is one of seven special studies examining the major types of nutrition programs operating in developing countries. Two of the other studies, Supplementary Feeding (Study I) and Nutrition Education (Study II), are closely linked with formulated foods. Thus, the reader is urged to review those studies in conjunction with this one. The remaining studies cover fortification, consumer price subsidies, agricultural productivity, and integrated programs.

The purpose of this series is to provide guidance to planners in developing countries and international development agencies on the nature and design of these major types of nutrition interventions. The lack of knowledge about intervention design, costs, and effectiveness, was cited by the National Academy of Sciences in its 1976 World Food and Nutrition Study as a major impediment to efforts to reduce the malnutrition problem. Our work, which was carried out for the Office of Nutrition of the U.S. Agency for International Development, is an attempt to help close that knowledge gap.

We have tried to make a partial assessment of the "state of the art" of nutrition interventions through a review of published and unpublished literature, a mail survey of 200 nutrition projects in 64 developing countries, interviews with professionals from many disciplines and institutions involved in nutrition programming, and direct field analyses of selected nutrition programs. From these multiple sources and voluminous data, we have attempted to present a representative picture of each nutrition intervention. A commonly cited difficulty for planners, especially in developing countries, is ascertaining what is going on elsewhere and obtaining factual information on the many facets of designing a nutrition program. We have attempted to alleviate that problem by providing fairly complete, although not exhaustive, documentation and supporting references. Such attention to detail is needed when one is actually going through the intervention design process. However, not all readers will need to immerse themselves in this detail. To facilitate their use of the studies, we have preceded each subsection with a set of Key Questions that are addressed therein. At the end of each subsection we have presented a short Summary of the major points observed. Both the Questions and Summary sections are blocked off to facilitate the readers' scanning the document and identifying those parts which are of most interest to them.

Despite our efforts for completeness and our intense desire to provide useful guidance, the relative paucity of reliable evaluative data on nutrition programs and the limitations of this work leave us far short of the ideal. It has not been possible to verify the quality of the data or research designs presented in most of the literature we reviewed. Our analyses and suggestions should be viewed as tentative, subject to further verification. It is hoped that these documents will facilitate such future evaluative efforts and that this study and the others in the series will at least provide a firmer foundation upon which others can build.

This study on formulated foods has benefited from the collaboration of many individuals. Bo Wickstrom, Elizabeth Orr, Max Milner, and Neil Wilkie reviewed the manuscript and provided many invaluable suggestions. The authors are also grateful for the comments of the HIID Expert Review Panel. The case study in Upper Volta on home-mixed formulated foods would not have been possible without the excellent cooperation of Dr. George Sempore, Head of the Nutrition Cell in the Ministry of Rural Development; Dr. Emile Gouba, Head of the Nutrition Cell in the Ministry of Health; Dr. Francois Gourier, District Medical Officer - Yako Subsector; and John A. Hoskins, Mission Director - USAID. The document was also enhanced by the editing services of Elizabeth Duvall, Ellen Goldberg, and Karen Mifzner, as well as the administrative assistance of Thomas Belding, Melanie Mahin, and many other members of the HIID staff. The financial and technical support of the AID Office of Nutrition was also essential, as was the original vision of Dr. Martin Forman whose initial guidance was invaluable to the realization of this study.

On behalf of my colleagues and coauthors, Jerianne Heimendinger and Marian Zeitlin, I express our deep appreciation for the efforts of all these individuals and institutions. It is our fervent hope that this collective undertaking assists others in more effectively addressing the pressing problems of global malnutrition.

James E. Austin
Project Director
Cambridge, Massachusetts

CHAPTER ONE

OVERVIEW

I. PURPOSE AND ORGANIZATION

The purpose of this study is to provide the reader with a greater understanding of the characteristics and potential of formulated foods as a nutrition intervention in developing countries. More specifically, the document attempts to specify the principal considerations relevant to designing and employing such an intervention.

This first chapter discusses the role of formulated foods in confronting the malnutrition problem and also describes the common forms the intervention takes and the extent to which countries have utilized it. Chapter Two is the heart of the study, as it sets forth the main intervention design considerations based on an assessment of reported experience. Chapter Three presents evaluative data on the costs and nutritional impact of past formulated foods efforts. The final chapter is a case study of a formulated food program in Upper Volta, illustrating some aspects of the intervention design and evaluation methodology.

To facilitate use of the chapters, each subsection is preceded by a listing of the key issues to be addressed and is followed by a summary. Thus, those readers interested particularly in certain aspects can more readily find those areas and delve more carefully into the detail presented in them. Such detail is relevant to the more specific tasks involved in designing a program. Furthermore, we have included abundant references because other information sources are often difficult for planners and researchers in developing countries to find. A partial subject index is provided at the end of the monograph to increase usability.

II. THE ROLE OF FORMULATED FOODS

A. KEY QUESTIONS

- What are formulated foods?
- What is the rationale for their use as a nutrition intervention?

The term "formulated foods" as used in this study refers to nutrient dense supplements based largely on mixtures of vegetable protein and designed to meet the growth needs of weanling children in deprived populations. Ingredients may be grains or staple starches, oilseeds, legumes, protein isolates or concentrates, fats, vitamins, minerals, and sometimes nonfat dry milk or other sources of animal protein. Milk substitutes and milk-based commercial products such as Similac and Enfamil are excluded from this definition. Formulated foods may vary markedly in nutrient composition, depending on the diets they are designed to complement.

Processing ranges from simple home-based procedures (Yako's bouillie), to village intermediate-level technology (Nutripak), to industrial processing (Incaparina). Formulated foods can be delivered through public or private, nonprofit or commercial channels. Accordingly, the definition focuses on the physical characteristics of the product and methods for its formulation. The delivery system is a separate design issue, but one which influences strongly the effectiveness of the product.

Historically, the major emphasis in the development of formulated foods was placed on protein content because the high prevalence of protein-calorie malnutrition (PCM) was attributed primarily to insufficient protein in the diet. The literature strongly reflects this focus, and formulated foods are referred to variously as protein-rich, high-quality protein, plant protein, blended, or nutrient-dense foods. The latter appelation is more descriptive of recent trends to de-emphasize protein and recognize the importance of achieving a balance of nutrients. Thus, calories and micro-nutrients have emerged from the background into more prominence.

In the 1950s, maldistribution of high-quality animal protein was identified as a major problem and the U.N. Protein Advisory Group was organized to guide the development of remedies (PAG Statements No. 20 and 25). Of the populations affected, the most vulnerable were weanling infants of low-income families in developing countries, who received insufficient quantities of both proteins and calories. Milk and other animal proteins were and remain largely unavailable to these infants. The question arose as to what appropriate alternative food sources might be used.

Attention turned to the possibility of mixing vegetable proteins, and the idea of a blended or formulated food was born. The basic rationale for formulated foods was their ability to meet the special nutritional requirements of weanling infants which generally could not be satisfied by the traditional diets because of economic restrictions, food habits, or physiological constraints. One basic element in the concept is the theory that amino acid patterns in staple cereal grains can be improved by mixing them with other complementary protein sources, such as oilseeds and pulses. Such a combination can provide a protein roughly comparable in quality to milk protein. Beans and rice, corn and beans, and the Middle Eastern dish "hummos" with wheat bread are examples in common dietary practice. Thus, the new formulated foods utilized protein sources consisting of locally acceptable staples and unconventional sources, such as oilseed press cakes, commonly discarded or fed to animals. Expectations were that the resultant weaning foods would be less expensive than, yet similar in protein quality, to animal protein.

The reason for focusing on the weaning age (which usually ranges from six months to 2.5 years) was the high prevalence of severe PCM at this critical juncture in a child's life. Breast milk is nature's well-designed infant food, adequate (assuming the mother is well nourished) until approximately six months of age, at which time the child requires more diverse food supplements for growth. During this critical growth phase, a young child needs two to three times as many calories and proteins as an adult, per kilogram of body weight. (See Table 1 and the section on Nutritional Design.)

The weanling infant is particularly vulnerable to PCM for a variety of reasons, including deleterious weaning practices, food taboos, intrafamilial food distribution, and bulk constraints (i.e., the bulkiness of the food exceeds the child's stomach capacity - the nutrient density is too low). For example, a child may be given almost nothing other than breast milk for the first year or two. Alternatively, an infant is frequently taken off breast-milk abruptly and either transferred directly to the unmodified adult diet, as in Sudan, Somaliland, and Saudi Arabia (Brown 1977), or fed only a thin gruel made from the local staple, such as rice, millet, or cassava. Use of the adult diet as a weaning food is desirable <u>if</u> nutrient density is adequate and the food is made easily digestible; however, these two conditions are frequently not satisfied.

Ideally, the breast milk supply should be maintained at as high a level as possible by frequent demand feedings well into the child's second year. In addition to receiving breast milk, the child should be gently and gradually introduced, beginning around six months of age, to well-cooked, mashed, and chopped nutritious foods. The infant needs time to adjust to the mechanics of chewing, new tastes and textures, and non-sterile fare. According to Cameron and Hofvander (1976):

> One of the greatest dangers of the weaning period can be the results of the changeover from sterile breast milk and its anti-infective factors to animal milk and semi-solid and solid foods, often acquired, stored, and fed in unhygienic and unsanitary fashion. In fact, the weaning process is associated with the highest rate of infection, particularly of the gastrointestinal tract, that the child will encounter in its entire lifetime.

The resultant "weanling diarrhea" may easily precipitate PCM or death if not handled properly. (See Cameron and Hofvander, page 28, for further discussion.)

Mothers frequently do not recognize their infant's special nutritional needs at the weaning age and are not in the habit of preparing special foods for the child. In addition, various taboos may deny children more nutritious available products. For example, some children in midwest Nigeria are not given eggs, milk, and meat because it is believed that they may later steal to satisfy their acquired tastes for these expensive foods (Ogbeide 1974). In some areas of Haiti, people

TABLE 1

RECOMMENDED DAILY INTAKES FOR INFANTS AND YOUNG CHILDREN

Age	Months				Years			
	< 3	3-5	6-8	9-11	1	2	3	4
Weight (kg):	4.6	6.7	8.3	9.6	11.4	13.6	15.6	17.4
Energy:								
kcal/kg	120	115	110	105				
kcal/day			915	1,000	1,180	1,360	1,560	1,720
Protein:								
g/kg*	2.4	1.85						
g/day**			14	14	16	16	16	20
Vitamin A (ug)	***	***	300	300	250	250	250	300
Vitamin D (ug)	10	10	10	10	10	10	10	10
Vitamin C (mg)	20	20	20	20	20	20	20	20
Thiamine (mg)	***	***	0.36	0.4	0.47	0.54	0.62	0.69
Riboflavin (mg)	***	***	0.50	0.6	0.65	0.75	0.86	0.95
Niacin Equivalents (mg)	***	***	6.0	6.6	7.8	9.0	10.2	11.4
Folate (ug)	40	40	60	60	100	100	100	100
Vitamin B_{12} (ug)	0.3	0.3	0.3	0.3	0.9	0.9	0.9	1.5
Iron (mg)	***	7	7	7	7	7	7	7
Calcium (mg)#	***	***	550	550	450	450	450	450

*This protein is equivalent to breast milk protein.

**This protein is the safe level of high-quality protein as calculated by FAO/WHO. See Cameron and Hofvander for calculations of requirements based on diets of lower-quality protein, useful for field application.

***Breast-feeding is assumed to be adequate if the mother is well nourished and her calcium intake is 1200 mg per day.

#Variances are noted with other sources. See also: FAO/WHO (1973), Energy and Protein Requirements and FAO (1974) Handbook on Human Requirements.

Source: Cameron and Hofvander 1976.

believe that eggs turn children's teeth black and that meat causes worms (Rawson and Berggren 1973). In some parts of India, "cold" foods such as cow's milk, water, bananas, and grains are not given to children in monsoons or cold weather for fear of ill effects (Shah 1975; Patodi et al. 1976).

Intrafamilial food distribution practices may also work to the detriment of the infant, not yet able to fend for himself. For example, in some parts of Nigeria, the head of the family and other men in the household are served first, then women, and finally children under thirteen. Similar patterns are true for parts of Kenya, Zambia, Pakistan, Indonesia, Guatemala, and many other countries (den Hartog 1972). Thus, if any animal products are available to the family they are usually eaten by the men. The results of such practices have been documented in surveys such as the 1962 National Nutrition Survey of Ghana, which indicated that in the forest zone, adults received nearly sufficient quantities of protein. Children, however, lacked 30% of their requirements, and the very young lacked 50% (den Hartog 1972).

Finally, the human weanling faces another limitation called the "bulk constraint." According to Jelliffe (1970), the stomach capacity of a six-month-old child is 5 to 7 ounces or 150 to 200 grams. But starch in cereal grain gelatinizes in the cooking process, trapping water, expanding the grain, and decreasing the concentration of nutrients per volume or weight. For a one year old to meet his protein requirements by consuming a rice staple, he must eat 1,230 grams (about five 8-ounce cups) of cooked rice. Since this amount is more than he can comfortably hold, he does not get enough to eat to support growth.

Questions have been raised as to whether bulk is a true physiological constraint or a variable associated with frequency of feeding or taste appeal. B.M. Nicol examined the bulk constraint concept in 1967. He determined that children aged four to six years could eat enough of a sorghum, rice, or millet staple to meet their calorie and protein needs, if it were fed in four meals. But he felt that children eating a starchy root staple in West Africa already consumed as much as they could (1,250 ml), yet needed additional intake to meet energy and protein requirements. Nicol presents no evidence that a physiological limit had been reached, but states emphatically that "such children cannot eat that amount of unattractive low-protein food, even if it can be, by a stretch of the imagination, divided into many meals a day."

As Nicol points out, a number of things affect the amount of food people can eat, including frequency of meals, taste appeal, and form of the food. Apparently, if fed from four to six times a day, a child might be able to consume enough of the grain staples, depending on how many nutrients were lost in cooking. However, there is some evidence that children may just not care to chew and swallow such quantities day after day. In a trial of the effectiveness of a corn-soy-wheat noodle in recuperating malnourished Brazilian children, Beghin and co-workers (1973) found the caloric intake of the experimental group to be problematic. Their low calorie intake was attributed to high amounts of noodles in their diet

(68.9% of the protein intake in ages one to four). The average consumption of noodles was 121 grams. According to Nicol's calculations, presented above, more could have been consumed. Beghin and co-workers do not mention a bulk constraint, but assume that satiety caused by the bulk of the noodles precluded higher intake.

Clearly, the etiology of the bulk constraint would profit from more exploration. Nevertheless, the bottom line is clear. Whether the cause is physiology, frequency of feeding, or ennui, the child, especially the weanling child, is not receiving sufficient quantities of nutrients. Nicol concludes:

> Due to the method of food preparation and the spacing of meals, the younger post-weaning children will have some trouble in any ecological zone in "stomaching" enough of the local diet to meet their calorie and protein needs, particularly in areas where starchy tubers are staple foods. ...Therefore the writer considers it best, if one is thinking of preventing juvenile malnutrition in developing areas, to develop fully formulated foods, preferably from locally available foodstuffs. ...They should be properly balanced (emphasis added) in respect of protein and calories which will probably require some concentrated form of energy such as oil or sugar to reduce volume, and contain vitamin/mineral mix.

Thus formulated foods have attempted to address the economic restrictions, food habits, and physiological constraints which adversely affect a weanling child and have been shown to be effective in treating PCM when consumed. Furthermore, the technical and administrative feasibilities of producing them industrially, in village shops, or in the home have also been documented. Nonetheless, deficiencies in their distribution and particularly their price when they are sold, unsubsidized, through commercial channels have severely limited their consumption by the neediest groups. With proper design of the economic aspects of the intervention, its potential contribution appears significant.

B. SUMMARY:

ROLE OF FORMULATED FOODS

In summary, the rationale for formulated foods is that they are designed with high nutrient density to meet the urgent growth needs of the weanling child. These foods either fill a gap in many countries where no concept of weaning foods previously existed or where the quality of foods needs improvement, or they replace imported commodities, such as nonfat dry milk, sold or distributed to mothers

and infants. Industrially produced formulated foods cost less than sources of high-quality animal protein and may utilize vegetable ingredients that were previously fed to animals, or discarded, or not eaten by this age group.

An advantageous feature of formulated foods is that they may be specifically targeted to the weanling child, who often does not receive an adequate supply of nutrients because of deleterious weaning practices, food taboos, intrafamilial food distribution, and bulk constraints. The intervention has had serious difficulties with distribution and price, but does have the potential for preventing and treating protein-calorie malnutrition (PCM) in preschoolers if systems can be designed to ensure access and consumption of these weaning foods by the target group.

III. FORMS AND USAGE

A. KEY QUESTIONS

- What physical forms do formulated foods take?
- What are their general nutritional characteristics?
- What is the extent of home and village production? Of industrial production?

B. Forms and Nutritional Characteristics

Formulated foods come in different shapes, sizes, textures, and physical forms. Nutrient content varies depending on form and intended usage. Beverages range from 2% to 15% protein; biscuits, cookies, and pastas from 8% to 17%; and soup mixes and weaning flours (to be used either as beverages or porridges) from 10% to 51%. The average weaning food contains about 20% to 30% protein and 350 to 400 kilocalories in a 100-gram dry portion. Thus, if a one-year-old child eats 100 grams of dry weaning food, prepared by mixing it with a liquid, he would consume slightly more than his daily requirement of protein and one third of his calorie requirement.

The forms of nutrient-dense foods vary with the type of processing chosen. Foods produced at home or in the village are likely to be in familiar forms, such as ground grains and pounded or mashed legumes, combined to make a flour. A gruel is prepared by adding water to the flour and cooking for 10 to 15 minutes. For foods that are industrially

processed, a diversity of forms is more likely, including beverages (Saci, Vitasoy, and Miltone), breads (Baladi Bread, Modern Bread), biscuits (Kupugani Biscuits, Milk Biscuits), pasta (Nutri-Noodle, Golden Elbow Macaroni), soup mixes (Mung Instant Soup Mix), and powdered weaning foods (Faffa, Superamine, and Peruvita). At all processing levels, protein isolates and concentrates and vitamin and mineral premixes can be added if desired. Isolates have been mixed with other ingredients to form such commercial products as Carne Vegetal (Brazil), Banana Soy Beverage (Israel), and Proteimax (Brazil). See Appendix A for a tabular presentation of formulated foods, their content, form, manufacturers, and prices.

The trend in the form of industrially processed and commercially distributed foods is toward more textured and instant products. Advantages are convenience to the homemaker, sometimes improved palatability or nutrient quality, and less chance for nutrient loss in home preparation. A major disadvantage of instant foods is the high probability of reconstitution with contaminated water, which may make the child ill.

The introduction of any new food will have to be accompanied by a certain amount of nutrition education. The promotion of home-made "multimixes" is primarily dependent on such an intervention and is illustrated in the case study in Chapter Four (also see Volume II, Nutrition Education, Zeitlin and Formacion).

C. Home and Village Production

Multimixes for home and village-level production are promoted in many countries, but we do not have a good estimate of how extensive this phenomenon is. Some of the products mentioned in the literature include Hyderabad Mix and Poshak (India), Likuni Phala (Malawi), Bennimix (Sierra Leone), Nutripak (Philippines), Isma and Niama (Sudan), Kitobero (Uganda), and a sprinkling of unnamed multimixes in Ethiopia, India, Gambia, Upper Volta, and Chile (Chaudhuri 1964; Selinus 1970; Shah et al. 1971; El-Shazali 1972; Barja et al. 1974; Gopaldas et al. 1974; Pak et al. 1975; Mathur and Madhavi 1976; Zeitlin 1976a; Agriculture Abroad 1977; Kapsiotis 1977).

As of 1976, the outreach of Nutripak from 18 plants was 20,000 preschoolers or about 4% of the target group. By 1977 there were about 90 plants in operation (Ropes 1977). Approximately 7,000 children in selected villages of the Chevalla Block of Hyderabad District have been reached with Hyderabad Mix (Indo-Dutch Project for Child Welfare, n.d.). During acceptability trials on Likuni Phala, beginning in February 1977, a total of 11,625 persons of all ages received the food over varying periods of time (Jones 1977). However, this number cannot be used to reflect normal usage since distribution was made from a trial sample manufactured specifically for the acceptability tests, and portions distributed were frequently suboptimal (40 grams per person). It can only be assumed that the remaining products mentioned have small localized distribution. Some, such as Bennimix and Likuni Phala, are being considered for larger-scale production.

D. Industrial Production

In her 1972 report, Elizabeth Orr estimated annual formulated foods production capacity for 21 plants in developing countries for which she had information at 62,000 metric tons. Production figures extracted from her 1977 report estimate actual production at 72,240 metric tons for 13 plants (see Table 2). These figures omit the popular beverages like Vitasoy, U.S. production of products such as Corn-Soy-Milk (CSM) and Wheat-Soy-Blend (WSB), and any estimate of home or village production. As of 1970, well over 450,000 metric tons of CSM had been distributed in 90 countries. Production capacity for products like CSM and WSB exceeds 100,000 tons per year (LIFE 1973). In fiscal year 1975, the United States provided 170,000 tons of Corn-Soy-Blend (CSB), CSM, and WSB through its donated food aid programs (USDA 1977). However, since our focus in this study is on formulated foods produced within developing countries rather than on imports, U.S. products will not be discussed in detail.

According to Elizabeth Orr's 1972 calculations, the potential production capacity of 62,000 metric tons of products that averaged 29% protein, represented 17,890 tons of crude protein or 11,687 tons of usable protein (assuming an average biological value of 65). This would provide 6.7 million children, aged one to three, with one third of their protein requirement for one year. Estimates of children in need of food supplements range from 100 million (U.N. Economic and Social Council 1971) to 250 million (Berg 1973). Thus, at this level of production, formulated foods could reach only 3.5% to 7% of this target population, even if delivered with 100% efficiency.

Table 3 presents estimates of world production from several sources. Formulated foods are used or manufactured in over 78 countries. Approximately 126 products, using 24 ingredients, have been attempted by over 100 different producers (LIFE 1973). Orr (1977) estimates that only 35 of the 60 schemes she mentiones are in regular production. Most are located in Africa and Latin America, with fewer in the East. India is an exception, with a number of foods being produced. A few foods, such as Protea (Indonesia), Vitabean (Singapore), and Nutro Biscuits (India), have been in existence since the 1950s. Vitasoy has been in production since 1940. Incaparina (Guatemala) and Kupugani Biscuits (South Africa) began regular production in 1961. Products of the 1970s have included foods such as Supramine (Egypt), Milk Biscuits (Zambia), Sekmama (Turkey), and Uni-Protein Biscuits (India). Products like Maisoy (Bolivia), Leche Avena (Ecuador), and Nutrebien (Panama) are in exploratory stages.

Other processed foods have been produced by private manufacturers in various forms (for example, baby cereals, filled cheese). However, these have been marketed privately primarily to middle and upper income segments rather than being conceived of, and distributed, for the purpose of supplementing poor diets or alleviating malnutrition among low-income, malnourished families. We do not include the commercially produced and distributed infant formula products in our definition of formulated foods

TABLE 2

ESTIMATED ANNUAL PRODUCTION OR SALES OF INDUSTRIALLY PROCESSED FORMULATED FOODS

Product	Country	Annual Total Production (MT)
Superchil and Fortesan	Chile	16,000
Colombiharina	Colombia	40
Duryea	Colombia	1,000
Bienestarina	Colombia	5,000*
Incaparina	Guatemala	2,000
Faffa	Ethiopia	1,500
Super Maeu	Mozambique	2,400
Pronutro	South Africa	2,000**
Superamine	Algeria	800
Supramine	Egypt	300
Special Weaning Food and Ready-to-Eat Snacks	India	700**
Nutri Nugget, Protesnac, Protein Plus, Shaktiahar, and Paushtikahar	India	500
Bal-Ahar	India	40,000
Total		72,240***

*The figure for Bienestarina is the 1975 initial production figure, which may not be a good estimate of annual production.

**This is an estimate.

***The source for these data included estimates of both sales and production. The total production tally of 72,240 MT includes annual sales figures for products with no total production figures (Colombiharina, Duryea, Incaparina, and Super Maeu). Thus, total production for these four products may be underestimated in this table.

Source: Calculated from figures in Elizabeth Orr (1977).

TABLE 3

GLOBAL PRODUCTION OF FORMULATED FOODS

Source	No. of Countries	No. of Schemes	Terminated	Regular Production	Exploratory	Annual Production (metric tons)
Orr 1972	36	69	12	33 (+4 irregular, +1 unknown)	19	62,000 (for 21 plants)
Orr 1977	21	60	13	35 (+5 irregular)	7	72,240 (for 13 plants)
LIFE 1973	78	126	--	--	--	--

Note: This analysis excludes U.S. production of such products as CSM and WSB and popular beverages such as Vitasoy.

because they are milk or milk-substitute products aimed at the infant rather than the weanling child. Consequently, the issues surrounding infant formula and breast-feeding are not discussed in this study.

Of 37 extant schemes discussed in the literature, five are distributed entirely through retail outlets; 12 use only institutional channels, and 20 employ both. The majority of producers of commercial formulated foods are private companies. A few are state-owned or partnerships with government. Research organizations and universities have played a role in developing formulas and safety testing. Most of the impetus for production and financing has come from international agencies, such as the United Nations, the U.S. Agency for International Development (AID), the Institute of Nutrition for Central America and Panama (INCAP), and others. (See Orr 1972 for more detail.)

E. SUMMARY:

FORMS AND USAGE

Formulated foods appear in various shapes, sizes, and textures. The range includes beverages, breads, biscuits, cookies, pasta, soup mixes, and powdered weaning foods that are cooked as porridges or gruels. Products prepared in the home or village are most likely to be in common forms such as breads, flours, or porridges. Industrially processed foods generally have a wider variety of forms. The typical formulated weaning food contains about 25% protein and 375 kilocalories per 100 grams dry weight.

Home-formulated mixes and village-processed foods are used in many countries, but data are not available to quantify global usage. Indications are that production of formulated foods at this level is a growing and promising trend. Industrially processed formulated foods, manufactured in 78 countries, have received more attention. Nonetheless, the nutritional significance of this output in developing countries is small, with current production capacity having a potential of reaching only 3.5% to 7% of those in need. Inclusion of blended foods produced in the United States and distributed through food aid programs triples this potential coverage figure.

CHAPTER TWO

INTERVENTION DESIGN

I. INTRODUCTION

Designing a formulated food intervention requires decisions about nutrient content, raw material supply, processing, consumer acceptability, distribution, and pricing. Nutrition education, which is an indispensable accompaniment of formulated food programs, is discussed separately in the nutrition education study.

II. NUTRITIONAL DESIGN

A. KEY QUESTIONS

- How should you ascertain the nutrient needs of the target group?
- What are the appropriate levels of and balance between caloric and protein content in the formulated foods?
- What are the main protein quality considerations?
- What vitamins and minerals should be added?
- How do you control the nutritional quality of the formulated foods?

The supplemental food should be designed to satisfy the unmet nutrient needs of the target population. Therefore, it is necessary to know the existing consumption patterns of the families served, which may be obtained through direct observations and dietary surveys. National food consumption data derived from food balance sheets should not be relied upon as the basis for designing a nutrient-dense food, since they mask the variance in food distribution and overestimate consumption by the poorer populations. (For further discussion, see Mauron 1975, and Reutlinger and Selowsky 1976.) A household dietary survey with special emphasis on the consumption of the weanling child is necessary; household food consumption and 24-hour dietary recall data may be collected from sample households in the population.

Reference may be made to the PAG Guideline Number 8 (1971) as a starting point for designing the nutrient profile of the formulated food. These guidelines, with some modifications incorporated by the authors, state that:

- the Net Protein Utilization (NPU) should not be less than 60 and preferably nearer 65 (the standard, cow's milk, equals 80)

- the Protein Efficiency Ratio (PER) should be not less than 2.1 and preferably above 2.3 (the standard, casein, equals 2.5)

- caloric density per volume of the food in the weakest dilution in which it is consumed should be at least as high as breast milk, or about 75 calories per 100 grams, and should be higher if feasible

- the products should contain adequate nutritive density with high protein availability, low fiber content, and low water retention capacity ("bulkiness")

- a level of fat contributing about 25% of calories is desirable

- linoleic acid content should be at least 1% of calories

- the foods should be fortified with vitamins and minerals, especially A, riboflavin, niacin, folate, thiamine, pyridoxine, B12, ascorbic acid, D, calcium, iron, iodine and zinc

- sugar is permissible if it enhances acceptability.

The recommendations of the Protein Calorie Advisory Group of the United Nations System (PAG) for total nutrient composition of formulated foods are attached as Table 4. (See Appendix B for a listing of PAG statements and guidelines.)

These guidelines must be adapted to the peculiar needs and tastes of the target groups. For example, foods designed to fill small nutrient deficits will be less nutrient dense than those designed for more inadequate diets. Sugar, flavorings or salt have been added frequently to make the food acceptable to both the mother and the child. It is easy to increase caloric density by additions of fat and/or sugar. Both, however, should be used prudently, with consideration given to short- and long-term health effects as well as the cost implications of the dietary habits being created. The emphasis should be on a proper balance of nutrients, and enthusiasm for the beneficial effects of one particular nutrient should not make intervention designers short-sighted. In the United States the tendency is to use less salt, sugar and other condiments in weaning foods, recognizing their deleterious health effects.

Attention must be paid to the nutrient density of the foods, so that the target child can comfortably eat enough to satisfy nutrient requirements. If new ingredients are being combined, potential toxicity must be carefully assessed.

TABLE 4

GUIDELINES FOR COMPOSITION OF FORMULATED FOODS EXPRESSED ON DRY WEIGHT BASIS PER 100 g

Protein	≥ 20 g*
Fat	≤ 10 g
Crude fiber	≤ 5 g*
Moisture	5-10 g
Total ash	≤ 5 g
Acid-insoluble ash	≤ 0.05 g
Vitamin A	1300 I.U. (400 mcg retinol equivalent***)
Thiamine	0.3 mg
Riboflavin	0.4 mg
Niacin	5.0 mg
Folate	0.2 mg
Vitamin B_{12}	2.0 mcg
Ascorbic acid	20 mg
Vitamin D	400 I.U.
Calcium	300 mg
Iron	10 mg
Iodine	100 mcg

*This protein level assumes an NPU not less than 60 and a PER not less than 2.1. If these values are higher, the level of protein may be reduced accordingly. Issue may be taken with the level suggested here. Protein content of such mixtures rarely exceeds 20%.

**Crude fiber higher than this may be acceptable, although it would require clinical testing.

***The values for vitamins A and minerals are considered minimal, except for vitamin D, where no further increase is desirable. In some cases, addition of B_6 and vitamin E should be considered.

Source: WHO 1974.

Finally, an important design consideration is the context in which the food will be used. It is meant to supplement a basic diet and provides only a portion of required nutrients, but a safety margin for leakages (for example, sharing with other family members, or substitution for previously eaten foods) will be necessary if the food is expected to have any measurable impact on growth, morbidity and mortality. These margins will depend on answers to a number of questions. How might availability of nutrients be affected by processing or food habits? For example, what losses might occur in the village grinding process, spray drying in the factory, or cooking practices in the home? How might absorption of nutrients be affected by endemic infections?

Foods are often watered down to stretch further, shared with the whole family, or used to substitute for rather than supplement a child's basic consumption. Most attempts to change this "misuse" have centered on educating the consumer. An alternative course of action is to modify nutrient design, as was done by the Department of Nutrition Research in Tamil Nadu (Pereira and Sundararaj 1975). The reasearchers increased the nutrient density, especially the calories, of the supplement fed to children aged two to five years, to compensate for the substitution that they knew was occurring. Pereira and Sundararaj felt that the increase in cost was justified by improvement in the rate of growth of the children, which was not seen at lower levels of supplementary feeding.

A closer look at design considerations for the individual nutrients (calories, proteins, essential fatty acids, vitamins and minerals), as well as a discussion of quality control, follows.

B. Calories

The trend in formulated foods in the last several years has been to increase caloric content and decrease the emphasis on protein. Naismith (1973) concluded that protein deficiency in Yoruba tribes was caused by a severely restricted food intake rather than by poor protein content of the foods consumed. Gershoff and co-workers (1977) found food intake to be the limiting growth factor in two of three experimental Thai villages. There are, of course, instances in which calories are not limiting. However, the point here is that caloric content has been underemphasized, and that "energy and protein needs should be considered together in planning for the nutritional improvement of populations whose diets are deficient in either" (FAO/WHO 1973).

The average calorie content of most formulated weaning foods has been around 375 kilocalories per 100 grams (dry weight), which is only about 40 kilocalories higher than ordinary cornmeal or wheat flour. However, a cooked corn porridge which might be used as a weaning food has only half as many calories as a cooked formulated weaning food of the same consistency, mainly because the formulated food has about ten times more calorie-dense fat than the cornmeal (see Table 5).

TABLE 5 - MACRONUTRIENT CONTENT OF STAPLES AND FORMULATED FOODS**

(In 100 g edible portion)

Food	Kcal (g)	Protein (g)	Fat (g)	Carbohydrate (g)
Prototype Industrially Processed Formulated Food (dry)	400	20.0	10	60
Prototype Industrially Processed Formulated Food (cooked)	100	5.0	2.5	15
Degermed, Unenriched Cornmeal (dry)	364	7.9	1.2	78.4
Degermed, Unenriched Cornmeal (cooked)	50	1.1	.2	10.7
Unenriched White Rice (dry)	363	6.7	.4	80.4
Unenriched White Rice* (cooked)	109	2.0	.1	24.2
Whole Wheat Flour (dry)	333	13.3	2.0	71.0

*Drier-stiffer consistency than cornmeal.

**Food values taken from U.S. Department of Agriculture, 1963.

Energy intake may affect protein metabolism in two ways. A slight reduction in energy intake below requirement slows the growth rate in children and a severe calorie deficit impairs utilization of dietary protein. In young rats whose growth rate is limited by inadequate calorie intake, increasing the percentage of dietary protein above ordinary requirements is ineffective in stimulating growth (FAO/WHO 1973). This finding implies that both protein and calorie needs must be addressed simultaneously to restore normal growth patterns in malnourished children.

C. Protein

Scrimshaw (1978a) has suggested that preschool children in LDC's may require a higher safety margin for protein requirements than the normal population because of the protein demands occasioned by recurrent infections, decreased absorption, catch-up growth spurts, and the low quality of the protein in the diet. The U.N. University Working Group recommended in February 1977 that protein should provide 13 to 14% of calories for children eating a diet based on roots and tubers, and 11 to 12% for a diet based on grains and legumes (Scrimshaw 1978a). For comparison, human milk contains 7.8% of calories as protein (Lowe et al 1967) and FDA recommendations for schoolchildren are 6 to 7% of total calories. When unrestricted in intake by food availability or economic circumstances, the human tends to choose a diet that provides 11% of calories as protein (FAO/WHO 1973).

The protein content of formulated weaning foods varies from 7.9% (Kupugani Biscuits) to 45% (Protamin). (This excludes the bottled protein drinks.) As previously mentioned, most formulated foods contain roughly 20% of calories as protein, a content that has been criticized by some as being too high a concentration of protein. If formulated foods contain 25% or more protein and become the only food given to an infant in sufficient quantity to meet caloric needs, a heavy load will be placed on the child's kidneys, requiring ingestion of large amounts of water. On the other hand, foods with poor protein density may not provide adequate protection against kwashiorkor. Graham (1967) states: "It seems to us that foods supplying between 15 to 20% of calories as protein, depending on the quality of the protein, will prove more nearly to be adequate for the vast majority of children."

On a dry weight basis, the most nutrient dense of the formulated foods contain only slightly more kilocalories than rice, maize, wheat flour, and cassava flour, but 2 to 10 times as much protein of higher quality (see Table 5). One to 10 parts of water may be used to prepare the product, depending on the desired form: beverage, gruel, porridge, pudding, or dough. Thus, on the average, cooked, ready-to-eat industrially processed formulated foods contain approximately the same amount of calories as cooked rice, and two to three times as much protein. For example, 100 grams of Hyderabad Mix as eaten contains about 185 kcal and seven grams of protein. A glass of Incaparina, containing about 25 grams of dry

mix has an energy content of 92.5 kcal and protein content of 6.9 grams. The average locally-prepared multimix contains about 80 to 100 kcal in 100 grams of prepared mix and four to six grams of protein.

Even though protein content may have been overemphasized, protein quality continues to be an important consideration in the design of formulated foods. Protein quality is determined by the mix of essential amino acids and the digestibility of the protein. The efficiency with which protein is used for growth or maintenance depends on its quality and quantity in the diet, adequacy of the total diet, environmental conditions, age, and the physiological state of the consumer.

Animal protein contains amino acids in the most useful proportions for human needs, whereas vegetable protein is relatively low in one or several essential amino acids. For example, maize is low in lysine and tryptophan, wheat in lysine, and rice in lysine and threonine. Mixing proteins from several vegetable sources, each with different amino acid patterns, however, can form a protein of quality comparable to that in egg, meat, or milk. For example, legumes are rich sources of lysine and are excellent complements to wheat, maize or rice.

Therefore, in the design of formulated foods it is important to appropriately match amino acid patterns. For example, the maximum Protein Efficiency Ratio (PER) of a bean and corn mixture is reached when 50% of the total protein is from corn and 50% from beans. On a dry weight basis, the mix should be 72% corn, 28% beans (Bressani, Valiente, and Tejada 1962; Bressani and Behar 1964; Bressani and Elias 1974). Furthermore, the supplementary use of formulated foods as part of the overall diet should be considered so that basal amino acid patterns can be complemented most effectively.

Other considerations are digestibility of the protein, which is affected by various factors such as fiber content of the diet and the methods of processing. Protein availability is greatly affected by moisture, pH, temperature, and duration of heating. The availability of lysine in particular is likely to be reduced by excessive heat, with cooking losses possibly reaching 40%. Furthermore, the addition of crude sugar before cooking increases the loss of lysine availability (Gopalan 1967). It can be seen, then, that methods of processing raw materials and home cooking must be considered in product design. For further information, see two reviews on the effects of processing by Kuiken (1958) and Liener (1958).

D. Essential Fatty Acids

Little concern has been expressed about the essential fatty acid content of formulated foods. However, Naismith (1973) reports that evidence of essential fatty acid deficiency was found in children with kwashiorkor in Nigeria. In all 20 infants suffering from kwashiorkor there was a reduced proportion of linoleic and arachidonic acids in the total plasma lipids.

Although essential fatty acid deficiencies do not appear to be a major problem, it is prudent to heed the PAG Guideline No. 8 (page 27). Linoleic acid content should be at least 1% of calories. Most formulated foods meet this requirement, especially if oilseeds or vegetable oil are product constituents.

E. Vitamins and Minerals

Some or all of the micronutrients suggested by the PAG Guideline No. 8 are frequently added to industrially processed formulated foods. Exactly which vitamins and minerals to add will depend on the identified nutrient deficits of the target population, amounts of other nutrients such as minerals in the diet, chemical forms of the nutrients, malabsorption problems, and any processing, cooking, or storage losses. Vitamins and minerals thought to be essential to maintaining health include: Vitamins A, C, D, E, K, thiamin, niacin, riboflavin, pyridoxine, folacin, B12, biotin, pantothenic acid, choline, calcium, phosphorus, sodium, chloride, potassium, magnesium, sulfer, iron, chromium, copper, cobalt, manganese, zinc, molybdenum, iodine, selenium, and fluoride. Recommended daily intakes for infants and children are available for Vitamins A, C, D, E, thiamin, riboflavin, niacin, pyridoxine, folacin, B12, calcium, iodine, phosphorus, iron, magnesium, and zinc. Estimates are available for some of the remaining nutrients such as copper. (See Goodhart and Shils 1975 and Fomon 1974.)

Foods distributed through the U.S. food aid program contain vitamin and mineral levels calculated to supply at least one-half the recommended daily allowances for ages one to three. For example, the total mineral and vitamin content of CSM may be seen in Table 6.

CSM, because of its world wide distribution and centralized processing, has a mix which covers commonly found deficiencies. The mineral premix added to CSM (2.7 grams premix/100 grams CSM) contains tricalcium phosphate, zinc sulfate, ferrous fumarate, and iodized salt. The vitamin premix (0.1 grams/100 grams CSM) consists of thiamine mononitrate, riboflavin, pyridoxine hydrochloride, niacin, calcium D-pantothenate, folic acid, vitamine B12, vitamin A, vitamin D, alpha tocopherol acetate, and ascorbic acid (AID 1977).

For foods mixed at the village level, it may not be necessary to add extra vitamins or minerals, unless cooking methods would reduce the micronutrient content of fresh ingredients. For example, heat causes losses of Vitamins A, C, D, E, pyridoxine, riboflavin and thiamine. Remedies may include education or some micronutrient premixes for household or village level fortification (see Volume V in this series: Fortification).

F. Nutritional Quality Control

Nutritional quality testing of nutrient-dense foods consists of the following components:

TABLE 6

CORN SOY MILK (CSM)

VITAMIN, MINERAL, AND ESSENTIAL AMINO ACID CONTENT

PER 100 GRAMS

Vitamins

Vitamin A - I.U.	1700
Vitamin D - I.U.	200
Vitamin E - I.U.	8
Thiamin - mg.	0.8
Riboflavin - mg.	0.8
Niacin - mg.	8
Vitamin B_6 - mg.	0.7
Vitamin B_{12} - mcg.	4
Pantothenic Acid - mg.	3
Folacin - mg.	0.2
Ascorbic Acid - mg.	40

Minerals

Calcium - mg.	1000
Phosphorus - mg.	800
Magnesium - mg.	100
Iron - mg.	18
Zinc - mg.	3
Sodium - mg.	300
Potassium - mg.	800
Iodine - mcg.	50

Source: Protein Grain Products International Flyer on CSM, undated.

- examination of raw materials to determine the levels of pesticides, fungicides, and solvent residues or other undesirable constituents

- microbiological assays to check for salmonella and clostridium botulinum

- sanitation indices to insure that the processing environment is not a source of contamination

- animal and human growth and nitrogen-balance tests to determine protein quality (for further discussion on human testing, see the section on acceptability, which follows)

- tolerance and acceptability tests to determine whether the product causes physical problems and fits consumer tastes

- supplementation tests to see if the product is in fact a good complement to the basic diet for which it was designed.

Ideally these procedures should apply to village-level processing as well as commercial enterprises. At the very least, multimixes must be tested for toxicity effects. Undesirable factors such as trypsin inhibitors in legumes and oilseeds need to be eliminated by processing.

1. Toxicity

A food can be contaminated via naturally occurring toxins, additives, pesticides, residues from industrial processing and packaging materials, radioactive pollution, or microbes. Metals like selenium, which are essential for health, have a small range of optimum activity and can be toxic if large quantities of crops grown on seleniferous soils are consumed. Other potentially toxic minerals of concern are cadmium, lead, and molybdenum. Substances that inhibit nutrient utilization occur naturally in some foods, such as antitrypsin and hemaglutinins in soy; oxalates in spinach, lamb's quarters, poke; goitrogens in cabbage; and thiaminase in bracken fern. Some of these factors can be eliminated with prescribed processing techniques. For example, the potentially toxic factors in soy can be eliminated by proper toasting.

A variety of chemicals may be added to a food during processing, including acids, alkalis, preservatives, antioxidants, sequestrants, emulsifying agents, flavorings, texturizers, etc. Levels of these additives need to be carefully controlled, as do residues of pesticides, processing chemicals such as washing agents or extraction solvents, and bacteria or molds, such as Aspergillus flavus.

Many countries have food handling regulations which establish sanitation standards, allowable additives, and maximum levels of toxicants in the food supply. Since toxicity is of great importance when dealing with the food supply for infants and very young children, food scientists and health authorities should be consulted, and animal tests done before feeding children a newly formulated food.

2. Measures of Protein Quality

There are two categories of protein quality measures: chemical and biological. The chemical or amino acid score is a means of comparing the most limiting amino acid per gram of test protein with a reference protein, deriving a chemical score. The biological assays are based on direct or indirect measures of nitrogen retention and are valuable for determining the availability of protein. Examples include the Protein Efficiency Ratio (PER), Biological Value (BV), Net Protein Utilization (NPU), Relative Protein Value (RPV), Relative Nutritive Value (RNV), and Nitrogen Growth Index (NGI). For a comparison of methods and the latest information, see UNU/ WHP (in press). See also NAS/NRC (1963); Young and Scrimshaw (1978); Allison (1964); Bressani and Viteri (1971); Campbell and McLaughlin (1971); Irwin and Hegsted (1971); White and Fletcher (1974); and Young (1975).

3. Tests of Tolerance, Acceptability, and Supplementation

Tolerance and acceptability tests determine whether consumers like the product and can digest it without harmful or unpleasant side effects. (These tests are discussed in greater detail in the section on consumer acceptability.) In addition, the ingredients and quality of the diet to be supplemented must be studied to know how best to augment it. Once the formula for a food has been developed and tested for quality independently, its supplementary quality should be tested when fed in conjunction with the basic diet of the target group. When this procedure was used in the early testing of Incaparina, it was found that Incap Mixture 9 did not enhance the protein quality of the low-income rural Guatemalan diet because lysine was the first limiting amino acid in both the basic diet and the formulated food (Bressani 1969). Consequently, lysine enrichment of Mixture 9 was recommended. Tests of supplementation should point up any unanticipated effects of the food when added to the total diet.

4. The Quality Testing of Laubina

The quality testing of Laubina is an example of the process of developing a formulated food. Dietary patterns and sources of protein in the Middle Eastern diet were studied by the American University of Beirut in the 1960s in order to develop a weaning food, Laubina, for children ages 4 to 18 months. Wheat consumption accounted for two thirds of the protein intake, followed by maize, rice, pulses, and seeds. Cereal and legumes were normally eaten together and hummos, a mixture of ground chickpeas, sesame, and lemon juice eaten with wheat bread, was well accepted. Therefore, parboiled wheat was chosen as the basic ingredient of Laubina, to be mixed in varying amounts with chickpea and sesame.

Numerous mixtures were examined, using cost and palatability as constraints. The Laubina researchers evolved formulas for their product by studying the effects of the varying proportions of ingredients on amino acid balances and digestibility. Guidelines established that the mixtures should contain not less than 50% bulghur or parboiled wheat, and not more than 40% lentils, 10% chickpeas or milk, and 5% yeast. Six mixtures that came close to meeting these guidelines were further tested (see Table 7).

Laubina 102 evolved from the conjecture that the digestibility of Formula 101 could be improved by reducing the chickpea content and increasing the parboiled wheat. Laubina 103 resulted from the substitution of vegetable oil for sesame (which maintained the caloric value) because of the expense of sesame and the complexity of its decortication.

The oil was removed from Laubina 104 because rancidity shortened shelf life. The dry skim milk was removed from Laubina 104 to evaluate cost savings, but its removal had adverse effects on protein quality. Further experimentation resulted in the substitution of less expensive lentils for chickpeas, and Laubina 106 was developed.

The mixtures were chemically analyzed and then biologically tested on rats and humans. (For details see Asfour et al. 1965; Tannous et al. 1965; and McLaren et al. 1967.) The shelf life was tested for periods up to seven months. PER and NPU trials following procedures recommended in Evaluation of Protein Quality (NAS/NRC 1963) were performed on rats. Attempts were made to simulate in rats two poor local diets and to investigate the supplementation effects of Laubina. These tests showed that Laubina was a beneficial adjunct to the diet and indicated the most efficacious levels of supplementation. For example, only when Laubina provided 50% by weight of the bread-sugar diet was NPU improvement satisfactory.

Finally, nitrogen balance studies were performed on children between 5 and 12 months of age who were recovering from malnutrition. Laubina was effective in promoting positive nitrogen balance, leading to normal growth. Acceptance and tolerance tests are usually run at the same time as balance studies and are discussed in greater detail in the section on acceptability. For other examples of nutritional quality testing for formulated foods, see Bressani and Behar (1964) and Graham and co-workers (1969, 1971, 1972, and 1973.)

A word of caution is warranted. Nutrient quality control does not guarantee major nutritional impact in the field, as proven by the limited impact of Laubina, due to difficulties in distributing the food to the target group. Thus, it is a necessary, although insufficient, condition for success. Other factors discussed subsequently are also key impact determinants.

TABLE 7

COMPOSITION OF LAUBINA (PERCENTAGE BY WEIGHT)

	Laubina Formulas					
	101	102	103	104	105	106
Parboiled wheat	40	60	60	62	68	60
Chickpea	35	20	20	25	27	--
Lentil	--	--	--	--	--	28
Decorticated sesame	10	10	--	--	--	--
Dry Skim Milk	5	10	10	10	--	10
Vegetable oil	--	--	5	--	2	--
Sugar	10	--	2	--	--	--
Bone ash	--	--	1	1	1	1
Citric acid	--	--	1	1	1	--
Vitamins A and D in sugar	--	--	1	1	1	1

Source: Tannous et al. 1965.

G. SUMMARY:

NUTRITIONAL DESIGN

The nutritional design of formulated foods should strive to achieve an appropriate balance between macronutrients and micronutrients. Caloric density should be given primarey attention and protein content should provide from 15% to 20% of the calories. Achieving high protein quality through appropriate matching of amino acid patterns is important. So is digestibility. Vitamins and minerals should be added in levels dictated by the deficits identified through dietary surveys of the target group. Control of the nutritional quality is critical and can be achieved via raw material analyses, microbiological assays, sanitation indices, growth and nitrogen balance tests, tolerance and acceptability tests, and supplementation tests.

III. RAW MATERIAL SUPPLY

A. KEY QUESTIONS

- What are the actual and potential uses as nutrient sources of oilseeds, protein concentrates, other manufactured proteins, legumes, oil, sugar, and dry skim milk?
- What are the key considerations in insuring an adequate supply of the raw material?

Formulated food ingredients include cereal grains, such as wheat, corn, oats, rice, barley, and millet; oilseeds such as soy, cottonseed, sesame, groundnuts, and coconut; legumes, such as chickpeas and black beans; starches, such as plantains; fish protein; leaf protein; dry skim milk (DSM); sugar; oil; salt; vitamins and minerals; and various flavorings. Most formulated foods are based on the indigenous staple, with other acceptable ingredients added to achieve the desired nutrient density and quality. Protein concentrates may be made from cereals, oilseeds, fish or coconut and added as a high-quality ingredient.

It should be noted once again that in the published literature, discussion of ingredients focuses on protein quality. Raw materials, however, must be chosen on the basis of complementing the total nutrient composition of the diet, acceptability, accessibility, storage characteristics, absence of toxic materials, and cost.

This section will discuss the actual and potential use of the following raw materials as nutrient sources for formulated foods: oilseeds, including soy, groundnuts, cottonseed, sunflower, sesame and coconut; protein concentrates; other manufactured proteins; legumes; oil; sugar; and dry skim milk. It is assumed that staple grains will be incorporated in formulated foods and that information on their characteristics is widely available. Thus, they are omitted from this discussion. The major emphasis here is on oilseeds and concentrates as unconventional ingredients. A final section examines supply availability considerations that apply to all ingredients.

B. Sources

1. Oilseeds

Approximately 110 million tons of oilseeds are harvested each year (Berg 1973). Salvage of the oilseed cake from oil pressing operations has expanded the human food supply. World production of oilseed cakes was 3.1 million tons in 1976 (FAO 1978a). Oilseeds most frequently used in formulated foods are discussed below.

a. Soy

Although soy and groundnuts are legumes, they are also classified as oilseeds. Compared to other pulses, they are both rich in oil, which is frequently extracted, and it is the remaining meal or presscake which is used in formulated foods. In 1970, two thirds of soy meal was used for animal feed. Now, soy flours, isolates, and concentrates are increasingly used in beverages, baby foods, cereals, bread, and simulated meats. Soy forms the basis of the nutrient-dense foods Vitasoy, Bal Amul, Multi Purpose Food, Pronutro, and later versions of Incaparina.

Soy has a relatively high biological value, high protein yield per acre, and a well-developed technology of production, and it has been used for years as a food base for infants allergic to milk. Its limiting amino acid is valine. It is the least expensive of the major oilseeds on the basis of price per pound of utilizable protein, and it has none of the more serious toxic factors that plague other oilseeds. It does, however, contain trypsin inhibitor, hemagluttinins, and a goitrogenic factor, which are almost completely inactivated by proper processing. Soy's drawback is its bitter, beany taste, unacceptable in some populations. Processing techniques, however, have been found to ameliorate if not eliminate the adverse taste characteristics. World production in 1977 was 77.5 million tons, of which 29 were produced by developing countries (FAO 1978b).

b. Groundnuts

The groundnut (peanut) contains low levels of lysine, threonine, and methionine, making its protein quality inferior to that of soy or cottonseed. However, it has a widely acceptable flavor and color. A major drawback to its usage is the possibility of micotoxins in some varieties. For example, aflatoxins (toxic compounds produced by the mold

Aspergillus flavus) may develop in groundnuts growing, harvested, or stored in damp conditions. Although problems with aflatoxins appeared in the 1960s in Brazil, Kenya and Uganda, there are now processes that will eliminate the toxin. This, however, adds to the cost. Groundnuts are used in the village production of Hyderabad Mix and of Bal Ahar, Pronutro, and Nutresco. Of the 1977 world production of 17.4 million tons of groundnuts, 89% was produced in developing nations.

c. Cottonseed

Cottonseed was used as the first protein base for Incaparina. About 50% by weight of the cottonseed flour is protein (Berg 1973). The flour also contains high levels of calcium, phosphorous, thiamin, niacin, and iron. A major difficulty with cottonseed is gossypol, a toxic polyphenolic pigment in the glands of cottonseed that also produces an unacceptable greenish hue. Heat must be applied to render the toxin biologically inactive. In the process, lysine binds to gossypol and is made unavailable, thereby reducing the biological value of the protein (Milner 1969). Isolencine is the limiting amino acid. A glandless cottonseed was developed to obviate this problem. Unfortunately, the hybrid produced undesirable changes in the cotton fiber and may be more susceptible to insect damage from at least two species. Since the seed is a byproduct of the fiber, its supply will be subjected to variations caused by cotton price changes. Developing countries produced 57% of the world's 41.8 million tons in 1977.

d. Sunflower

Sunflower seed contains high levels of thiamin and niacin and is an acceptable protein source because of its bland flavor, digestibility, and lack of toxins. Major drawbacks are its high fiber content and the fact that it darkens foods to which it is added, sometimes making their appearance unacceptable. It has been used in the formulated food Leche Alim. Its limiting amino acid is lysine. The total world production in 1977 was 11.8 million tons, with the USSR being a major producer and 14% coming from developing nations.

e. Sesame

Nutritionally, sesame is an excellent oilseed and is nearly free of toxins. However, sesame grown in seleniferous soils may have a high selenium concentration, which is potentially toxic. It is also important to note that the seeds should be dehusked, since the husks contain oxalic acid. Its limiting amino acid is lysine. In spite of its good nutritional qualities, including high levels of calcium, sesame accounts for only 6% of the oilseeds. It has been used in Incaparina produced in Colombia and Frescavida produced in El Salvador. Ninety-nine percent of the world's production of 1.9 million tons of sesame in 1977 came from the developing world.

f. Coconut

The dried coconut kernel, copra, is 20% protein. It is grown where other oilseeds are not, but protein yield is low. Its limiting amino acid is lysine. One hectare will produce enough protein for two people for a year. The same hectare planted in soy (if that were possible) would yield sufficient protein for 40 people. Ordinary copra is usually inedible and requires special processing. In addition, the high fiber content of coconut makes it less suitable as a food for infants. Basically all of the world's 32.4 million tons of coconuts and 4.8 million tons of copra came from developing nations in 1977.

In summary, the oilseeds are rich sources of proteins, fats, and some of the B vitamins, but contain little or none of vitamins A, D, C, and B_{12}. Soybean has the highest protein content at 35% to 50%. The peanut is 26.3% protein, the sunflower seed 24% (or more with new varieties); sesame seed 18.6% and copra 6.5% (Swaminathan 1975). The flours made from oilseed range in protein content from 20% for copra to 50% by weight for soy.

The fat content of soy is about 20%, which is lower than most oilseeds at 35% to 54%. Sunflower, soy, safflower, and sesame are good sources of polyunsaturated fats. Peanut and cottonseed oils are moderately good sources. The screw-pressed oilseed meals contain about 5% to 8% oil, whereas solvent-extracted meals contain only about 1%. Most oilseed residues require special processing to ensure their sanitary utilization in human foods.

2. Protein Concentrates

Protein concentrates or isolates of grain fractions, fish, oilseeds, and leaves are sometimes used, particularly in formulated foods that are centrally processed. Concentrates are less practical for village or home mixing. The isolation process increases protein concentration, removes some toxic factors, and generally improves digestibility. Fish, wheat and leaf concentrates are discussed below.

a. Wheat Protein Concentrate

A 70:30 mixture of wheat to protein concentrate contains 25% to 50% more protein than regular wheat flour. Berg (1973) states that using the wheat concentrate stretches the availability of flour by 30% without increasing land usage, since concentrate is made from the cast-off wheat fractions of the flour milling process. In fact, he contends that 5 million tons of mill feed produced annually in the United States is converted to 100,000 tons of animal protein. It could alternatively be converted to 500,000 to 1,000,000 tons of protein to be consumed directly by humans as wheat protein concentrate. Wheat fractions have been used mostly to fortify and extend baked goods and are ingredients of WSB and Frescavida.

b. Fish Protein Concentrate

Fish Protein Concentrate (FPC) is a refined version of fish meal, used in animal feeds. In its most refined form, it is a fine, grayish powder made from grinding whole fish and extracting the fats and water via alcohol. U.S. government scientists claim that 10 grams of FPC per day could meet the animal protein needs of the average human (Holden 1971). Protein content is 80% or better (Berg 1973), and is 100% of the standard (LIFE Files 1973).

FPC has been used in infant foods in South Africa, Ethiopia and Chile; breads in Brazil, Sweden, and Perú; and corn products in Guatemala (Berg 1973). However, it has had a difficult history and is still not well accepted. Major problems have been with costs, technology, and public acceptance. Costs have been high because the technology is still developing, scale of production is small, and fish supplies have been erratic. The cost of the cheapest grade of FPC is 50 cents a pound (Wallerstein 1978), more than two to three times the cost of oilseed flours. If processed poorly, FPC may have objectional odor, taste, and color, and acceptability may be a problem even in coastal countries. During testing in Morocco, infant intake was limited because of the mother's objections (Tavill and Gonik 1969).

FPC seemed promising at first, but enthusiasm is on the wane. Nevertheless, several companies in the United States and Scandinavia are still working on the concept and FPC is still used in products such as Pronutro and Nutresco. For further information, see Tannenbaum, Stillings, and Scrimshaw 1974, and Pariser et al. 1978.

c. Leaf Protein Concentrate

High levels of water (70%-80%) and cellulose in edible green leaves decrease protein concentration and digestibility by humans. The original concept for Leaf Protein Concentrate (LPC) was to produce a more nutrient dense, digestible product from waste leaves of sugar beets, sugarcane, and water hyacinth. Estimates of crude protein in the concentrate range from 17% to 25% (Scrimshaw, Wang, and Milner 1975) to 60% to 70% when dried (Devadas 1970; Fox and Waterlow 1967).

Local processing has consisted of pressing the juice from fresh leaves and adding hot water to the juice. The juice coagulates to form a dark green solid with a texture similar to cheese and a taste like tea or hay. Keeping qualities are similar to cheese, but shelf life may be extended by pickling, canning, or drying the concentrate. When dried, it contains 60% to 70% protein and 20% to 30% unsaturated fat, which causes problems with rancidity and interaction between the protein and fat, making the product less digestible (Pirie 1970).

Problems with LPC are the same as those with FPC - cost, technology, and acceptability. Pirie feels that suitable manufacturing processes can be worked out at the village level and he has designed machinery that will process 300 kilograms of wet forage per hour (Martin 1977).

Research is continuing into commercial production and on-the-farm production from silage such as alfalfa (Scrimshaw, Wang, and Milner 1975). Acceptability trials have been run in Jamaica and Coimbatore, India, with mildly successful results (Fox and Waterlow 1967; Martin 1977).

A practical approach in village-level production of weaning foods is the incorporation of fresh green leaves. The Jelliffes have recommended dark green, leafy vegetables (DGLV) as part of their triple and quadrimixes for a number of years (Jelliffe 1967). Edible weeds and garden greens are usually available, but mothers are sometimes reluctant to give leaves to their infants because of color or fear of indigestibility (E.F. Jelliffe 1971). In fact, one must be exceedingly careful of potentially toxic factors in the leaves and the mineral content of the soil in which greens are grown (see the section on toxicity).

3. Other Fabricated Protein Sources

Single-cell protein and synthetic amino acids are potential additives to commercially processed formulated foods and have been used in cereal fortification (see Study V: Fortification). Single-cell protein is a generic term for protein derived from microorganisms such as yeast, bacteria, fungi, and algae. Fermentation of natural products, such as molasses, fits into this category, although other substrates, such as hydrocarbons and industrial wastes, are used. PAG Statement No. 4 and Guideline No. 12 provide some guidance on the subject.

4. Legumes

Legumes, such as chickpeas or black beans, may be incorporated into formulated foods, particularly at the village level. The Jelliffes (Jelliffe 1967) recommend the inclusion of legumes in all their multimixes (double, triple, and quadrimix). Usually legumes are a part of the staple diet and therefore well accepted. They are usually good sources of thiamine, riboflavin, niacin, folate, calcium, and iron (Cameron and Hofvander 1976) and are good amino acid complements to grains, since they contain high levels of lysine and low levels of methionine and cystine. Mung beans are one source of protein and calories in Nutripak and Kasetsart Infant Food and bengal gram is used in India's Hyderabad Mix.

5. Oil

Fat content of formulated foods is derived from its various ingredients. Rarely is oil added directly. Exceptions are such products as Sev and Solein. Adding oil is one means of increasing caloric density and overriding the bulk constraint. Problems with its usage are its expense and short shelf life, although antioxidants may help prevent rancidity. If desirable, and feasible, oil may be added by the mother when the food is mixed.

6. Sugar

Sugar is sometimes added to foods to increase palatability and caloric density. Frequently the mother's taste must be satisfied if the infant is to receive the food. However, children also respond positively to sweetened products.

Zeitlin (personal communication 1978) attempted to feed an unsweetened Wheat Soy Blend mixture to mothers and infants in a maternal-child health center in Pakistan. Infants either rejected or ate only one or two spoonfuls of the food. However, after sugar was added to the same food, most of the infants finished their six-ounce portions. Nevertheless, sugar should be added prudently and only if necessary, with attention to balancing nutrient content.

The local, unrefined sweetening agent, such as India's jaggery, is preferred to refined white sugar because the former usually contains some trace elements and is more accessible. Flavorings may also be added to enhance acceptability.

7. Dry Skim Milk

Dry skim milk (DSM) remains a part of many weaning foods because of its various good nutritive properties and its positive effect on palatability and protein quality. Often it is included because it is made available through international food donations. It is an ingredient in Superamine, Simba, Bal Amul, Faffa, Peruvita, Pronutro, Ladylac and CSM. Since continued availability is always an issue, local supplies or acceptable substitutes for the DSM ingredient should be devised.

C. Supply Availability

The foregoing sections have delineated some of the possible raw material sources for a formulated food. The planner should also carefully design a procurement system that will insure that the raw material can be obtained in the correct quantity and quality, at the appropriate time, and for a reasonable price.

For the quantity factor, one should determine the size of local production, the portion of the crop marketed, and who the existing buyers (users) are. If the supply is tight, the incremental demand for use of the formulated food might cause prices to rise significantly, at least until greater production can be achieved. Imports can be used to alleviate this short-run supply problem until local production can be increased. Care should be taken, however, not to let imports increase supply and decrease prices excessively, thereby creating a disincentive to production.

For centrally processed foods, the factory could enter into forward supply contracts with farmers (or processors, if using a byproduct) to insure supply. Such contracts could also specify quality standards, but technical assistance might be necessary. Village-level formulation operations can elicit involvement by making the provision of raw materials the community's responsibility. Where a new crop is involved, technical assistance to producers may be necessary.

The time dimension is important in that in most cases the supply becomes available only once or twice during the year; yet demand occurs constantly throughout the year. This requires a storage system to balance supply and demand and is especially critical for large factories which need a constant and high volume to offset their fixed costs.

Where the formulated food is to be prepared by the mother in the home, the ingredients should be those that she can readily obtain from her own home-grown food supplies or from the marketplace. They should be within her food expenditure budget. The mixes may have to be varied to accommodate the seasonal fluctuations in supply availability, or the mother may have to be instructed on proper storage methods to help offset such fluctuations. At this lower end of the technology spectrum, the need increases for nutrition education designed to overcome possible resistance to using known foods in novel ways.

D. SUMMARY:

RAW MATERIAL SUPPLY

Oilseeds are rich sources of proteins, fats, and some of the B vitamins. Oilseed residues generally require special processing to insure their adequacy as human foods. Protein concentrates of oilseeds, grain fractions, fish, and leaves can be used in industrially processed formulated foods, but are less practical for village or home mixing. Synthetic amino acids have been used in some foods. Legumes are good sources of raw materials for village and home processing. Oil and sugar can often be added to achieve caloric density. Dry skim milk has often been used in formulated foods because it has been donated through food-aid programs. Local substitutes are desirable to avoid the uncertainties of such aid. Vitamin and mineral premixes can also be added, when necessary to meet the defined nutrient needs of the population.

The selection of the nutrient source will also depend on the adequacy of the supply. The raw material procurement system should be designed to obtain the correct quantity and quality of raw material at the right time for a reasonable price. The use by factories of forward contracts with farmers and the provision of foods by communities to village operations are useful mechanisms. The seasonality of supply requires attention to storage means or variations in formulas.

IV. PROCESSING

A. KEY QUESTIONS

- What are the advantages and disadvantages of home mixing?
- Of village-level production?
- Of industrial processing?

The major options for processing formulated foods are home mixing, village-level production, or industrial processing. Distinctions among these classifications can be made on the basis of the site of processing, the technology employed, and the degree of organization required. Each option is discussed below.

B. Home Processing

In home processing, the mother may toast and/or mill her own grains and mix them, or she may receive milled or processed ingredients (for example, grains from the village miller, distributed commodities such as DSM, or premeasured ingredients such as Nutripak) which she mixes and cooks at home. The technology required is none other than existing food preparation procedures, except the mother might be cautioned to grind her grains more finely. Thus, the new knowledge which must be taught consists of the types and quantities of ingredients to be mixed and how to cook them.

Technologically speaking, home mixing is the least complicated of the processing options. However, from the perspective of a governmental agency attempting to institute home production procedures broadly, a great deal of organizing is required. Mothers must be taught how to prepare, mix, and cook the ingredients, either via personal demonstrations in each village or group of villages, or when possible, via the media. In effect, this approach uses nutrition education to elicit the sought-for behavior change. If ingredients such as DSM are necessary, a procurement and distribution system must be organized. Finally, potential detrimental health effects from improperly prepared foods must be anticipated and prevented through educational efforts and an ongoing monitoring system at the village level, as is described in the case study.

D.B. Jelliffe was one of the first to popularize the concept of "multimixes" of indigenous ingredients that could be combined at home or through village production to make nutritious infant foods (Jelliffe 1967). He classified multimixes as double (cereals and legumes), triple (cereals and legumes and dark green leavy vegetables) and quadrimixes (adding animal protein to the triple mix).

Multimix ingredients can be combined in the form of a coarse meal or flour produced on home grinding stones or with mortars and pestles. Cooked beans or legumes can be mashed or put through a sieve. Ingredients are all mixed with water and cooked until they thicken into a porridge or gruel. Examples of home-processed multimixes are discussed below.

1. A Homemade Weaning Food in India

R.N. Chaudhuri, director of the School of Tropical Medicine in Calcutta, reported in the Journal of the Indian Medical Association (1964) on a homemade vegetable protein food he helped to introduce. The concept was to use the bengal gram or chickpea flour that was consumed by adults and make it acceptable for feeding to infants, to replace the low-nutrient gruel normally fed.

Clinical trials were conducted from 1957-1961 and it was found that a malnourished child would accept and tolerate a bengal-gram flour preparation. The preparation consisted of 2 parts chickpea flour, 1 part local greens, and 1 part jaggery (sugar).

The flour was prepared by baking, dehusking, and grinding the legume. One ounce of the flour was mixed with 6 ounces of water and cooked with the green leaves to form a porridge or gruel. To this, 3 ounces of jaggery were added. This mixture, occasionally alternated with a pulse pudding and a soup, was fed for one month to 32 children with kwashiorkor. The children showed weight gain, reduced edema, and increased serum albumin and hemoglobin.

A later study on 75 children, divided into an experimental and two control groups, showed that the mixture compared well with milk in its efficacy for the treatment of kwashiorkor. Since the mixture was accessible and well tolerated, the pediatric clinic of the School of Tropical Medicine began advising mothers to use this regimen in 1961.

2. Homemade Recipes in Ethiopia and Sudan

Ruth Selinus (1970) commented on homemade weaning-food recipes developed for Ethiopian children:

> This food should be semi-solid, easily digestible, not too bulky, and made of locally available food items. Whenever possible, the food should be based on the tradition in the community (for example, using porridge, which in the form of "gonfo" is well-known in several parts of the country). The utensils used for measurements and preparation of food should be of the type available in all houses (Ethiopian coffee cup or "tella" beer glass and simple household equipment).

Several recipes developed in this manner are described in Table 8. For other multimix recipes, see Cameron (1976); Cameron and Hofvander (1976); and Jelliffe (1971).

TABLE 8

MULTIMIX RECIPES - ETHIOPIA

In Ethiopia, a low-fat sour cheese (ayib), which is cheap since the expensive milk fat is used for other purposes, is made. Ayib may be used in double and triple mixes and is prepared as follows:

Put buttermilk (arera) in clay pot and heat slowly until the mixture curdles. Cool, pour the liquid off the curd or ayib.

DOUBLE MIX AYIB-CEREAL PORRIDGE

1 Serving

Whole wheat flour	- 1 Ethiopian coffee cup (level)
Ayib	- 1 Ethiopian coffee cup
Niger oil (nug)	- 1 teaspoon
Salt	- to taste
Water	- 3 to 4 Ethiopian coffee cups

Mix the flour, water, oil, and salt. Boil the porridge about 15 minutes. Add the ayib and bring back to a boil. Serve. The porridge should provide 12 grams protein and 260 calories.

DOUBLE MIX WHEAT-CHICKPEA PORRIDGE

1 Serving

Whole wheat flour	- 1 Ethiopian coffee cup
Chickpea flour	- 1/2 Ethiopian coffee cup
Niger oil (nug)	- 1 teaspoon
Salt	- to taste
Water	- 4 to 5 Ethiopian coffee cups

Mix ingredients and boil 15 minutes. This porridge will provide 8 grams protein and 270 calories.

To make a triple mix, add 1 coffee cup ayib to the recipe above.

Source: Selinus 1970.

Dr. Hafiz El-Shazali of the Faculty of Medicine, University of Khartoum, Sudan, developed several multimixes that included animal protein (1972). His recipes are as follows:

Niama		Isma	
Sorghum flour	55 g	Sorghum flour	55 g
Milk	60 ml	Dry meat	10 g
Egg	1	Oil	15 ml
Sugar	15 g		

For preparing Niami, the flour is made into a paste by adding water. The egg and milk are beaten together and added with the sugar to the paste. The mixture is then cooked. To prepare Isma, the meat is cooked in the oil. The sorghum flour is made into a paste and added to the meat. It is not clear from the literature how accessible these ingredients are or whether these mixtures are widely used.

3. Homemade Foods in Malawi, Sierra Leone, and Upper Volta

Missionaries have encouraged the women in Lilongwe, Malawi, to make their own weaning porridge of indigenous maize, beans, and groundnuts in the proportion of 2:1:1. Under the initiative of Sister Trinitas, who developed the mixture, a small mill at Likuni Hospital has been producing Likuni Phala (LP) for about eight years. The mixture is both used for patients and sold at the hospital and its six clinics for $0.13 a pound. The actual cost of production is $0.165. The difference between the price and cost is covered by a subsidy from donations to the hospital. The food is apparently well accepted, and the World Food Programme is considering the possibility of producing LP on a quasi-industrial scale (Kapsiotis 1977a).

Bennimix was developed as a supplementary infant food prepared from subsistence crops in Sierra Leone. Rice, benniseed (sesame), and groundnuts are hand-pounded to make a meal. This is cooked with water to form a gruel. Original preparation was at the household level. Women then began to form cooperatives to produce Bennimix on a weekly or monthly basis. The Sierra Leone government subsequently established a pilot plant, which regularly produces Bennimix at subsidized prices as a community service. The National Development Bank of Sierra Leone is examining the feasibility of producing the food commercially (Agriculture Abroad 1977).

In Upper Volta, a formulated food was developed by Dr. Francois Gourier for treating severely malnourished children in rehabilitation centers. The bouillie (a French word meaning porridge or soup used for weaning) is now being widely used as a weaning food in the Yako district. About twenty public health nurses provide nutrition training to about 300 village volunteer nutrition workers, who in turn teach the mothers how to prepare the bouillie. In this manner, approximately 18,000 children between 0 and 6 years of age are reached.

The basis of the bouillie is approximately three parts of sorghum, millet, or maize flour and two parts of soumbala (fermented nere beans), groundnut cake or paste, baobab fruit, pounded dried fish or cowpeas. All of these foods have been in common usage by the population, but they had not previously been mixed in this manner. The food appears to be well accepted by children and adults, and is targeted to the weanling child, who is fed first, or to all of the preschoolers. Other children or adults may eat any leftovers. The case study in Chapter Four provides further information concerning this program.

C. Village Processing

There is a thin line of distinction to be drawn between village processing and home mixing, and as we have seen with Likuni Phala and Bennimix, one may merge into the other. Village-level processing refers either to the situation in which the village miller or a new processor prepares ingredients specifically for multimixes, or to that in which the community members themselves work together to mill and/or mix ingredients, some of which may be imported.

Processing at the village level may imply the need for a facility, equipment, manpower, quality control, and perhaps a power supply and storage facilities. Equipment and processing technology are likely to be more complex than is feasible in the homes. For example, hand grinders or powered equipment such as spray dryers or extruders may replace the mortar and pestle or grinding stone. Larger quantities of raw materials and finished product are handled, requiring quality control and attention to packaging and storage.

Village processing requires some degree of community coordination and cooperation, especially if the villagers collectively make their own multimix. From the perspective of a regional or national government wishing to promote village production on a large scale, success is largely dependent on a cadre of indigenous community organizers and the special attention paid to quality control and distribution problems. Two examples of products of village-level processing are Hyderabad Mix and Nutripak, discussed below.

1. Hyderabad Mix

The Indo-Dutch Project for Child Welfare originated in 1969 and covers 50,000 people in Hyderabad, India. In a dietary survey, it was determined that preschool children received 300 calories less than recommended. Therefore, a supplement of locally grown foods was formulated and prepared at the Institute of Child Health. Seventy grams of the powder provides one day's supplement of 260 calories and 10 grams of protein per child. Ingredients are as follows (Mathur and Madhavi 1976):

Hyderabad Mix

Ingredients	Weight in Grams	Percent
Wheat or sorghum	35.0	50.0
Bengal Gram Dhal	17.5	25.0
Groundnuts	6.0	8.5
Sugar	11.5	16.5

The making of the supplement has been transferred to members of the local "Mahila Mandal" (women's club), who clean, roast, grind, mix, and package ingredients, for which they earn a profit of 3 to 4 paise per 70-gram packet (Indo-Dutch Project for Child Welfare undated). Local farmers sometimes contribute ingredients. Various combinations of the original mixtures are now being prepared in most of the villages, substituting jowar (sorghum) or green gram for wheat, green gram for chickpeas, and jaggery for refined sugar. The cost of the packet varies from 15 to 18 paise (2 to 3 U.S. cents). The mix may be consumed dry or as a porridge, in laddoos (balls), or in bread cakes (chapathies).

The results claimed for the Hyderabad Mix are its adoption as a weaning food, a reduction in the prevalence of PCM, and a multiplier effect of improving the diets of mothers, who have increased their own consumption of infrequently used foods such as peanuts and bengal gram.

2. Nutripak

The concept for Nutripak originated in Laguna in 1974 when the governor organized local production of a protein powder. Ten to fifteen mothers were divided into four processing groups for cooking, grinding, packing, and sealing. Each packet contained only one teaspoon (9.1 grams) of protein powder and was sold through feeding centers, schools, and clinics (Ropes 1978). Mothers were told to add the protein to the traditional lugao.

With some alterations, the concept was promoted nationally. Nutripak is now a calorie- and protein-dense, ready-to-cook food supplement distributed in two six-week feeding operations per year by participating municipalities. The Municipal Nutrition Council (MNC) produces the packets locally through a food processing shop, using either hand-operated or mechanized grinders. As of May 1977, two regional and 87 municipal plants were operating (Ropes 1978).

Nutripak comes in three sizes, one each for ages 6 to 12 months, 1 to 3 years, and 4 to 5 years. Each polyethylene pack contains ground rice; a protein such as shrimp powder, dilis (tiny fish) powder, or mongo (mung bean) grits; DSM (for younger infants only); and cooking oil. Nutripak provides about half the daily food requirements of a healthy child and is prepared by adding the rice and oil to boiling water, cooking for ten minutes, then adding the protein powder and cooking five more minutes. The milk and sometimes green leafy vegetables are added before serving. Mothers are encouraged to assemble the Nutripak contents at home from the family food supply.

The trainer's manual of the Philippine National Nutrition Council suggests that the municipal government could use health-center kitchen facilities as production shops for Nutripak. Barring this, simple shops could be made of wood or bamboo. Equipment consists of a weight scale, plastic sealer, stone grinder, hand grinder, cooker, etc. Three or more qualified workers can manage the processing, packaging, and storing, which proceeds as follows: Rice is ground with a stone grinder. Mongo is ground to fine grits, not a powder. Fresh dilis is dried under the sun, toasted over a low fire, and ground to a fine powder. Fresh mini-shrimps are cooked for 10 to 15 minutes, sun-dried, and ground.

Each raw material is weighed, packed in a plastic packet, and sealed. A day's supply for one child is packed in a larger bag with accompanying instructions for preparation (Nutrition Center of the Philippines 1975).

3. Poshak

Project Poshak was an integrated health and nutrition program for mothers and children implemented in Madhya Pradesh, India, and involving CARE, the government of Madhya Pradesh, the government of India, AID, and UNICEF. Its aim was to evaluate the feasibility and cost effectiveness of combining a take-home food distribution with health services and education. An issue of great concern was what the take-home food supplement should be.

After several problems with acceptability, Project Poshak settled on the imported Instant Corn Soy Milk (ICSM) as the food supplement to be used in the project's extensive phase. In a later, intensive phase, a substudy was conducted to evaluate the ability and willingness of a rural village to make and use its own preschool multimixes or supplements (Gopaldas et al. 1974, 1975). These multimixes would replace ICSM. Criteria were that the mixes should yield at least 300 calories and 12 grams of protein; cost no more than 25 paise per child; have a minimum shelf life of eight weeks; pass palatability and acceptability trials; retain flexibility in composition; utilize village-level technology; and meet standards of quality. A major objective of this experiment was to demonstrate to mothers that it was possible to prepare these mixes themselves.

Fifteen weaning mixes were developed during October and November 1972, consisting of staples (wheat, corn, rice, jowar), grams (mung, bengal), oilseed (groundnuts), and jaggery. The multimixes were found to be more acceptable than ICSM, but it appears that production did not progress beyond the pilot stage.

The project directors saw the advantages of village-level production as direct involvement of the mothers, savings in government spending for transportation and administrative costs, economic benefits to the small entrepreneur, nutrition education, and more affordable prices. Disadvantages were the need for supervision, intermittent production, possibility of fraud, lack of quality control, and unhygienic conditions.

D. Industrial Processing

At the other end of the spectrum are industrially processed formulated foods, which encompass the majority of existing products. Movement along the continuum from home level to central processing connotes increasing complexity in terms of quantity of goods handled and technology employed. The need for community coordination is greatly decreased. Central or industrial processing is developed for a regional, national, or international market and implies larger-scale needs for facilities, equipment, manpower, maintenance, storage, and transportation. However, larger-scale production also permits the use of more expensive and sophisticated technology, which may enhance flavor, texture, and nutritional quality of the product. Impetus for product development has frequently originated with a donor agency, such as UNICEF, and efforts must be coordinated among the funding agency, national and local governments, and private industry, adding to the complexity of the production. This section will look briefly at the technical concerns of industrial processing and the product Superamine.

1. The Technicalities

Economic and analytical data on raw material availability, quality, and acceptability help determine the food formula, which is the result of a compromise between the desired quality and the price of the product (Buffa 1971). Once this is decided, the industrial process itself can be considered. The first industrial operation is the grinding of the grains (cereal, pulse, oilseed) into flours. Equipment has been designed that can grind all types of grain, enabling production of 400 to 600 kilograms per hour. All ingredients are then mixed. In some cases, the mixed flour is the finished product. In other cases, the flours are diluted with water at a ratio of 1:4, heated or passed through a steam ejector, and then roller-dried (Buffa 1971). Throughout the process, care must be taken to avoid contamination by aerobic and anaerobic microorganisms.

Alternatively, relatively new extrusion processes may be used. Extrusion is a procedure for forcing the food material through a die or other restriction by a compression screw. The process heats the food to 250°-350° for a few seconds. The result is usually a flaked or puffed product, which may be reground to a flour or meal. Some advantages of extrusion are replacement of raw, uncooked flavors with more palatable toasted flavors; gelatinization of starch, decreasing bulk; destruction of growth-inhibiting enzymes; increased digestibility; and pleasing texture changes.

Extrusion is used in the manufacture of textured soy products and to precook the cornmeal in CSM. Machines range in cost from several thousands to hundreds of thousands of dollars, and in production capacity from a few pounds to several tons per hour. Some of the simplest equipment can be set up as independent units, operable by easily trained labor. Therefore, machinery such as low-cost extrusion cookers (about $10,000) are being considered for use in village and intermediate level production with increasing frequency. The more sophisticated machines require skilled labor and supporting equipment such as steam generators, cutters, dryers, and coolers. For more information see Harper, Jansen, Wilson, and Stumpf (1976).

In many nutrition projects, the average daily allotment of formulated food for a child is 100 grams, but the package size more economically viable to industrial operations is 250 to 300 grams. The package material should be water- and air-tight and preferably should not allow light to penetrate. In addition, it must be resistant to damage caused by transport and storage. The product should have a shelf life of 8 to 12 months. (As we shall see in the distribution section, the product could be in transit for half this time.) The most economical packaging material seems to be plastic.

Plant location will depend on proximity to raw material supply, energy sources, distributive outlets, labor, etc. Other concerns include training of personnel, equipment maintenance, and marketing. Buffa estimates that of an expected annual production of 1,000 tons of formulated food, only 20% to 30% can be successfully commercialized. The rest will need to be subsidized by the government and distributed free or at reduced prices. Following are examples of the development and processing of several industrially produced foods.

a. CSM

To manufacture CSM, the following process and mixture are used (AID 1976): Corn (59.2% of the finished product) is dehulled, degermed, and partially precooked to gelatinize the starch. This makes it more easily digestible, decreases cooking time, and increases storage stability. Soy flour (17.5%) is defatted and toasted. Nonfat milk (15%) is spray-dried. Soybean oil (5.5%) is refined, deodorized, and stabilized. USDA vitamin premix (0.1%) and mineral premix (2.7%) are then added.

CSM may be used as a beverage, porridge, or unleavened dough. ICSM, or Instant Corn Soy Milk, differs slightly from CSM in its proportion of ingredients; the cornmeal is fully precooked, eliminating the need for cooking before serving.

b. Superamine

A high-protein food mixture for infants and young childre, Superamine was developed in Algeria with the cooperation of FAO, UNICEF, WHO, and the Algerian government. Since Algeria has no oilseed cake byproducts (the oil used comes from olives), the protein concentrate had to be derived from cereals and legumes.

The first pilot experiments on mixtures of wheat flour, chickpea flour, lentils, and DSM were conducted in Neueneg, Switzerland. Experimentation was then transferred to Algeria for analyses of chemical composition, amino acid content, microbiological assays, NPU, and acceptability. The following formula emerged: wheat flour, 28%; chickpea flour, 38%, lentil flour, 19%; DSM, 10% and sugar, 5%.

The manufacturing procedure is to mix the wheat, chickpea, and lentil flours with 50% water to make a stiff dough, which is then kneaded and pressed into a sheet of pasta. The dough is cooked in atmospheric steam for 20 minutes and dried at 100°-105°C for 30 minutes. It is then ground and sieved (70 mesh) and blended with DSM, sugar, flavorings, vitamins, and minerals (WFP 1976).

The product was tested for acceptability in Algeria in 13 maternal and child health centers, in which it was fed to children aged 6 months to 2 years for three weeks. It was well accepted, with no manifestations of rejection or gastrointestinal disturbances. UNICEF then financed production at an extension of the Blida pasta plant of the government-sponsored mother company, SEMPAC. By incorporating production into a going concern, large start-up costs were avoided.

2. Producers

According to Elizabeth Orr's listing of 56 manufacturers of high-protein foods in 1972, 40, or 71%, were owned by private companies, two by government in partnership with private companies, nine by state enterprises, and four by institutions. Orr's 1977 update on formulated foods indicates that though the numbers have changed, the distribution remains roughly the same. A number of schemes have failed for a variety of reasons, such as high price, promotional problems, lack of support of government or the health sector, competition from donated foods, consumers' lack of nutritional knowledge, and poor acceptability.

In general, the food processors involved in manufacturing formulated foods have been smaller companies, although some of the multinational corporations such as Quaker Oats, Coca-Cola, and General Mills have been involved. Other companies have been based in Kenya, Nicaragua, Brazil, Colombia, India, Thailand, West Indies, Panama, Mexico, New Zealand, Egypt, Ethiopia, Korea, Japan, Senegal, Venezuela, Nigeria, Peru, El Salvador, South Africa, Indonesia, Philippines, Canada, Israel, Chile, and France.

Researchers involved have been mostly universities around the world and institutions such as INCAP and CFTRI. Funding and promotion have been provided by U.N. agencies such as UNICEF, FAO, and WHO, and by various governments. As we shall see later in this paper, government involvement is imperative if products are to reach low-income groups. Joint ventures between governments and private industry hold promise for combining the technical expertise of private industry with the subsidizing and social welfare distributive capabilities of governments.

E. Choosing the Appropriate Level of Processing

Choosing the appropriate level of processing for a formulated food may determine the product's success. Too often modern technological innovations have been inappropriately transplanted in developing nations. As Bourne (1976) observed:

> There have been too many examples of this type of technology introduced into developing countries before their time, where the cost is really above the peoples' ability to pay, the capacity is too high to be used properly and alternative simpler methods would have served the purpose well and at a lower cost.

It is probable that the developing world itself contains the seeds of the solutions to malnutrition. Low-income populations are well schooled in the science of survival, and many traditional food mixtures and processing techniques have served them fairly well. Beans and rice, corn and beans, tortillas, hummos, yogurt, natto, and tempeh are examples. Not all of these are products suitable for a weanling infant. However, the point is that planners would be well advised to begin with the traditional foods that fit the social context, calling upon their armamentarium of technology only to improve on what already exists.

Multiple factors must be considered in choosing the appropriate technology. Each of the three levels discussed in this section has pros and cons, and in general terms some of these are shown in Table 9. It should be recognized that the three modes are not necessarily mutually exclusive, and the particular circumstances prevailing in different areas within a country will ultimately determine the technology choice.

F. SUMMARY:

PROCESSING

Processing options are home, village-level, and industrial. Home mixing involves the simplest technology and has the fewest logistical problems if local ingredients are used. Its major advantages are that the mothers receive an education in the process of preparing their own weaning foods, and the ingredients of the multimixes are familiar and accessible. However, if home mixing is to be an effective remedy for reaching significant numbers of malnourished children, it must be promoted by large-scale intensive nutrition education, requiring a great deal of coordination by governmental or voluntary agencies.

Village-level processing may utilize more sophisticated technology and may require more initial investment in assets such as facilities, equipment, etc. Getting the community to work together requires a coordinator. Advantages are similar to those of home processing, plus encouragement of community participation and perhaps the generation of some employment opportunities. In addition, the product may be more nutritious and palatable because of the more sophisticated processing.

Both quality control and hygiene are potential problems at both home and village levels. These are more easily controlled in a central industrial plant, which also enables use of the most sophisticated technology. As the scale of manufacture increases, the scale of necessary community organizing decreases. Commercial production calls for more

TABLE 9

FACTORS RELEVANT TO TECHNOLOGY CHOICE

	Home Processing	Village-Level Production	Industrial Processing
Technology-level sophistication	Low	Medium	High
Nutrition education	High	Medium	Low
Community organizational requirements	Medium	High	Low
Community participation	High	Medium	Low
Quality control	Low	Medium	High
Flexibility in product form	Low	Medium	High
Packaging requirements	Low	Medium	High
Distribution system requirements	Low	Medium	High
Cost	Low	Medium	High

equipment, larger quantities of raw materials, manpower, maintenance, and packaging for longer shelf life. Distribution systems become more important. Community involvement is decreased, but education in use of the product is still necessary. The problems which most frequently interfere with successfully reaching the target groups with industrial products are high costs, inadequate distribution, and lack of consumer knowledge about the use of the product. These will be discussed subsequently.

V. CONSUMER ACCEPTABILITY

A. KEY QUESTIONS

- What dimensions of acceptability should be tested?
- How should these tests be done?

Consumer acceptability, previously mentioned in the section on quality testing, falls under the more general rubric of human trials, which merits a brief discussion. Some guidance is provided by the PAG Guideline No. 7 (November 1975), entitled, "PAG Guideline for Human Testing of Supplementary Food Mixtures," and PAG Nutrition Document R.10/Add.81 prepared by PAHO/INCAP (1965) entitled, "Recommendations for Human Trials on New Protein Rich Foods." The main thing to remember is that no human trials should be undertaken on new formulated foods, especially those using unconventional ingredients, until freedom from toxicity has been proven. Elaborate testing may not be feasible at the village or home level of processing. If commonly used staples are merely mixed together, few problems would be anticipated except improper handling of the cooked food in the home. However, if new ingredients or green leaves are incorporated, testing is imperative for the presence of naturally occurring toxicants.

Ideally, qualitative and quantitative tests for toxic substances such as intentional additives, natural toxins, microorganisms, pesticides, and fungicides should be run in the laboratory. Animal trials for acute toxic effects should be done if feasible. Chemical composition, biological value in animals, and shelf life or stability of the product should also be known. Only then and when trials meet ethical standards should human trials proceed to determine the food's biological value, supplementary effects, and tolerance and acceptability.

"Tolerance" is defined by PAHO/INCAP as the physiological reaction of the child to the product and is measured by signs of persistent gastrointestinal upset, such as vomiting, flatulence, loss of appetite, diarrhea, and undigested stool contents. "Acceptability" is measured by

the individual's reaction to the food's organoleptic properties, such as taste, texture, smell, and appearance. Both infants and mothers must be pleased. An infant's response can be judged from facial expressions, and food rejection.

It seems academic to state that a formulated food must be acceptable to its target population. Yet, in her 1972 analysis, Elizabeth Orr reported that of 20 schemes that had terminated or were having trouble developing at a satisfactory rate, at least four and possibly eight failures were due to poor acceptability and five were due to lack of knowledge of local food habits and tastes. A variety of information bearing on acceptability must be gathered early in the product design phase, long before acceptability trials. How often do people eat? What do they eat most frequently? How is it prepared? What are the food taboos? What food textures and tastes are preferred? As many familiar properties as possible can then be incorporated into the formulated food, increasing the likelihood of its acceptance.

According to Orr (1972), there has been a lack of two types of research for industrial products: research into food preferances prior to product development, and broad-based acceptability trials. All too often, simple acceptability trials have been performed on convenient or captive audiences, rather than on a representative sample of the relevant target groups. Generalizing acceptability from one area to another or one country to another can be risky. The Faffa mixture was tested in the highlands of Ethiopia, where one of the ingredients, teff, was a staple. It was marketed, however, in the lowlands, where teff was considered an inferior grain. Incaparina, prepared as an atole, was acceptable in Guatemala where atoles were popular hot drinks. It was a failure in Nicaragua and El Salvador, however, where atoles were not familiar foods.

These examples point out the importance of a thorough understanding of the cultural context of the formulated food intervention. Having solved the technological problems and produced a food of excellent quality is but half the task in implementing this intervention. The results of acceptability tests should be incorporated into the product design process.

Acceptability testing for weaning foods in developing countries differs from such testing in industrialized countries which is primarily conducted by mail questionnaires or by telephone. In a developing country it is important to meet directly with the mothers and infants, either in the house or in a simplified test laboratory. In-home tests are more realistic and can assess the use of a product over time. Use of a mobile test laboratory stationed outside mother-and-child care centers is less expensive than house-to-house visits, however. Respondents should be interviewed immediately after the test. They may be asked to rate the product on a series of attributes such as flavor, sweetness, and color, and to compare it with other products. The sample who participates in the test should be determined with the assistance of a statistician in order to assure the validity of the conclusions. A variety of experimental designs for product tests are detailed by Nermark (1972).

Consumer acceptability and marketing trails are imperative for a centrally processed food with a presumably large and heterogeneous market. The problem of acceptability does not disappear with processing at the village level. However, if the product design is well conceived, villagers are involved in mixing their own foods of indigenous ingredients, and acceptability becomes part of the process. Discussed below are the acceptability trials of Laubina and the field problems with acceptability of imported foods that arose during Project Poshak.

B. Laubina

Acceptance and tolerance tests for Laubina mixtures 103 and 104 were performed on 24 infants between the ages of 5 months and 1 year. (See Table 7 for formula contents.) They were all full-term, healthy infants who were breast-fed until 5 months of age. They were then given Laubina as the only supplement. A comparable group of controls was fed solid foods including egg yolk, bananas, cereals, and vegetable soup. Laubina mixtures were assigned at random to infants in the experimental group. Seven received Laubina 102, ten Laubina 103, and seven Laubina 104. The amount of supplement was 100 grams per day, prepared by mixing 50 grams of Laubina with 150 to 200 milliliters of boiled water, to which 10 grams of sugar and 30 milliliters of orange or lemon juice were added. Laubina 102 was accepted by 5 of 7 infants; 7 of 10 accepted 103, and 4 of 7 accepted 104, making Laubina 104 the least preferred, probably because of its low fat content. However, the numbers are so small that nothing definitive can really be said. Two infants who refused 102 had difficulty in swallowing it because of its sticky texture.

The degree of acceptability of the Laubina mixtures compared well to the acceptability of the controls supplements. However, larger numbers in the sample would lend more credence to this conclusion. All Laubina mixtures were equally well tolerated. No gastrointestinal disturbances, vomiting, or diarrhea was observed.

C. Poshak

In the process of looking for a suitable supplement for the intensive phase of Project Poshak in Madhya Pradesh, India, CARE was notified in December 1970 that a large quantity of Post Kwashiorkor Feeding Mixture (PFKM) (consisting of corn meal, soy flour, dry milk, sugar and a vitamin-mineral premix) developed by UNICEF for emergency feeding of Biafran children in Nigeria) could be made available to the project. Thus, PKFM became the food supplement of choice. First deliveries of the food packages to the target group were made in November 1971. Seventy-five percent of the enrolled recipients collected their first food package. Within one month, collections had dropped precipitously. The recipients complained of bitter taste and smell and children became ill.

Upon investigation it was discovered that the shipment was in good condition upon arrival in Bombay in May 1971. But by December, the shelf life of the product had apparently been exhausted. Chemical analysis revealed a uric acid content that exceeded the tolerable limit of 10 milligrams per 100 grams of product, indicative of insect infestation.

A replacement needed to be found quickly. Instant Corn Soy Milk (ICSM) was similar to PKFM and was being used for UNICEF emergency feeding in Bangladesh. However, it was available in only two forms: sweetened and flavored with vanilla, or unsweetened. Vanilla was well liked in Bangladesh but unfamiliar in Madhya Pradesh. It was recognized that acceptability trials would be necessary upon receipt of the commodity.

The first test was conducted on 38 preschoolers (6 to 36 months old) and 52 guardians. The varieties of ICSM tried included unflavored, unsweetened; unflavored, sweetened; and vanilla-flavored and sweetened. The second test was performed on 93 preschoolers and their guardians. The ICSM was unflavored and unsweetened; sweetened and flavored with almond, banana, cardamom, chocolate, lime, orange, or vanilla; or salted and flavored with bay, coriander, and garlic.

The results of the acceptability trials indicated that the preschool children accepted all samples equally well. The adults preferred the sweetened and unflavored ICSM and attributed their preferences to their children, emphasizing the point that the mother's criteria for taste acceptability must be addressed (Grewal et al. 1974, Gopaldas et al. 1974).

D. SUMMARY:

CONSUMER ACCEPTABILITY

A new formulated food must pass a battery of tests, including safety, nutritional quality, tolerance, and acceptability. Only after careful consumer acceptability testing and corresponding adjustment in product design should a new product be introduced. A mistake made at this stage could cause difficulties in any subsequent efforts to introduce a reformulated product. The first steps necessary in making a product acceptable are to determine food habits, taboos, and traditional forms of victuals. Products should be in a form similar to the diet normally consumed, with familiar and acceptable ingredients, and no off-flavors, smells, or colors. Frequently, the mother's tastes must be addressed in order for the food to be given to the infant.

VI. DISTRIBUTION AND PRICING

A. KEY QUESTIONS

- Should the formulated foods be distributed through private commercial channels, public institutional outlets, or both?
- Are adequate transportation facilities available?

- What storage and packaging problems exist?
- What promotional approach will be needed?
- What are the considerations for product pricing?

Having formulated a nutritionally adequate and acceptable food, the planner still faces a major barrier in distributing it. When the concept of nutrient-dense foods first emerged, retail distribution was considered essential because social welfare institutions did not have broad population coverage, were not prepared to store and distribute food, could not be counted on for continuous functioning, and might give the new product an image of inferiority. Of course, neither does retail distribution adequately reach the poorest sectors of the population, especially rural dwellers, who do not participate significantly in the market for processed foods. In remote rural areas retail outlets are generally few in number and frequently charge relatively high prices, reflecting their low volume, high costs, and monopolistic positions. Poor families, even subsistence farmers, do patronize these stores or local market centers, but their purchasing power is very limited.

In the past, attempts to make products commercially viable yet affordable by target groups have been unsuccessful. As a result, either producers have terminated production or governmental subsidies, in the form of price support in the market or governmental distribution via social institutions, have been necessary.

It appears that the best long-range solution for isolated populations is to involve the community in making its own formulated foods. Foods that the mother can make in the home and that are readily available locally have no need of special distributive systems, so that the problems of food transportation, marketing, and bulk storage disappear, although difficulties in mounting the requisite nutrition education effort reappear. Foods formulated at the village level likewise circumvent these difficulties. However, since larger quantities of food are handled, packaging and storage become more important considerations.

If foods are centrally processed, distribution is a more complex issue. The two major options are to sell through the retail market or to distribute through institutions such as day care centers, health centers, and ration shops. Most producers use both avenues. Duryea and Cerealina are sold exclusively in retail outlets. At the other extreme, Bal Ahar is distributed only through institutions. Products such as Nutresco, Bal Amul, Simba, Superamine, and Vitatchad are supplied through both outlets (see Appendix A).

In the past, planners of many centrally processed products have aspired to the food's commercial viability, without paying adequate attention to the fact that the necessary distributive infrastructure was lacking. Wickstrom (1972) comments that:

> ...The commercial distributive system is often passive and has neither the scope nor the experience to introduce new packaged and branded consumer products. To this should be added the difficulties in continuously reaching outlying consumer areas because of bad roads, and insufficient transportation capacity.

From the perspective of those responsible for a successful nutrition intervention, the best distributive strategy is the one likely to give greatest access to the target group. An industrially processed food is more viable in an urban setting than in a sparsely populated rural one. However, one can often find brand food items in stores even in very remote villages. Where rural outlets are available, then ways to make the price within the target group's purchasing power become key. It will depend upon local circumstances as to whether more people in the urban areas can be reached via retail outlets or institutional outlets or a combination of both.

In the sections following, various aspects of distribution, such as transportation, storage (including packaging), promotion, and pricing, are discussed.

B. Transportation

Transportation receives almost no attention in the formulated food literature, except that it is noted when PL-480 supplies or other imports are delayed in arrival, creating unhappy discontinuities in food distribution schemes. One of the advantages of using commercial producers is tying into ongoing commercial distributive networks, as for example, retail outlets, storage facilities, existing personnel, vehicles, and transport systems. Social welfare institutions are rarely prepared to handle food and doing so usually taxes their resources.

Delays and loss are to be expected with any distributive system, and shelf life must be adequate to survive these conditions. Typical of the problem were the delays encountered in the shipment of Superamine from Algeria to Egypt for market trials in 1969. Custom clearance procedures required 4 to 6 months; sea shipment, 1 month; and storage and clearance at Alexandria, 2 to 3 months (Milner 1970). Furthermore, improper handling and storage caused package breakage, resulting in insect infestation.

Planning the distribution aspect of the intervention should include an assessment of the capacity, quality, and efficiency of the transport system to be used.

C. Storage

Storage and packaging are problems for nearly all formulated foods, requiring attention to availability of facilities, enviornmental conditions, prevention of pest contamination, adequate shelf life, and potential contamination during food preparation. For the homemade multimixes, the concerns are the conditions under which foods are prepared and held. Village processing may present some storage problems, depending on

frequency of mixing and amounts of food made. Mothers may either collect the foods in their own containers or it may be packaged, usually in polyethylene.

Packaging is a major issue for commercially produced weaning foods. Because imported prestige foods are handsomely packaged and identifiable, the acceptability of new formulated foods is enhanced by such imitative packaging. Packaging may also serve as an educational tool, particularly if pictographs or written instructions are given for preparation of the product. Thus, packaging is designed to meet two criteria: (1) maintaining product safety and (2) product promotion. However, satisfying these goals may add considerably to the cost of the product. The materials most impervious to infestation, like glass and tin, are the most expensive to use. The WFP report on Superamine (1976) notes that the bottling of Superamine increased total production costs by 50%. Polyethylene bags are now most commonly used, usually the 250-300 gram size, but cost increases in plastics are a concern (WFP 1976).

Project Poshak's storage problems provide an illustration of the realities faced in the field. Rat infestation of bulk supplements stored in distribution centers was deterred by obtaining steel trunks. However, finding suitable containers for distribution to recipients was not so easily resolved. In order to make distribution more efficient, it was decided that the 700-gram weekly ration should be packaged in polyethylene bags. But only one of six firms in Bombay was willing to manufacture the bags. Equipment failure brought a halt to the whole operation while parts were ordered from West Germany. Upon closer examination, it was determined that the polyethylene bags were too costly and too flimsy to survive transport anyway. The next alternative was to purchase refillable, airtight, screwtop plastic cannisters. They were ordered from a local supplier. The dye used in the plastic promptly faded onto the food. The order was cancelled and clear plastic cannisters were reordered, finally solving the problem.

D. Promotion

The barriers to the adoption of a formulated food are formidable. Many mothers do not understand the special nutritional needs of their infants or the concept of a special weaning food. Ingredients used may include foods considered by a particular culture to be unsuitable for children. Thus, the promotion of a formulated food may require more concentrated effort than that necessary for marketing other foods. For a detailed approach to marketing and promoting new foods, see Robinson (1972).

The mother must be given nutrition education for any level of production we have discussed. For home and village production, involvement of families and villages in the food processing itself is the educational vehicle, which may be reinforced by health personnel, posters, or other media. Intensive education, demonstrations, and monitoring are required at the local level.

Promotion of an industrially produced food usually connotes large-scale marketing, with less direct contact with the target populations. It is frequently important to convince key people, such as health professionals, to recommend the weaning food to their patients. Marketing trials may be useful for indicating how much may be successfully sold and what factors to emphasize in promotions. The marketing test for selling Superamine in Egypt indicated that sales of 1,000 to 1,200 tons could be achieved in the first year through normal commercial channels and institutions with budgetary autonomy. Much more could be distributed if the government would subsidize the distribution (Milner 1970).

Extensive marketing guidelines have been developed by the PAG (Wickstrom 1971). Tables 10 and 11, taken from the Guidelines, indicate interactions to be considered and the process of consumer adoption. Table 12 further characterizes the consumer's propensity to adopt the new product. Reactions are determined mainly by the initial purchasing pattern of the family.

In a survey on the formulated food Faffa by the Ethiopian Nutrition Institute (Wickstrom 1972), permanency of income was a major deciding factor for adoption. The results were as follows for consumers with preschool children in various employment groups:

Employment Group	Permanency of Income	Percent Faffa Consumers
Government	Stable	51%
Trade and Service	Semistable	46
Farmer, Laborer, Unemployed	Unstable	37

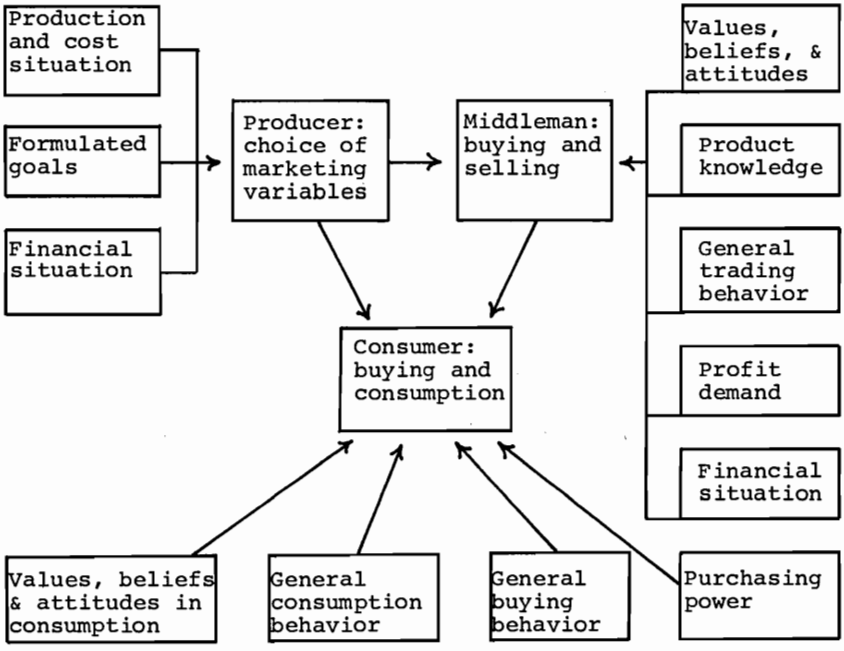
The extensive promotion of Superamine provides an example of a commercial marketing effort and its problems. A pilot area in Algeria which represented 14% of the total population in a representative mix was chosen. (For information on development of the marketing program, see Wilkie 1969). The campaign was to proceed in two phases: introduction into the pilot area, and progressive expansion after three to four months. The first phase began with a national public information campaign via radio, TV, and the press to stimulate interest in the nutritional and self-sufficiency objectives of the Superamine effort. Extensive promotion was aimed at health services.

Introduction into the test area proceeded as follows: a public-relations campaign via the media was launched for one month beginning in October 1967. Staffs of WHO and the Ministry of Public Health visited hospitals, maternal and child health centers, clinics, dispensaries, pharmacies, and physicians to present free samples of and information on Superamine. A sales conference was held to educate SEMPAC representatives who would be marketing Superamine. An introductory discount incentive was offered for the first six weeks of sales to retailers and wholesalers.

TABLE 10

THE INTERACTION SYSTEM IN THE

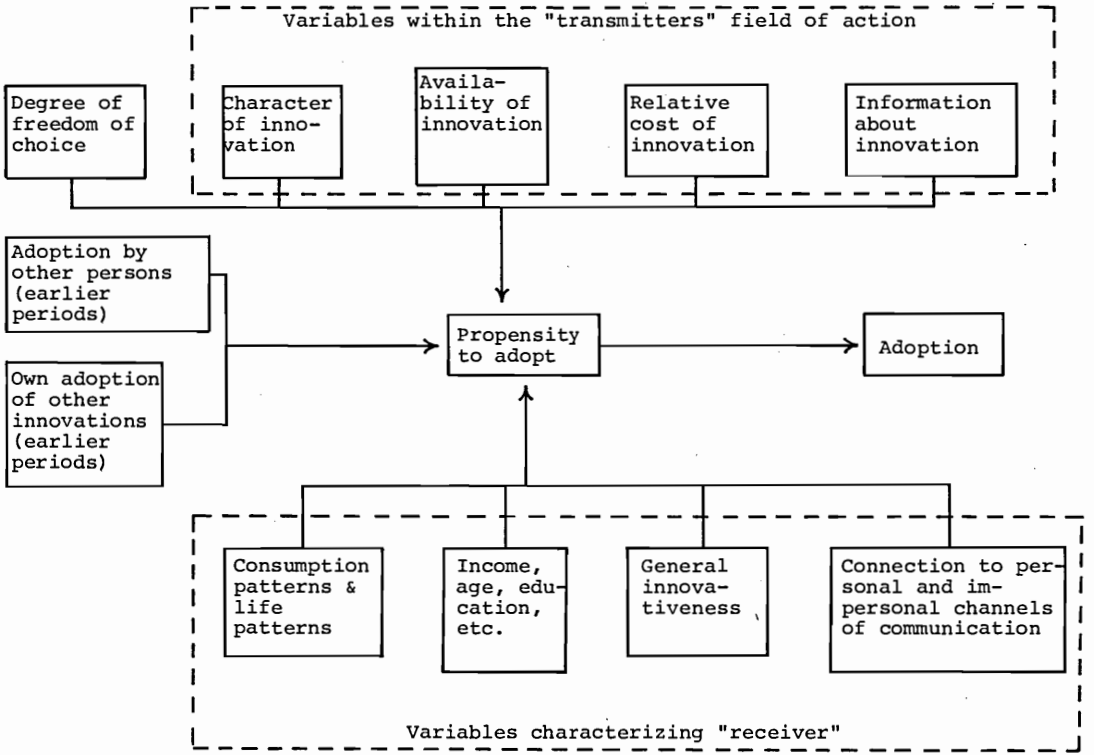
COMMERCIALIZATION OF NUTRITIONAL PRODUCTS



Source: Wickstrom 1971.

TABLE 11

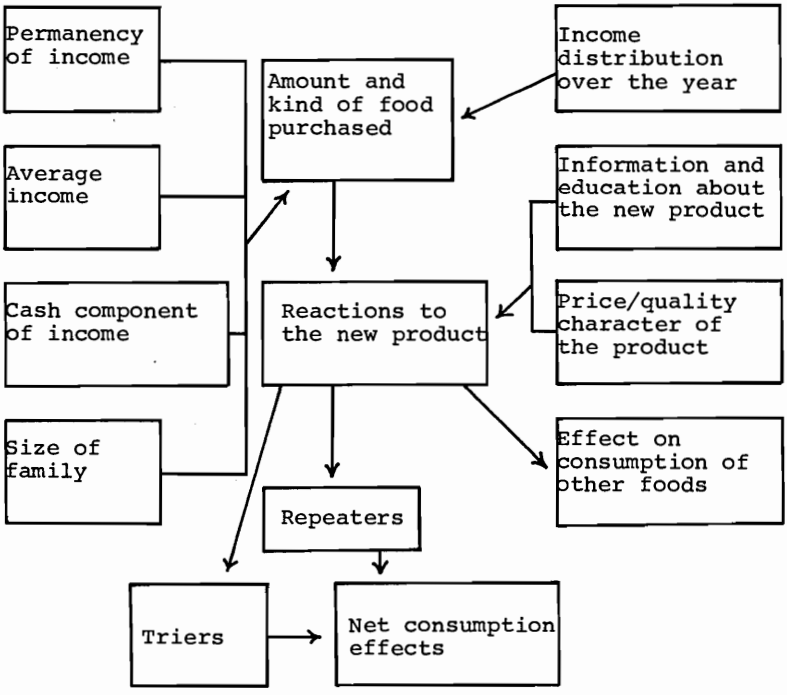
MODEL FOR THE ADOPTION PROCESS OF THE INDIVIDUAL CONSUMER



Source: Wickstrom 1971.

TABLE 12

DERIVATION OF NET CONSUMPTION EFFECTS FROM THE INTRODUCTION OF A NEW WEANING FOOD IN THE COMMERCIAL MARKET



Source: Wickstrom 1972.

Consumer promotion began in January 1968. Three thousand posters were displayed in the test area. Illustrated leaflets showing how to prepare Superamine were distributed to retailers, health service personnel and consumers. Then a nutrition team of the Ministry of Public Health began a six-week publicity and product demonstration tour of the test zone. Demonstrations were made at hopsitals, clinics, dispensaries, meetings arranged by the National Union of Algerian Women, municipal government centers, headquarters of agricultural cooperatives, girls' schools, and marketplaces. About 200 demonstrations were conducted, reaching an audience of about 25,000 people.

The second phase consisted of expansion, first into Algiers and its suburbs and subsequently into other regions. Further free publicity by the Ministry of Information via TV and radio was undertaken. Demonstration tours and conferences were conducted by the Ministry of Health and SEMPAC teams.

The progress of the effort was measured by the following figures (Kapsiotis 1969):

- by June 1968, 65,000 kilograms were sold;
- 900 stores were stocked, and
- regular purchases were made by hospitals, welfare organizations, private and state-owned pharmacies, state-owned department stores, and SEMPAC's normal food customers.

The costs of the effort were $48,000 for 1967-1968; $12,000 for 1968-1969; and $32,000 for 1969-1970 (Orr 1972). The strategy was not as successful as had been hoped. Considerable resistance to the product and packaging was experienced. The consumers were suspicious of the claims of excellent nutrition at one fourth the cost of imported weaning foods. Locally made products were considered inferior to imports. However, some observers felt that the problem was basically one of expanding too far too fast.

In 1975, the consumption of Superamine by age groups was determined in a survey of a representative national sample of 4,397 preschoolers. Results were reported in La Malnutrition Proteino-Calorique Chez L'Enfant (Cinquieme Congres du Mahgreb 1975):

Age in Months	Percent Receiving Superamine Yesterday
3-5	8.80
6-8	23.63
9-11	17.59
12-14	14.48
15-17	18.24
18-23	8.33
24-26	1.16

Although percentages reached are somewhat disappointing, it is encouraging to note that most of the consumption was by weanling infants in the targeted age ranges.

E. The Influence of Price

The price that consumers have to pay to acquire a formulated food will, as for any food, significantly affect its utilization and, therefore, its nutritional impact. In fact, one of the most significant barriers to the nutritional effectiveness of formulated food interventions has been excessively high prices relative to the purchasing power of the nutritionally needy. This has particularly been the case for industrially processed formulated foods distributed through commercial channels.

The social objective of the intervention is nutritional improvement. This may conflict with the profit objective of private processors or distributors. Consequently, mechanisms must be found to reconcile this conflict, by, for example, processor or consumer subsidies, state-owned production, or institutional distribution. These issues are discussed more fully in Chapter Three.

In terms of the pricing decision, the planner should consider the own and cross-elasticities of demand for the formulated food by the lower income target groups. The effect of price on the product's image, and thus its acceptability, should also be considered. A very low price might create a "poor man's food" image and reduce acceptability. Promotion and packaging might alleviate this. Also, a higher price but the use of food coupons to insure consumption by the target group might avoid the image problem and increase consumption by higher income groups. Food coupons have been used in this manner in rural Colombia. This would increase volume and permit cost reductions through economies of scale. (See Wickstrom 1972 for an illustration of the factors influencing pricing decisions of formulated foods.)

The pricing problem is illustrated by the experience of one of the best known formulated foods, Incaparina. Incaparina was developed in the 1950s by INCAP, the Institute of Nutrition for Central America and Panama. Sales rose to about 4.6 million pounds in 1975 (INCAP 1976), but the product is mostly consumed by middle-class, nutritionally nonneedy groups (Cordaro and Call 1975). Rising ingredient costs have pushed prices beyond the purchasing power of the low-income (Icaza 1976). It has been suggested that permitting the entrance of additional producers (one processor currently has an exclusive production license from INCAP), would lead to lower prices (Wise 1978). Changes in packaging sizes and distribution channels were also suggested as cost-saving mechanisms.

F. SUMMARY:

DISTRIBUTION AND PRICING

Formulated foods can be distributed through commercial channels, public institutions, or both. The former have the advantages of being functioning systems with existing infrastructures; government agencies generally lack such distribution capacity, but are often targeted toward the neediest groups. Combining the two is often most desirable.

In either case, transportation system capacity and quality must be carefully assessed. Promotion and nutrition education will similarly be needed in all instances. Finally, it is likely that the government will have to subsidize the distribution in order to insure economic access by the low-income groups. The home or village-level approaches may avoid direct government subsidies if the necessary foods are available in and contributed by the community. The eduational component of these approaches, however, would have to be financed or subsidized. Industrially processed foods seem more appropriate for urban than rural areas, given the greater availability of outlets in urban areas and the lack of family gardens. However, where adequate distribution networks exist in rural areas and price subsidies are employed, such products might also be made available in rural areas.

CHAPTER THREE

INTERVENTION EVALUATON

I. INTRODUCTION

In selecting a particular intervention, a planner should consider the expected costs and nutritional impact of the program. With this information, outcomes and their costs can be compared with program goals. Cost-effectiveness assessment is the evaluation methodology of choice for nutrition intervention programs whose effects are most easily quantified in terms of changes in health and nutritional status. Cost-benefit analysis is useful when both costs and outcomes are easily quantifiable in terms of money (see Volume V, Chapter Four for sample cost-benefit analysis).

To facilitate marginal decision-making, evaluation should be an integral element of a program's design. It is important that care be taken to avoid overemphasizing data collection, however. When resources are scarce, the minimum amount of data that will be needed by administrators and planners for program evaluation should be collected. In the beginning of program development, it is quite useful to obtain the advice of a data expert regarding what information to collect and the data collection methodology. This preliminary expenditure can help save time and money throughout program operation by ensuring that resources are not being used to collect extraneous statistics and that data gathered are reliable.

Once the data are collected (or values carefully estimated if data are not available) one proceeds to analysis and interpretation. Cost-effectiveness indicators must be interpreted with caution so that any confounding variables are identified and the analysis may be adjusted accordingly. For example, one element which is not directly measurable as a cost or effect is the management capacity within the program. Thus, a program with an inexplicably poor effectiveness may suffer from insufficient management capacity that is manifesting itself in program flaws and outcomes. Programs such as formulated foods that may be divided among industrial, village-level and home processing need diverse management systems that are flexible to satisfy each component's needs. A breakdown in administration may reduce effectiveness and raise costs unnecessarily. The interpretation of results is discussed in more detail in the Nutrition Evaluation Methodology Section of Volume I of this series.

In this chapter we will discuss both costs and effects of the three forms of formulated foods intervention.

II. COSTS

A. KEY QUESTIONS

- What are the costs of home mixing, village-level production, and industrial processing?
- What are the prices of formulated foods?

B. Home Processing

Total costs for home production incorporate food purchases; time spent by whoever organizes and participates in the effort; education; quality testing to determine the safety, nutrient content, and supplementary effects of the new food; and distribution. If the homemaker merely mixes staples in a new way or uses new ingredients from her own garden, such as green leafy vegetables, her marginal costs will be zero, unless extra fuel and time are needed to prepare the infant's food. If part of her ingredients include distributed commodities, her time spent in collecting the free goods is an added cost. In either situation, she must perceive that the extra effort required is worthwhile.

From the perspective of whoever organizes the home mixing effort (for example, government, voluntary organizations, or individuals), marginal costs include distribution of raw materials (if necessary), quality testing, and education. Few figures are available that would indicate the relative costs of these elements. Quality testing can be done by sending food samples to various labs, which might ascertain product content free of charge.

It is possible that requisite raw materials may have to be transported at some expense, but most multimixes are based on locally available ingredients. Thus, the largest cost elements are education and promotion of the weaning-food concept. As we noted previously, to reach about 8,000 preschool children in the Yako District of Upper Volta successfully requires a continuous educational effort by 300 village workers and 20 nurses (see Chapter Four).

The evolutionary trend for a successful product is expansion of coverage, promotion on a grander scale, and perhaps more centralized processing. Escalation of promotional strategy from home demonstrations to broader media coverage demands increased expenditures. The latter become a concern if the target group pays a portion of the cost. For example, Likuni Phala can now be purchased in grocery stores in the Likuni area and in Lilongwe. As noted in an information sheet on Likuni Phala (Sr. Trinitas 1978):

Several problems prevail. Publicity is the most important and most costly detail. Demonstrations and samples are given in the hospital and on the Mobile Clinic and posters are being printed in the Government Printing Office. Ideally, radio time and newspaper space should be purchased to reach the people, particularly in the Northern and Southern Regions, but one of the major aims of the phala is that it should be a "low-cost" food supplement; expensive publicity is out of the question.

If home mixing is truly done at home, costs to the target population should remain minimal. Raw material procurement and education are the major concerns. If the effort progresses to commercial distribution, promotional and distributive costs escalate.

C. Village Processing

Total costs for village processing include raw materials (some of which may be donated by local farmers), time spent by whoever organizes and participates in the effort, facilities (if necessary), extra power, packaging, educating, distributing, and possibly capitalization. Costs will vary depending on who does the processing: the food vendor, the village miller, a new processor, the villagers themselves, or some combination of these.

Some cost estimates are available for village-level processing of Nutripak. It has been estimated that one municipality will need 16,800 Nutripaks per year. If the municipality uses a hand stone grinder, total capital outlays per year (for two months of operation) are about $1,500. With a mechanical grinder, costs are $2,900. (See Table 13 for a cost analysis.)

Rather than make their own Nutripaks, the municipal governments may buy either prepackaged Nutripaks or the protein powders from the National Nutrition Council. Costs per kilogram for the powders are $1.00 each for mini-shrimp and mongo grits and $1.70 for dilis powder. Costs for the completed Nutripaks are $0.13 each (Ropes 1978).

Simple milling and mixing technology is usually used at the village level. However, as noted in the Processing section, if capital is available, it is feasible to use fairly sophisticated equipment, such as extruders.

D. Industrial Processing

Total costs for industrial processing include raw materials, facilities, manpower, equipment, power, packaging, education, distribution, and cost of capital. Several points should be kept in mind as we examine some general guidelines and some of the cost data available for a few of the formulated foods. First, as the sophistication of the equipment and

TABLE 13

PRODUCTION COST ESTIMATE NUTRIPAK
(2 months per year)
16,000 Nutripaks

		Cost (in U.S. dollars)
Building Rental (2 months)		$ 27
Equipment and Supplies		
with stone grinder		333
with mechanical grinder		1,683
Personnel		71
1 weigher	22	
1 sealer	22	
1 sorter, foreman, bookkeeper	27	
Raw Materials		1,087
Transportation and Travel		27
Miscellaneous		27

Total with stone grinder: $1,572

Total with mechanical grinder: $2,922

Source: Nutrition Center of the Philippines, 1975, using the exchange rate of 7.36 pesos to one U.S. dollar.

the size of the facility increases, fixed costs become greater and require larger total production to reach the break-even point for operating the plant. Second, it is true that more sophisticated technology requires a larger capital investment, but raw material costs, especially given the rising food price trends, account for a large percentage of total costs. Finally, costs of processing at the various levels should be separated from costs of distribution. Each production level has the option of distributing through institutions or commercial outlets.

Buffa (1971) produced some cost guidelines from UNICEF's attempts to promote industrial formulated food processes in North Africa and the Middle East. Although not universally applicable, they are illustrative. First of all, he states that in countries of more than five million people, a low-cost weaning food can only be economically viable if manufactured in large quantities. The under-five population can be estimated as about 10% of the total population in most developing countries, and the program would be expected to reach 10% to 20% of them. He estimates weekly consumption per child at 300 grams, which may be realistic but is about half of the ideal amount. Thus, annual consumption would be 600 to 1,200 tons for 500,000 children. Anything below this level of production would not be profitable. Only 20% to 30% of 1,000 tons produced annually could be sold through commercial channels; the rest would need a subsidy.

Buffa described a mill designed to function continuously which consisted of a cleaning and conditioning section, corrugated break rolls, smooth refining rolls, and a screening and sieving section. The annual output was calculated at 1,200 to 2,400 tons. The mill start-up costs were estimated at $100,000, and the costs of operation (including labor, electricity, water, amortization, and maintenance) were $0.028 per kilogram of treated product. The total cost to produce 1 kilogram of mixture with 19% to 25% protein would average $0.30. Raw materials would account for about 35% of total production costs and promotion for 28%.

Buffa makes the important observation that

> the manufactured cost is...very low and witnesses the fact that the technology permits the transformation of mediocre raw materials into sophisticated foods with a high nutritive value without exaggeratedly increasing the price of the finished product.

For example, a blended food consisting of 60% maize, 30% beans, 10% dry skim milk, and 1% vitamin/mineral premix was being considered in Swaziland in 1977, and a rough ex-factory costing was done. The raw ingredients cost $242 per metric ton. Adding in mixing and milling costs ($11) and 3% milling losses ($7), total costs were $260 per metric ton or $0.26 per kilogram. The report (Kapsiotis, 1977a) states that:

This rough cost estimate of the proposed blended food, even if increased by 150% for the price of individual small packages, the wholesaler's and retailer's profit, the promotion and distribution expenses, is dramatically lower than the commercial products. This cost is also much lower than the CSB and CSM, supplied by the World Food Program.

As previously mentioned, choosing appropriate levels of technology for production can keep processing costs within reasonable ranges. For example, a pilot plant in Kundesale, Sri Lanka has been in operation since 1976 to test the feasibility of a low-cost extrusion cooker system and to produce part of the requirements for a weaning food called Thriposha. The plant was a collaborative undertaking: AID financed the investment; CARE provided management and distribution assistance; the Sri Lanka government supplied the raw material grains; Cereal Products Factory, a private business concern, processed the grains for free at its rice mill; and the USDA Agribusiness and Nutrition Group and Colorado State University Department of Agricultural and Chemical Engineering provided technical assistance.

The plant used the rice mill to clean the grains and a Brady #206 Crop Cooker to cook and extrude various types of grains and legumes. The output consisted of 70% whole cleaned corn and 30% whole cleaned soybeans. A cooler, hammer miller and packer were the other main parts of the process equipment. The plant has a process capacity of 1,000 pounds of raw material per hour.

An evaluation (Ackels, Gaylord, and Kuphal 1977) of the plant's operation after one year concluded that "suitable formulations meeting nutrition standards could be processed into an entirely satisfactory foodstuff from the usual indigenous cereals, pulses, and vegetable oils found in developing countries." The evaluation also noted the economic benefits of this type of intermediate technology: "The installed cost of about U.S. $50,000 in Sri Lanka is far below the cost of conventional cereal cooking and extruding processes. It is unlikely that a continuous system of the same capacity, using conventional food processing equipment, could be installed in a developing nation with the most stringent design criteria for less than $250,000." The estimated direct and indirect processing costs (excluding raw materials and packaging) range from $0.0110 to $0.0233 per pound of finished product once the factory has eliminated its start-up problems.

An extrusion process cost analysis for two levels of production of the Chilean product Fortesan is attached as Table 14. Processing costs per kilogram are $0.017 for production at 4,000 pounds per hour and $0.035 for 1,000 pounds per hour. These estimates agree well with Buffa's projections and indicate some economies of scale.

Thus, it is not sophisticated technology that escalates cost as much as the expense of raw materials, packaging, and promotion. According to Rha (1974), raw materials accounted for close to 80% of production costs for Fortesan in 1974. However, raw materials included expensive components

TABLE 14

FORTESAN - PROCESS COST ANALYSIS FOR TWO PRODUCTION LEVELS

Processing Costs Per 2,000 lb. Ton	Larger Extruder X-200 4,000 lb./hr.	Smaller Extruder X-25 1,000 lb./hr.
1. Power costs/ton	$4.80	$7.55
2. Fuel costs/ton	0.74	0.75
3. Productive labor		
a. Warehousing, receiving, grinding, dehulling	1.00	1.00
b. Extruder and mixer operator	0.50	2.00
c. Packer operator 50 lb. bags/drum	0.50	2.00
d. Maintenance	0.20	0.25
4. Nonproductive labor, clean-up	0.22	0.86
5. Spare parts (est.)	0.62	1.56
6. Lubrication costs	0.16	0.05
7. Depreciation costs, based on 20,000 production hours	7.20	15.60
Total per 2,000 lb. ton	15.88	31.62
Total per metric ton	17.50	34.86
Processing cost per kilogram	$0.017	$0.035

Source: Rha 1974.

such as WSB, skim milk, and cocoa. In 1973, Kasetsart University's Institute for Food Research and Product Development (IFRPD) found that in the production of textured vegetable protein, raw materials accounted for 25% to 50% of total cost, rannging from the least- to the most labor-intensive operations within the factory (Austin and Mock 1974).

For a soya weaning food manufactured in Uganda and Kenya, costs in December 1975 were allocated as: raw materials, 35% of total cost; production, 31%; and packaging, 34%. For the company's production of a variety of nutrient-dense soya products, cost categories may be seen in Table 15. Raw materials accounted for 33% of total cost in 1975 and overheads for 36% (Hitt and Austin 1976b). For the same company's manufacture of five soya products, projected percentages of total cost are calculated for three levels of production in Table 16. This table reveals the economies of scale: as capacity utilization increases, fixed costs such as administration and most marketing expenses decline as a percentage of total cost.

Cost and revenue projections were made for Faffa by Wickstrom (1969). He estimated that as production increased from 100 to 1,500 tons per year, total production and distribution costs per kilogram would decrease from 98 to 69 cents. Eighty-five percent of total production and distribution costs in 1967 was production cost, of which raw materials accounted for 43%. Wickstrom figured that required government subsidies would be $40,000 at 100 tons of production, $70,000 at 400 tons, and $135,000 at 1,500 tons.

Transportation and storage costs can be considerable, especially for imported products. To use CSM as an example, in Swaziland the cost of ocean freight plus inland rail transport is $140 per metric ton (Kapsiotis 1977a). Damages in transport can amount to as much as 10% of the shipment.

Marketing costs are greatly increased by attempts to reach the rural area. Hindustan Lever Ltd. of India (Rajahyaksha 1969) estimated that rural selling costs 17 times as much per unit sale as urban selling. Distribution costs are greater, including longer distances covered per unit sale, wear and tear on vans on poor country roads, etc. (Rajahyaksha 1969).

Total social cost of the intervention is increased by spoilage, pilferage, and losses in transport. Leakages more specific to nutrition interventions result from intrafamilial distribution or inclusion of non-needy recipients in the program. (For examples, see Volume II, Supplementary Feeding.)

E. Price

The price of formulated foods ranges from about $0.21 per kilogram (Vitabean) to $1.71 per kilogram (Sekmama). One analysis of the price components of a formulated food was done by the Thriposha program in Sri Lanka in 1975 (Mock and Austin 1975):

TABLE 15

AFRICAN PROTEIN PRODUCTS

Costs	Percentage of Total Cost 1975
Raw materials	33
Packing materials	23
Wages	7
Stock adjustments	1
Factory overheads	17
Marketing overheads	8
Administrative overheads	11

WEANING FOOD, DECEMBER 6, 1975

Costs	Percentage of Total Cost
Raw materials	35.4
Production	30.5
Packaging	34.1

Source: Hitt and Austin 1976b.

TABLE 16

AFRICAN PROTEIN PRODUCTS: PROJECTED PERCENTAGES OF TOTAL COST

Capacity Utilization	55%	75%	100%
Production			
Wages	10	8	7
Raw materials	37	42	45
Packing materials	15	17	18
Fuel and services	4	5	5
Maintenance	1	1	1
Vehicle	2	2	1
Total	69	75	77
Marketing			
Wages and commission	5	5	4
Sales and expenses	4	3	3
Promotion expenses	2	1	1
Advertising	2	1	1
Vehicle	1	1	1
Rent	--	--	1
Office expenses	--	--	1
Total	14	11	12
Administration			
Wages and benefits	6	5	4
Director's fees	1	1	1
Office expenses	2	1	1
Insurance and licenses	1	1	1
Bank audit, etc.	1	1	0
Total	11	9	7
Depreciation			
Buildings at 5%	2	1	1
Equipment at 10%	3	3	2
Vehicle at 20%	1	1	1
Total	6	5	4
Grand Total	100%	100%	100%

Source: Hitt and Austin 1976b.

Cost	Percentage of Total Price
Packaging	13
Blending	6
Cereal	14
WSB	45
Transport	4
Overheads/other	9
Marketing	9

This is not necessarily representative, especially since WSB (unsubsidized) is one of the ingredients. It does, however, indicate the high cost of materials.

Table 17 is a cost comparison of three formulated foods with milk, meat, egg, and cheese in Colombia. The majority of formulated foods are less expensive than animal protein and imported baby foods, which are usually less nutritious. However, they are frequently more expensive than staple commodities, which are their true competitors. Staple costs are roughly $0.25 per kilogram of rice in Asia and $0.20 per kilogram of corn in South America (HIID 1976). Per pound of protein, blended foods may cost roughly the same or from 1.5 to 6 times as much as staple grains (see Table 18) depending on the method of calculation.

It is for this reason that Barry Popkin and Michael Latham (1973) criticize commercial formulated foods. They claim that marketing these products encourages the low income family to buy expensive prestigious foods which may give fewer nutrients per dollar spent. Using data from India, they compare the upper 5% income levels of the population with the lower 30%. The lower income groups are more efficient in their food purchases (that is, they get more calories and proteins per rupee).

Table 19 shows the economic efficiency of selected Indian commercial infant foods and multimixes in terms of rupees per 100 kilocalories or 10 grams of protein. Costs of a normal mixed diet are 0.02 rupees per 100 kilocalories for the poor and 0.06 for the wealthy. Costs per 10 grams of protein are 0.06 and 0.21 rupees, respectively, for the poor and rich. Thus, for the poorest 30% of the population, costs of calories purchased as the more prestigious commercial products are 8 to 40 times as high as for the mixed diet, and protein is 3 to 18 times as expensive. However, miltimixes are only 1.5 to 2.5 times as expensive for calories and no more than 1.5 times as expensive for protein.

The Popkin and Latham analysis points up two important facts. First of all, multimixes appear to be a viable option for target populations. Although they are a little more expensive than stamples, small government subsidies might breach the economic gap and make such foods available to the populations in need. Second, there is a great danger in promotion of prestigious commercial infant foods whose purchase by target groups would decrease their net intake of calories and protein, doing them a nutritional disservice. Thus, the promotion of any

TABLE 17

COMPARISON OF THE COSTS AND NUTRITIVE VALUE OF FORMULATED FOODS

WITH OTHER COMMON FOODS

	Colada* of Bienestarina (1 glass)	Colada of Incaparina (1 glass)	Colada of Duryea (1 glass)	Milk (1 glass)	Meat (1 ounce)	Egg (1 unit)	Fresh Cheese (whole milk) (1 ounce)
Estimated Price to the User (US$)	.013	NOT AVAILABLE	.020	.035	.047	.054	.056
P.E.R.	2.50	2.29	2.15	2.7	2.5	3.5	2.5
Calories	168*	138*	140*	141	36	80	79
Protein, grams	7.2	6.9	7.0	6.9	6.4	5.6	5.2
Cost per 100 calories	.007	NOT AVAILABLE	.014	.025	.131	.068	.071
Cost per gram protein	.0018	NOT AVAILABLE	.003	.005	.007	.010	.011

*One glass of colada is prepared by dissolving 25 grams of the powdered vegetable mixture in one glass of water, sweetening it with 12 grams of sugar, and boiling the mixture for 15 minutes. (Presumably the cost of sugar has not been included in the prices to the user.) The 12 grams of sugar adds 46 kilocalories to the formulated food.

Source: AID/Colombia 1976.

TABLE 18

RELATIVE COSTS OF FORMULATED FOODS AND STAPLES

	Price of Product ($/lb)	Protein (%)	Price of Protein* ($/lb)	Price of Protein** ($/lb)
Stables				
Chickpeas	$0.05	20%	$0.06	$0.25
Wheat Flour	0.05	11	0.11	0.45
Beans	0.09	22	0.24	0.41
Skim milk powder	0.15	36	0.31	0.42
Formulated Foods				
Multipurpose food (India)	0.18	42	0.36	0.43
Arlac	0.21	42	0.40	0.50
Incaparina (Guatemala)	0.19	28	0.47	0.68
Pronutro	0.15	22	0.47	0.68

*To allow roughly for the value of calories, Abbot priced the calorie content of each food on a par with pure sugar (at $.04/pound) as representing a nearly pure calorie food, and deducted this value from the price of protein.

**The prices of protein in this column reflect the author's calculations, based on obtaining enough of the product to make one pound of protein.

Source: Abbot 1969.

TABLE 19

COST (IN RUPEES) OF PURCHASING 100 KCAL AND 10 G PROTEIN, USING SELECTED FOODS

	Rs/100 kcal	Rs/10 g protein
Processed Commercial Products		
Uniprotin	0.29	0.80
Threptin	0.55	0.35
Complan	0.75	1.08
Protinex	0.79	0.98
Skim milk powder	0.17	0.17
Multimixes		
Hyderabad Mix	0.03	0.09
Indian Multipurpose Food	0.05	0.05
Normal Diet		
Overall cost of mixed diet		
Bottom 30% income group	0.02	0.06
Top 5% income group	0.06	0.21

Source: Popkin and Latham 1973.

industrially processed formulated food must be done with a social consciousness of the danger that use of the food may result in the purchase of more expensive calories and proteins than would be necessary.

The substitution of any weaning food for breast-feeding is another danger, although this applies principally to infant formulas rather than weaning foods. Some quantification of substitution effects of the Ethiopian weaning food Faffa has been provided by Wickstrom (1972): 54% of the consumers reported consciously replacing the following dietary items with Faffa:

animal products	37%
cereals	25
legumes	10
breast milk	7
bread	2

Popkin and Latham have rightfully pointed to a cause for concern in the formulated food intervention. However, their analysis focuses on the quantities of proteins and calories. As we have seen, an adequate prescription for malnutrition for the weanling child must address the problems of quality, a proper mix of nutrients, and the bulk constraint. Thus, some tradeoffs might be necessary between the improved quality of nutrient-dense foods and their higher prices relative to staples.

Although the costs of formulated foods may not be excessive relative to their enhanced nutritional quality, they still may be beyond the low income consumer's food budget. It is highly likely that government subsidies will be essential to ensuring access to such foods. The subsidies might be price controls for basic staples used in multi-mixes or coupons for industrial formulated foods. Volume VII in this series discusses various forms of and considerations for such consumer price subsidies.

F. SUMMARY:

COSTS

Formulated foods have been criticized most severely for their high prices, preventing their usage by the most needy target populations. As we have seen, their prices are actually reasonable for the quality of the product, but still out of reach of target groups. By examining the cost profile of industrial formulated foods, we have seen that major contributors are raw materials, packaging, and promotion. The more sophisticated technology is not unreasonably expensive unless production levels are low, escalating the cost per kilogram of product. If high technology is

chosen, the producer is economically compelled to increase the volume of production, which he will probably have to do via a combination of institutional and retail distribution. He is not compelled to sell commercially if the volume of institutional distribution is sufficient.

It is unlikely that a producer, introducing a new product unfamiliar to the target group, will quickly generate sufficient quantities of demand. A more effective approach is to first develop local multimixes, simultaneously educating the consumer and thereby addressing a major barrier to success. It is possible that once such a food habit is accepted, a market for improved products would be more readily developed, making capital-intensive investment less risky. However, any commercial product must be marketed conscientiously with a social awareness of potential detrimental effects on low-income groups.

III. EFFECTIVENESS

A. KEY QUESTIONS

- Have formulated foods been able to produce nutritional improvement?
- What are the main barriers to achieving greater effectiveness?

We know that formulated foods, if consumed, can be effective in treating PCM (Chandhuri 1964; Wicks and Whittle 1968; Rao and Ramchandran 1971; Beghin et al. 1973) and as supplements to normal preschoolers (Akinrele and Edwards 1971; Devadas, Chandrasekhar, and Lalitha 1973; Habicht, Schwedes, Arroyave, and Kline 1973; Graham and Baertl 1974; Pereira and Sundararaj 1975).

But we also know that the products are not adequately reaching the target groups (Behar 1966; Orr 1972, 1977; WFP 1976; HIID personal interviews with Kapsiotis, Lunven, Ronchi-Proja, Gongora, Stainier, Sevenhuysen 1978). First of all, products sold through the retail market will not always reach the rural poor who do not participate significantly as consumers in the commercial food market economy. Second, the prices of the products are reasonable relative to costs, but are frequently too high to be afforded by low-income urbanites. Third, the world production of these products (roughly 82,600 tons per year, excluding WSB and CSM) is small relative to need. Fourth, distribution through institutions

does not necessarily mean that the food reaches the intended beneficiaries. Finally, for those infants reached, it is not certain in many programs that the foods are fed frequently enough or in adequate quantities to affect nutritional status significantly.

A detailed cost-effectiveness analysis of the Yako program in Upper Volta, given in Appendix C, provides an example of a methodology for calculation of cost-effectiveness of formulated food programs. Measures appropriate for such programs will be illustrated and the interpretation of results will be discussed.

The barriers to effectiveness that face industrially processed and commercially distributed formulated foods can be illustrated by returning to our earlier example of Incaparina, one of the oldest formulated food products. Bodenheimer (1972) stated:

> ...in its ten years of existence, Incaparina has had a negligible impact on the Central American nutrition problem. In several countries, attempts to market Incaparina have failed completely. In Guatelama, where it is produced by a local company, it is a growing concern, but a small one. Whereas over 20 million pounds per year would be required to feed all children under five, Incaparina sales are under three million pounds per year. And the greatest use of the product is among middle-class families rather than the poor.

Kracht (1973) states that less than 5% of the target groups in Guatemala or Colombia in 1969 consumed Incaparina in significant quantities.

In the Guatemalan portion of the 1965 Central American Nutrition Survey, 389 families in 39 communities were interviewed. Sixty-seven percent knew of Incaparina and 45% were consuming it. Of the consumers, 12% reserved it for the children and 79% served it to all family members (Shaw 1969).

In a 1968 study of five communities, 92% of the families were familiar with Incaparina; 37% used it regularly; 29% used it occasionally; 16% had never tried it; and 14% had tried it but stopped using it, apparently for reasons unrelated to the product. Of the consumers, 64% fed Incaparina to children less than one year in age, 89% fed it to children one to two years old, and 91% to the two-to-five age group (Shaw 1969).

In Icaza's 1968 marketing study, a total of 1,246 families were interviewed. The main sources of information on Incaparina were radio, 33%; local stores, 22%; neighbors, 11%; and health centers, 9%. Socioeconomic distribution of consumers was (Icaza 1976):

Monthly Income	Percent Consuming
< $20	29
$21-$100	61
> $100	76

Behar (1966) states that a total of 1,383,559 pounds of Incaparina were sold in 1965, which constitutes 8,301,354 recommended daily rations of 75 grams. To determine effectiveness, he made the following admittedly unrealistic assumptions:

- that only the population groups in need consumed Incaparina, that is about 60% of the total population;
- that it was fed only to children aged one to four; and
- that it was consumed at the daily recommended amount of 75 grams per child.

Even in this idealistic situation, the amount sold could only meet the needs of 6.4% of the target group.

Clearly, to make a success of a formulated weaning food is a formidable undertaking, especially at the commercial level. The hurdles are many: making sure novel raw ingredients are safe and acceptable; mixing them in a nutritious and palatable manner; packaging; storing; transporting; marketing; changing food habits; and pricing the food low enough so that it is affordable.

Private food companies require an acceptable return on their investment if they are to allocate resources to the production of formulated foods. They would likely be more efficient producers of the foods than the governments. Consequently, the most cost-effective solution may be to have governments subsidize the production or purchase of the industrially processed foods. Interproduct subsidization could also be encouraged, perhaps by guaranteed minimum quantity purchases for the government's supplementary feeding programs.

Mobilizing target groups to make their own weaning foods may be particularly appropriate for rural areas where public or private distribution systems are very limited. By involving the community in formulating their own weaning foods at home or in the village, the intervention can serve simultaneously as a means of organizing communities, educating to stop leakages, introducing the weaning food concept, and promoting self-sufficiency. For example, the Yako project in Upper Volta has helped reduce severe malnutrition rates at national prevalence levels of at least 3% (FAO 1976) to six malnourished per 1,255 vaccinated in 1976 and to three malnourished per 1,360 vaccinated in 1977 (see Chapter Four).

It appears that the formulated food intervention, as a means of reaching low-income at-risk groups and malnourished preschoolers, is viable only with strong government backing. The government must be committed to leveling the barriers which prevent these nutrient-dense products from reaching the intended beneficiaries. What combination of processing and distributing strategies is most likely to succeed in any particular circumstance depends on a government's knowledge of its own people.

B. SUMMARY:

EFFECTIVENESS

Formulated foods have the demonstrated ability to alleviate malnutrition if consumed by the needy child. The main barrier to effectiveness, particularly in commercially marketed formulated foods, has been prices in excess of the target group's purchasing capacity. Subsidizing to processors or consumers seems necessary to ensure participation by private producers and access by low-income groups.

Industrially processed foods seem most appropriate in the urban areas, while village-level and in-home mixing appear to be most cost-effective for the rural areas.

The need for a formulated weaning food is clear. Regardless of the intervention design chosen, effectiveness in meeting that need will largely be determined by the degree of financial and political commitment.

CHAPTER FOUR

UPPER VOLTA CASE STUDY OF HOME-BASED COMMUNITY-LEVEL WEANING FOOD DEVELOPMENT*

I. INTRODUCTION

> Take a small calabash of water, two soupspoons of sorghum flour, three cubes of sugar, a ball of fermented nere seeds, or a ring of fried peanut cake, or a small amount of dried fish flour, a handful of bean flour, or pounded peanuts. Put the water on to boil and dissolve the other ingredients in more cold water. Stir this mixture into the boiling water until smooth and let it cook for a while.

Ninety-four percent of mothers of 6- to 24-month old infants in three villages in Yako District, Upper Volta, were able to give recipes like this one for bouillie, a French word for weaning food, and 60% claimed to have given this food to their children during the 24 hours before the interview. Eight years ago, the idea of preparing a special food for babies was not a part of the local Mossi culture. Then, as in other Mossi areas now, a mother commonly waited until an infant indicated by some sign or gesture that it wanted to eat foods in addition to breast milk, and introducing even token amounts of solids was commonly delayed until nine months of age or later. None of the 62 infants of the mothers surveyed above in April 1978 were third-degree malnourished, and only 12% fell into second-degree (below 75% of weight for age). Incidence of third-degree malnutrition in Yako District in 1977 was down to 0.2%, based on detection by vaccination teams. In contrast, estimates of national prevalence of third-degree malnutrition range from 3% (FAO 1976) to 13% (WHO 1976) to 15% (Martin-Santos 1976).

II. GOALS OF THE CASE STUDY

This case study will examine the design, impact, and cost effectiveness of nutrition education and weaning food development both in Yako and in the ecologically and culturally similar district of Koupele, using the results of the above-mentioned survey, additional interviews, and other background materials. Its purpose is to identify successful approaches, apparent constraints limiting the effectiveness of current weaning food development programs, ways in which these constraints might be reduced, and further research required to solve basic problems. On the basis of these findings, the study will suggest guidelines for programs in ecologically similar areas that promote weaning food development in the home through nutrition education.

---

*Marian F. Zeitlin designed, conducted, and analyzed the case study survey with the collaboration of the Ministries of Rural Development and of Health and the USAID mission in Upper Volta. The case study was written by Zeitlin and edited by James E. Austin.

Regarding the types of formulated food interventions discussed at the beginning of this monograph, this case study obviously deals with the lowest end of the technology spectrum, and thus blends into a combined nutrition education and formulated food undertaking. Two reasons determined the choice of a case study that illustrates formulated food development at the village level. First, there is considerable literature on industrially processed formulated foods, as noted in Chapter Two; in contrast, information on village-level and in-home formulation of new foods is relatively scarce. The case study attempts to reduce that void. Second, village-level and in-home programs appear to hold potential for wider population coverage at lower cost than currently can be achieved by industrially processed foods. Nutrition planners of Upper Volta have opted for the village-level approach for this second reason. Of particular interest to other planners may be the successful use of illiterate village workers as key disseminators of the weaning food message.

III. THE UPPER VOLTA SETTING

Situated in West Africa along the southern border of the encroaching Sahara desert, Upper Volta is a country of six to seven million people with a predominantly subsistence-level rural economy and an average per-capita income of $110.

The Voltaic population is 95% rural and is composed of more than 60 ethnic groups; 48% are Mossi who live primarily on a central savanna plateau. The population density of 50 to 100 persons per hectare in the areas of the plateau where both present survey sites are located is beyond the holding capacity of the land as currently managed (FAO 1976). A population growth rate estimated at up to 3% (ODC 1975) is counterbalanced by the outmigration to the south of about one million seasonal workers and permanent settlers, who go mainly to the Ivory Coast and to Ghana. North of the Mossi Plateau, the Sahelian landscape blends gradually into the desert and is sparsely settled by cattle-raising seminomadic and nomadic groups. In the southwest are the fertile Volta river valleys, which are infested with black flies that cause river blindness and render large areas uninhabitable.

Remittances of migrants from abroad contribute as much to the national economy as does total foreign aid, which covers 75% of government annual expenditure (Johansson 1978). With a lack of major mineral resources, top exports by value in 1974 were live animals, 35%, cotton, 21%, and groundnuts, 20%. The country has run an increasing trade deficit since it became independent in 1960 (FAO 1974).

A. Nutritional Conditions

Total calorie supply in Upper Volta is estimated at 15% to 20% below requirement in nondrought years (Republique de Haute Volta 1972), and is derived mainly from subsistence production of sorghum and millet in a ratio of about 2:1.

Preharvest food shortages are endemic in Upper Volta and are largely dependent on rainfall. The country was seriously affected by the Sahelian drought in the early seventies, which brought starvation conditions in the northern and north central parts of the country. Shortfalls were considered critical in 1978 by Catholic Relief Services (CRS), which monitors nutritional status of zero- to five-year-old children by means of master weight charts (Capone 1977) in the Maternal and Child Health (MCH) centers receiving their rations. Areas of nutritional deterioration and early famine in 1978 did not include Yako or Koupele.

Malnutrition prevalence derived from measurements among 10,002 zero- to six-year-old children in the Central Mossi Plateau from December 1973 to October 1974 is between 7.8% to 10.2% of the children at the "acute undernutrition threshold" with weight for height measurements less than 80% of the Stuart-Meridith standard (Center for Disease Control 1975). A much smaller sample in Kaya District (FAO 1976) revealed that severest deficits in weight for height occurred between 12 and 24 months; 4.1% of the 1-2 year olds had weight for height measurements between 80%-89% of the standard. It is unfortunate that neither of these available studies provide weight for age figures, which are most accurate for judging the nutritional status of children below age two, when total growth achievement as measured by weight is a more sensitive indicator of nutritional adequacy than relative plumpness or height. (For an illustration of the relative merits of these indices by age, see Zeitlin 1977.)

B. Health and Nutrition Services for Preschool Children

A program to develop maternal and child health services was first instituted in 1969, and a five-year plan for the progressive development of MCH centers was initiated by the Government of Upper Volta, UNICEF, and WHO in 1975 (Martin-Santos 1976). By 1976 a total of 206 such centers, including 28 mobile units, had been established under the administrative supervision of the country's ten medical districts. In addition to services provided by these centers, smallpox and measles vaccination teams regularly tour rural areas.

Nutrition courses for extension workers in health and rural development were started by FAO in the mid-sixties. Nutrition education - teaching mothers how to cook bouillie - is a current part of the job description of the country's 120 female home economics extension agents working under the Ministry of Rural Development, and of many of the 1,280 nurses and 12 trained midwives working under the Ministry of Health (unpublished estimates collected by Nutrition Cell, Ministry of Rural Development 1978). Nutrition education is most commonly carried out in MCH facilities. Rural development and health activities frequently are closely coordinated at the field level, both with each other and with development activities carried out by private voluntary organizations. The greatest limitation to the effectiveness of these programs in addressing weaning-age malnutrition in the country as a whole is the shortage of middle-level workers in proportion to the country's total population - a ratio of about 1 to 1,000 preschoolers.

C. The Extension of Services by Village-Level Workers

The village-level extension system employed in the Yako District has several promising features of interest to nutrition planners: a village-based (rather than clinic-based) focus; the use of illiterate village-level workers; the employment of a simple, yet efficient, means of training and supervision; the minimization of external resources; and the active participation of the community. The eight-year-old program developed by the Yako District's chief medical officer, Dr. Francois Gourier, has extended the services of a handful of middle-level personnel to a population of 100,000 by training illiterate village workers who are recompensed by their communities. Since foods, local supplies and buildings used by the program are also provided by the communities, external costs have been extremely low. The primary care workers fill roles within the local chieftancy system as subchiefs in charge of health, the midwives are retrained traditional birth attendants, and the monitors appear to fill a social role analogous to that of the midwives.

The medical doctor and 20 public health nurse auxiliaries (secondary school graduates) in Yako supervise 200 village-level primary-care workers, who provide first aid and dispense simple medicines; 300 village midwives; and about 300 village "monitrices de bouillie" or weaning food monitors.

Each nurse is assigned on a relatively permanent basis to supervise and continue to develop community-level programs in from three to ten villages. Most nurses also have some additional responsibilities in the hospital or as dispensers of pills for chronic diseases such as leprosy. Dr. Gourier himself spends most of his time in the field and personally visits each of the 100 or more participating villages at least once a year.

Within this program, malnourished children have regularly been identified by vaccination teams and referred to seven rehabilitation centers. The rehabilitation centers have served as field laboratories for evolving the low-cost local weaning food recipes used to rehabilitate the infants, and taught to mothers in the villages. They also serve as the centers for training village-level workers, who remain one month in residence for primary-care training, two weeks for midwifery, and one week for the role of weaning food monitor. (See Study II, Nutrition Education, in this series for a fuller description of nutrition rehabilitation centers.)

Group nutrition education lessons and weaning food demonstrations are provided once a month to all mothers in participating villages by the following, "echo" method: groups of monitors, who are themselves mothers of preschoolers, meet with their public health nurse supervisor in a central market village to learn and rehearse the month's lesson, which is structured as a question-and-answer session. Each monitor then returns home and repeats the lesson and the cooking demonstration with her own neighborhood mothers. Monitors also provide nutrition education individually to

the mothers of weaning-age children and are responsible for simple screening and referral of several malnutrition cases, treatment of eye infections with zinc sulphate, and for making regular home visits to children recently discharged from a nutrition rehabilitation center.

Because of the apparent success and potential outreach of the Yako model, other health and nutrition programs in Upper Volta have been motivated to replicate its best features. To date, however, none of the three or four small-scale pilot projects attempting to reproduce the Yako service structures have been in operation long enough for it to be possible to draw conclusions concerning the program's replicability within the constraints of current government programming. Moreover, until the present survey, no formal attempt had been made to study nutrition education and weaning food development in Yako. Although improvement of nutritional status was clearly reflected in the declining numbers of children referred to the rehabilitation centers by vaccination teams and village workers, the impact of the program on nutritional status of the region also had not been assessed.

IV. THE CASE STUDY SURVEY

In April 1978, nutritionists from the nutrition cells of the Ministry of Rural Development (MRD) and the Ministry of Health (MOH) collaborated with USAID and the Harvard Institute for International Development in conducting a small preprogramming study of weaning food development. Yako was selected as the MOH project site. Villages in the neighborhood of a town called Koupele were selected by the Ministry of Rural Development both for the quality of the MRD program and the accessibility of the location.

A. Survey Procedure and Sampling

Survey teams representing the nutrition cells in both ministries visited Yako and Koupele, respectively. According to the sampling plan and methodology, the two teams from the capital, Ouagadougou, were to enlist the assistance of exemplary middle and village-level nutrition educators in the evaluation of their programs. The decision was made to survey the best sample each site had to offer rather than to sample randomly, because the goal of the survey was to observe each program operating at full potential. With a total sample of only 100 mother-infant pairs, the inclusion of mothers who had not had access to either program because of lack of transportation or worker supervision, for example, would have effectively risked not observing the program in operation.

The implementation of this plan differed in the two sites. In Koupele four nutrition educators, who were middle-level home economics "animatrices," directed the team to interview mothers with whom they worked directly and some neighboring mothers within their project villages. These samples were relatively representative of the families receiving nutrition education, but may not have been typical of the villages as a whole. In Yako, on the other hand, mothers of all weaning-aged children (6 to 24 months) in three villages were interviewed. These three villages were

served by four village-level weaning food monitors, under the supervision of the same public health nurse. Sample sizes totaled 40 in Koupele and 62 in Yako.

B. The Data and Their Limitations

The questionnaire investigated a number of sociodemographic variables: mother's time use; family meal patterns; knowledge, attitudes, and practices relating to weaning foods; child's diet over the past 24 hours; and weights as registered on CMS infant scales (CMS Weighing Equipment, London), lengths, and arm and thigh circumferences of the infants. Lengths were measured with fiberglass tapes on mats on the ground by some interviewers because the number of length-measuring boards was insufficient. Budgetary and time limitations did not allow for a pretest of the questions in the field for precoding purposes or for more than minimal interviewer training and interobserver standardization. Thus, although all interviewers were experienced field workers trained in nutrition and literate in French, their interpretations of some of the questions differed. The 24-hour dietary recall in particular suffered because some interviewers did not understand the desirability of quantifying amounts eaten by the infants and of probing to discover foods eaten in addition to the staple. Age registration presented some problems.[1] The questionnaire was drawn up with the assistance of several anthropologists, but because it could not be pretested, some of the findings are more useful for defining further questions than for suggesting definitive answers. These questions will be noted as they arise.

Regarding the comparability of the two locations studied, Yako and Koupele are both primarily Mossi in ethnic composition, although some Bissa, a tribal group closely related to the Mossi, also live in Koupele. While Koupele is slightly more distant from the capital than Yako, it can be reached by car over an asphalt road in less than two hours; whereas Yako is at least a three hours' drive over a dirt road, which limits its accessibility during the rains. Although no reliable figures exist, the chief of the nutrition cell of the Ministry of Rural Development estimated informally that the Koupele region might be marginally wealthier than Yako. However, families estimated that the mean number of months during which they had to ration their food supply was ten in Koupele, versus seven in Yako. The meaning of the question "When do you start rationing food?" may have been differently understood when posed by different interviewers, however, since in the Yako sample the reply was significantly correlated to the number of meals eaten by the family per day, whereas this correlation was not present for the Koupele group. As the majority of rural Voltaic families are known to experience shortages before the October harvest, different families or groups may in fact practice different rationing strategies.

C. Survey Results

We will present here the salient results of the survey. Those readers who want greater detail should consult Appendices C and D.

1. Sociodemographic and Dietary Information

Based on the survey results, Table 20 presents a sociodemographic comparison between the two groups. Typical Mossi families live in compounds composed of round, mudbrick, thatch-roofed huts joined together by a mudbrick wall. The compounds composing a typical village of 1,000 inhabitants may be spaced 10 to 30 yards from one another. Mossi women divide their farming time between their husbands' sorghum and millet fields and their own private fields in which they grow vegetables and some grain. Appendix C, Tables C-1 to C-3 present fathers' and mothers' occupational activities by program and mothers' aspirations for their infants, which will later be shown to be significantly related to nutritional status.

Koupele appeared to be more integrated into the modern sector than Yako in that significantly more families were growing cash crops and thus had sources of cash income, and significantly more mothers desired their children to attend school (50% in Yako versus 75% in Koupele). In Yako 50% of mothers wanted their children to have traditional occupations, versus 13% in Koupele. A higher percentage of Koupele families found it necessary to purchase firewood, suggesting that cash cropping may have reduced areas of fallow land. Yako families appeared slightly more likely to be polygamous, possibly because of slightly higher rates of outmigration of young men. The Yako mothers lived farther from their sources of water (all water was from wells), but had more help in fetching water and significantly more child care assistance. Significantly fewer meals were cooked per day in Koupele than in Yako, and the number of months that families claimed to ration food was 9.9 in Koupele versus 7.1 in Yako (although this difference was not statistically significant).

It would be of interest to know whether and to what extent cash crops were displacing food crops in Koupele, and the rate at which cash cropping plus increased growing of cereals to match population growth was depleting the fragile holding capacity of the topsoils of the area. An anthropological study by Grace Hemming (in preparation) in Fada N'Gourma disclosed that increased cash croppings, primarily of cotton, by the men took them away from farming sorghum on the family plots, thus leaving the women the main responsibility for growing staple grains for the household in addition to farming their private fields, from which they traditionally provided much of the food for the children. This study suggested that cash cropping might produce a net negative effect on nutritional status of vulnerable groups by increasing the amount of labor required by women for subsistence food preparation. More market gardening might be expected in Koupele because forming market gardening cooperatives among women was one of the tasks of the home economists.

2. Family Meals

The design of any weaning food intervention must have a clear understanding of the family's meal pattern. The staple food, called to, was a sorghum or millet porridge which varied in consistency from barely firm enough to form into bite-sized balls with the fingers to the stiffness of scrapple, and which was cooked by a rather lengthy process in

TABLE 20

SOCIODEMOGRAPHIC AND DIETARY INFORMATION SUMMARY FROM 102 VOLTAIC FAMILIES IN YAKO (N=62) AND KOUPELE (N=40)

Sociodemographic Information	Yako Mean (Sd)		Koupele Mean (Sd)
No. huts/family	4.46 (1.7)		4.82 (2.2)
No. wives/family	2.31 (1.2)		1.98 (1.0)
No. huts/wife	1.93		2.43
No. children of sample mothers	3.18 (1.4)		2.75 (1.5)
No. children/hut	1.65		1.13
% mothers without child-care helpers	11%	(.005)*	39%
No. fields/sample mother	2.47 (1.5)		2.92 (1.5)
% fathers with cash income	71%	(.05)*	90%
% mothers with cash income	27%		35%
% mothers desiring child to attend school	50%	(.025)*	75%
% mothers desiring modern sector occupation for index child	58%	(.005)*	87%
No. months in year practice rationing	7.1 (21)		9.9 (21)
Meals/family/day	2.08 (0.6)	(.0035)*	1.71 (0.6)
Meals/wood-gathering trip	4.02 (2.0)		4.00 (1.9)
Hours/wood-gathering trip	3.24 (2.8)		3.54 (1.9)
No. families purchasing firewood	1(2%)	(.05)*	9(23%)
Distance to well (km estimate)	0.8 (.5)	(.000)*	0.27 (.4)
Mother alone fetches water	44%		63%
Other family members assist in fetching water	56%		37%

*Level of significance of differences between Yako and Koupele.

Cost of purchasing protein supplement for bouillie: five West African francs (CFA)/bouillie for one or two children.

Cost of firewood averaged 11.1 CFA per family meal, not including cooking of bouillie or other smaller meals. Average per actual cooking was probably closer to five CFA/adult meal and two to three for bouillie.

order to produce the desired textures. The women used large wooden mortars and pestles to thresh and crush the grain, and grinding stones inlaid in large earthen tables to produce finer flour. Both sorghum and millet also were used for brewing a beer called dolo. At meals, bit-sized balls of to were broken off from larger balls in a communal bowl or calabash and were dipped into a communal bowl of sauce. Sauces were made with a variety of vegetables, including a number of kinds of tree leaves and fruits. Sauces also tended to include a high-protein ingredient such as fermented nere seeds, dried fish, or, very occasionally, some kind of meat. Men, women, and children tended to eat in separate groups, with the youngest children eating with their mothers. The fact that family members were not served individual portions made dietary intake studies particularly difficult.

In well-functioning polygamous households, the wives took turns cooking common meals which were shared by the entire family. Wives who were not on cooperative terms with each other cooked separately for themselves and their children. While taking turns in cooking saves time for each wife, the communal meal might be too skimpy to satisfy all of the children and might be prepared rather late. Thus, it was customary in most households for the mother to supplement the family meals as she considered necessary by preparing some food individually for her own children.

Table 21 presents an overview of family meal patterns in Yako and Koupele. The questionnaire did not probe for the smaller meals or snacks prepared by individual mothers, so that meals listed were main family meals. Consumption of leftovers from the night before may have been common in the morning, but also was not specifically investigated. The list of sauces and other foods consumed is not inclusive because the questionnaire did not ask about foods which were not mentioned spontaneously. It is known that many wild fruits and leaves were gathered and eaten and that these probably contributed substantially to micronutrient intake. But it has proven difficult to include gathered foods in consumption studies because neither the subject population nor the interviewers tend to consider them seriously as foods (Robert Winterbottom, personal communication 1978).

The main problems that the Mossi meal pattern posed for the weanling child was the bulkiness of the staple and insufficient frequency of meals. The one- to three-year-old should eat at least four to five times a day. A special weaning food may continue to fill a need by providing additional meals beyond the age when the child starts to share in family meals. Since most infants were breast-fed on demand for 24 to 36 months (Martin-Santos et al. 1977), breast milk continued to be a significant but insufficient source of frequent nourishment.

3. Nutrition and Health Status of the Sample Infants

The nutrition and health status of the sample children in Yako and Koupele are presented in Tables 22 and 23. Relationships between nutritional status, knowledge and attitudes of the mother, dietary practices, and other sociodemographic variables will be examined later. Differences in nutritional status between the two samples are presented here as the outcome variables used to measure the impact of the Yako and Koupele

TABLE 21

FAMILY MEAL PATTERNS

	Yako			Koupele	
Respondent cooked yesterday	46	(75%)		29	(85%)
Co-wife cooked	7	(11%)		5	(15%)
Respondent and co-wife cooked	6	(10%)		0	
(Of polygamous families - whole family ate together yesterday)	35	(80%)		18	(90%)
(Of polygamous families - respondent and children ate alone)	9	(20%)		2	(10%)
No. meals cooked yesterday					
1	7	(11%)		13	(37%)
2	43	(69%)	(.000)*	19	(54%)
3	12	(19%)		3	(9%)
Mother-in-law cooked	2	(3%)		0	

	Yako (N = 62)		Koupele (N = 36)	
	No. Families Cooked To	Ate Leftovers	No. Families Cooked To	Ate Leftovers
A.M.	45 (73%)	1	15 (42%)	
Noon	20 (32%)		7 (19%)	
P.M.	54 (87%)	1	34 (94%)	

Sauces cooked yesterday:	Yako
None	1
Combo	13
Baobab	4
Kapok leaves/flowers	7
Kapok grains	5
Oseille	2
Other leafy vegetables	1

(Only sauce for first meal is listed because question regarding sauce for second meal was inadequately specified. Sauces were not listed for Koupele sample.)

Other foods eaten by families:	Yako	Koupele
Rice	1	5 (14%)
Beans	2	-
Beignets (kind of doughnut)	1	-

TABLE 22

NUTRITIONAL STATUS OF INFANTS IN YAKO AND KOUPELE

	Yako				Koupele		
	N	Mean	(Sd)		N	Mean	(Sd)
1. Weight for Age							
a. All 6-27 mo. infants	54	85.0	(9.1)	(.025)*	36	79.6	(14.6)
b. 6-27 mo. infants with exact ages (MCH attenders)	51	85.0	(9.6)	(.1)*	24	80.8	(14.6)
2. Length for Age							
a. All 6-27 mo. infants	54	96.9	(4.7)		36	95.6	(5.8)
b. 6-27 mo. infants with exact ages	51	97.1	(4.4)		24	96.5	(5.1)
3. Weight for Length							
a. All 6-27 mo. infants	54	90.0	(8.2)	(.1)*	36	87.2	(10.7)
b. 6-27 mo. infants with exact ages	51	89.8	(8.1)		24	87.5	(12.2)
4. All 6-27 mo. infants falling into nutritional categories	N	%			N	%	
a. Weight for Age**							
> 90%	15	(27%)			9	(24%)	
75%-89%	34	(61%)		(.03)*	15	(41%)	
< 75%	7	(12%)			13	(35%)	
b. Weight for Length							
> 85%	41	(73%)			17	(46%)	
75%-84%	14	(25%)		(.01)*	15	(40.5%)	
< 75%	1	(2%)			5	(13.5%)	
5. 6-27 mo. children with exact ages falling into nutritional categories							
a. Weight for Age							
> 90%	13	(25%)			7	(29%)	
75%-89%	32	(63%)		(.1)*	10	(42%)	
< 75%	6	(12%)			7	(29%)	
b. Weight for Length							
> 85%	37	(72%)			13	(54%)	
75%-84%	13	(26%)		(0.045)*	7	(29%)	
< 75%	1	(2%)			4	(17%)	

*Level of significance of differences between Yako and Koupele.

**Percentages of weight for age (weight/age), length for age (length/age) and weight for length (weight/length) were calculated against the international reference standards established by WHO (1978).

NOTE: The lowest weight for age in the Yako sample was 65%, with only two children below 70%. Two infants in the Koupele sample had weights for age of 42% and 44%, and nine were below 70%.

TABLE 23

HEALTH AND DEVELOPMENT OF INFANTS IN YAKO AND KOUPELE

	Yako			Koupele	
Health Status					
well now	51	(82%)		21	(53%)
sometimes or often has condition specified	--			9	
sick now	12	(18%)	(.005)*	19	(47%)
Health Problem					
eye infection	3	(2%)		--	
respiratory	3	(5%)		3	(8%)
fever/malaria	1	(2%)		5	(13%)
diarrhea/vomiting	4	(8%)		6	(15%)
respiratory and fever	--			4	(10%)
diarrhea and fever	1	(2%)		7	(18%)
Mother estimates child is growing and developing:					
well	57	(93%)		27	(68%)
poorly or has problem	4	(7%)	(.005)*	13	(32%)

* Level of significance of differences between Yako and Koupele.

programs and thus as points of reference to assist the reader in attempting to interpret the significance of the remaining survey results. Tables 22 and 23 show that the Yako infants were significantly better nourished and healthier than the Koupele group, despite the fact that all the children in the Yako villages were surveyed whereas the Kouple sample was drawn from families known to the interviewers and some of their neighbors.

Comparisons in Table 22 items four and five, which show distribution of infants by malnutrition category, yield higher levels of statistical significance than are found between mean values of weight for age (weight/age) and weight for length (weight/length) presented in items one through three. The most important difference between the two locations may thus be the relative lack of children falling into the severely malnourished category in Yako in comparison to Koupele. Since detection and referral of severely malnourished children to rehabilitation centers has been a focal strategy of the Yako program, lack of severe malnutrition may reflect this emphasis on intervention when malnutrition becomes noticeable. However, since none of the children surveyed had attended a center, the detection of incipient malnutrition and intervention in the village by the weaning food monitor would have had to have functioned preventively.

Mean differences of four to five percentage points in weight/age also are important. Infants with exact ages in the Koupele group were those with MCH growth charts, indicating they were recipients of two interventions, both from the home economists of the Ministry of Rural Development and from the local MCH program. These infants were significantly better nourished in weight/length than infants without exact ages. Figures for those without exact ages are included because it is assumed that the single yearly age estimate usually underestimates rather than overestimates actual age and that their poorer nutritional status probably more closely reflects the condition of recipients of the Rural Development nutrition program only. As is usually the case in such comparisons, weight/age functions more sensitively than either length for age or weight for length as an outcome variable for determining statistically significant differences between populations. This greater sensitivity results from the fact that variances in weight/age includes variation caused by both length and weight/length.

More infants were ill in Koupele than in Yako. Unfortunately, the study was not able to look closely enough at the nutrition-infection interaction to conjecture the extent to which high endemic infection caused malnutrition, versus the extent to which poor nutritional status predisposed to infection.

4. Differences in Intervention Design Characteristics Between the Yako and Koupele Programs

Two middle-level home economics field workers in Koupele and four village-level weaning food monitors in Yako were interviewed concerning their work. Although this number is very small, those interviewed were considered above average in performance by their superiors and therefore representative of each program functioning at maximum or near-maximum potential.

The women in both categories carried individual caseloads of from 20 to 40 families and delivered nutrition and health education talks and weaning food demonstrations at least once a month. Two of the weaning food monitors delivered talks monthly, one twice monthly, and one gathered all of the women in her neighborhood together to cook weaning food every Thursday evening. One of the home economists held three meetings a month.

Nutrition-related messages taught by both categories of workers appeared superficially to be similar. Although each talk included a weaning food demonstration, sanitation and other topics were discussed by both groups of workers, including cleanliness of wells and planting of trees. Major differences were that the home economists were paid, full-time workers earning $50 to $60 a month and whose job descriptions included agricultural extension activities, such as organizing the gardening cooperatives. The weaning food monitors were unpaid, part-time workers who gave about an average of seven hours a week specifically to nutrition education. Although these women were generally not paid, to call them volunteers probably would be no more accurate than to refer to the similarly unpaid village midwives as volunteers, because their service roles were taken more seriously than the word "volunteer" normally connotes. Dr. Gourier and his staff did encourage the village communities to reimburse monitors and midwives in the same way in which the subchiefs for health were recompensed by communal work in their fields equivalent in person-hours to the number of hours given by the subchief to health care of the community.

The monitors lived permanently among the families whom they served. Thus, in the open-air lifestyle of the villages, where neighbors observe each other's activities, the monitor could notice and give advice concerning the feeding of infants at any time without being technically "at work." Most home economists, on the other hand, experienced difficulties in being stationed "alone" in bush villages because of strong cultural values placed on marriage and child-bearing. Dropout rates among these workers were very high because the job could not be conveniently combined with marriage to men of their social class. At the time of the survey the Ministry of Rural Development was starting to attempt to solve this problem by training wives of agricultural extension agents as home economists so that husband-wife teams could be stationed together. The Yako approach to the problem of lack of permanence of middle-level workers was to recruit for training only those individuals who had been settled in the region for five years or more even if this meant training persons of a lower level of literacy than would be desired.

It is likely that formats of the nutrition talks given by the two categories of workers also differed. Formats used by the home economists were not provided to the writer, but may have tended to repeat the lecturing mode by which these workers had been taught during their own formal schooling. Formats for the Yako talks were specified in question-dialogue form which insured learner participation. The translation of one such Yako talk is given as Table 24 (Comite de Sante Infantile Secteur No. 10 de Yako 1976).

TABLE 24

HEALTH TALK FOR THE MONTH OF FEBRUARY 1976

SUBJECT: Nutrition
MATERIALS: One large and one small calabash

1. What is a healthy baby?

2. Up til six months when the mother's milk is enough, what is the baby like?

3. When is it necessary to give bouillie* to the baby? Why?

4. Should a baby eat bouillie when he has one tooth?

5. Look at this big calabash; you could fill it with mother's milk every day during the baby's first days of life. Does the baby have enough to eat? Now look at this little calabash. When the baby has two teeth, it is all that the mother gives him. Is it enough? What do we need to give him so that he eats enough? He ought to eat more because he is bigger.

6. Do you eat to only once a day?

7. If you only eat a little bit of to every day, what happens?

8. Do you eat to without sauce?

9. What do we need to put in the bouillie?

PROVERB: "When the stomach is filled, misery is strangled."
(A baby who gets both milk and bouillie, no need to fear illness.)

*Bouillie: either with baobab fruit or with dried fish flour.

An important difference between the two programs was their duration at the time of the survey. The Yako survey villages had participated in the intervention for the previous four to seven years, whereas the Koupele program was less than four years old. According to Dr. Gourier, the Yako program had taken at least two or three years to start functioning efficiently.

Another critical difference in design between the two programs was the nutritional quality of the recipes for bouillie taught in the two locations. Yako mothers consistently stated that they added a variety of protein- and calorie-rich supplements to their flour porridge, whereas only about 30% of mothers giving recipes in Koupele claimed to add such supplements. The result was that average recipes given in Yako were of high nutritional quality, whereas those given in Koupele generally were not adequate.

As mentioned in the previous chapters, cereal-based weaning foods often create problems because of the bulk constraint. When an unenriched cereal porridge is prepared in a dilution which is soft enough for a baby to eat, it does not provide enough calories or protein in ratio to its volume, so that the infant's stomach is filled before its nutrient needs are satisfied. This problem may be reduced but is not overcome by feeding the baby more frequently. The nutrient densities of recipes commonly given in Yako and Koupele were calculated from average amounts of ingredients specified and are given in Table 25 together with breast milk and cow's milk as points of reference. The Koupele recipes specified slightly more sugar - about six calories per ounce bouillie versus about five calories per ounce in Yako. Lemon and tamarind were not counted as contributing to nutrient content. The calculations are based on the ratio of water to flour taught in Yako: 250 grams to two heaping tablespoons (Comite de Sante Infantile Secteur No. de Yako undated). The consistency of thick custard is as the interviewers perceived it at a weaning food demonstration in Yako.

Table 25 illustrates the following points:

- Bouillie without additives is unsatisfactory in nutrient density of either calories or protein.

- Sugar alone can increase caloric density to the level of breast or cow's milk.

- Flour bouillie without a protein-rich additive is insufficient in protein quality and quantity.

- All the protein additives improve protein quantity to within an apparently adequate 12% to 16% protein per calories (Scrimshaw 1978), and also add substantially to caloric density. Thus 24 ounces or three cups of protein-enriched bouillie per day could readily supply the 680 calories estimated to be needed by a 12-month-old infant in addition to breast milk (Zeitlin and Formacion, Volume II, Nutrition Education). This

TABLE 25

AVERAGE NUTRIENT DENSITY OF BOUILLIE RECIPES

	Cal/Oz	Pro/Oz(g)
Breast milk	20	0.3 very high quality
Cow's milk	20	1.0 high quality
Plain sorghum or millet bouillie	14	0.3 low quality
Plain sorghum or millet plus sugar (77% in Koupele)	20	0.3 low quality
Flour plus soumbala plus sugar (84% in Yako, 28% in Koupele)*	28	1.1 medium quality
Flour plus groundnut cake plus sugar (52% in Yako)*	25	0.9 medium quality
Flour plus groundnut butter plus sugar (26% in Yako)*	36	1.1 medium quality
Flour plus tomato plus sugar (26% in Yako)*	19	0.4 low quality
Flour plus powdered fish plus sugar (35% in Yako, 3% in Koupele)*	20	0.6 high quality
Flour plus dried skim milk plus sugar (10% in Yalo, 3% in Koupele)*	28	1.5 high quality
Flour plus nere seed plus sugar (10% in Yako)*	25	0.7 medium quality

*Percentage figure of all mentioning protein supplement includes some mothers not using sugar. Sugar added an average of five calories/oz. in Yako and six calories/oz. in Koupele.

Note: Calculations are based on the water-to-flour ratio taught in Yako, 250 g water: two tbsp flour (Comite de Sante Infantile, Secteur N 10 de Yako, undated.

finding is no surprise since the same bouillie recipes used in the home in Yako were developed and successfully employed to recuperate severely malnourished children in the rehabilitation centers. (To say these foods are good supplements, however, is not to claim that they are adequate breast milk substitutes.)

5. Measuring Intervention Effects

With the wide variety of educational topics presented and other inputs of an integrated nature, including health care, water supply (the Yako program assists villagers to build new wells), and market gardening, for example, a wide spectrum of intervention effects might be expected to affect the nutritional status of infants in both Yako and Koupele. The present survey was not designed to look inclusively at these effects, but rather to focus on weaning food development and on closely related weaning practices and attitudes.

Weaning practices not directly related to bouillie are included in the summary overview of weaning practices presented in Appendix D, Table D-1. The estimated quantities of foods eaten presented in this table were based on small sample sizes and are likely to be inaccurate because spoons were not used for eating; consequently, these data were not used for statistical analysis. There is little doubt from the table, however, that Yako infants were starting supplementary foods earlier, and eating larger quantities of foods of better quality.

6. Knowledge of Bouillie

In answer to the question, "What is bouillie?" all of the Yako mothers and 78% of the Koupele mothers stated that they had heard of this food and were able to give varying definitions (see Appendix D, Table D-2). Fifty-eight mothers (94%) in Yako and 31 mothers (78%) in Koupele were able to give recipes for bouillie. Incorrect recipes, using unusual ingredients such as beer or specifying too small quantities, such as a pinch of flour, totaled one (2%) in Yako and five (13%) in Koupele.

However, the concept of bouillie appeared to differ in the two locations. All 31 mothers in Koupele gave a single recipe each, whereas 53 mothers in Yako (91% of those giving recipes) volunteered two or more recipes using alternative ingredients, such as soumbala (fermented nere seeds) and groundnut cake, for protein enrichment. The mean number of recipes given in Yako was 2.8; the mode, three; and the range from one to five. Thus, in Yako bouillie was conceived to be a type of food with numerous variations, whereas in Koupele it was considered to be a single food item.

7. The Recipes

As mentioned previously, the recipes given in Yako were nutritionally superior, in that only two Yako mothers specified a bouillie recipe without a protein-rich ingredient. By contrast, 70% of recipes given in Koupele consisted only of flour, sugar, and flavoring of either

lemon or tamarind. Nine mothers in Koupele (23%) versus one mother in Yako (2%) specified the use of millet flour in preparing bouillie, which put them at a comparative disadvantage to those using sorghum because millet is not as universally available. Ingredients used in cooking bouillie and average nutrient content of recipes given are presented in Appendix D, Tables D-3 and D-4. It can readily be seen from these tables that the average caloric content of recipes given by Yako mothers is almost double, and the average protein content is almost triple the amounts specified in Koupele. Counterbalancing this inequality, however, is the fact, presented in Table D-9, that Yako mothers are somewhat more likely to give bouillie to several children rather than to the baby only.

8. Attitudes, Perceptions, and Other Factors Affecting the Use of Weaning Food

Questions investigating reasons for the use or nonuse of bouillie examined food beliefs, the acceptability of bouillie, and its perceived effects on the infants. Food taboos, as listed in Appendix D, Table D-5, appeared to be common, particularly in Yako, but, as found previously by Martin-Santos et al. (1977), not of a nature that affected weaning practices. The common harmful practice of restricting the foods given to sick children also did not seem to be a part of the Mossi culture.

About one fourth of the infants in both locations had initial problems with bouillie, but Yako mothers appeared to be more persistent than Koupele mothers in overcoming these problems (Appendix D, Table D-6). Significantly more children in Yako (95%) than in Koupele (77%) were said to like bouillie at the time of the interview. The most common specific reason given by the mothers for liking the taste of bouillie was the presence of sugar. The field workers unanimously agreed that sugar increased the acceptability of the food to the infants. In answers to the question "Have you noticed any changes in the child since you started feeding bouillie?" a majority in both locations perceived that the child had grown either bigger and fatter or healthier (Appendix D, Table D-7). The percentages perceiving no change or negative changes were 4% in Yako versus 31% in Koupele.

To the direct questions "Why don't you prepare bouillie regularly?" and "Why don't you prepare bouillie more often?" the answer, "Think it would make child sick," was given by some mothers in Koupele but not in Yako (Appendix D, Table D-8). This suggests that this natural fear had been overcome by the Yako monitors. The answer "Used to but child is grown," or "Child eats adult foods," reveals a source of imprecision in the survey, which did not clearly distinguish between children who were receiving bouillie infrequently because they had graduated to the family diet from those who were not receiving it because their mothers had never regularly prepared it.

The question whether or not the mothers could afford to prepare bouillie is an interesting one. There was a general consensus among mother and monitors that it cost an average of 5 to 10 West African francs (CFA for the protein-rich ingredient used in making bouillie if this had to be

purchased. (This cost question was asked of 19 mothers, although it was not on the questionnaire.) In about 85% of the cases, this ingredient was not produced in the home. Monitors and mothers also asserted that not all women could afford to pay this amount; however, very few mothers claimed that they personally could not afford it. Still 10 CFA/day would have been more than one third of the cash income of a mother making 200 CFA/week, and many women had no cash incomes, although they may have received the money from their husbands.

9. Practices Regarding the Preparation and Consumption of Bouillie

The mothers' answers to questions concerning their habitual preparation and feeding of bouillie to infants is found in Appendix D, Table D-9. The fact that some children already had graduated from bouillie while others still were dependent on it or rarely ever received it made it difficult to interpret the meaning of frequency of consumption for any given child. Some mothers also apparently told the interviewer the frequency with which they normally prepared bouillie when their babies were eating it regularly rather than the frequency with which they were cooking it currently. The frequency of cooking bouillie was significantly higher in Yako (with a mode of twice per day) than in Koupele. The likelihood that bouillie was fed to more than one child or adult rather than to the weanling only was marginally higher in Yako (71% versus 63%) where the mode was once per day, as noted earlier. The average age given for stopping bouillie by the few mothers who specify an age in months was 15 months in Yako versus 11 months in Koupele.

The length of time bouillie was kept after cooking and the number of times it was served were problematically related to nutritional status, as will be shown later. The message of how to store bouillie, however, had been tailored to local conditions in Yako, where 41% of mothers who kept the food after cooking stored it in a calabash. None in Koupele stored it that way.

10. Factors Significantly Related to Nutritional Status

The foregoing knowledge, attitudes and practices provide insights into some effects of the program. However, to gain a greater understanding of the program's nutritional impact and the underlying determinants we analyzed the relationships between nutritional status and other variables. From this analysis the major findings were:

a) that the age of introducing supplementary foods was negatively correlated with nutritional status (late introduction, poorer status);

b) that the amount of bouillie eaten by the infant was positively correlated to nutritional status in Yako where nutritional quality of bouillie was adequate, but not in Koupele where nutritional quality was inadequate.

c) that keeping bouillie for several hours in tropical heat and feeding it frequently were negatively correlated to nutritional status, although mechanisms for this correlation were not clear.

d) and that other variables, such as morbidity and wealth indicators, correlated with nutritional status in the same ways that these variables have been found to correlate in other studies (contrary findings could indicate poor-quality data).

Appendix E presents the detailed results of the correlation analyses from which the foregoing conclusions were derived.

V. COST-EFFECTIVENESS ANALYSIS

Cost-effectiveness analysis is presented primarily for the Yako program, because evidence that the introduction of weaning food in Koupele has resulted in improvement of nutritional status is not conclusive. In Yako, the evidence points to the conclusion that monitored supplementation with protein and calorie-enriched bouillie has succeeded in preventing the nutritional status of infants from deteriorating during the weaning age.

Costs will be divided into fiscal costs paid by central or regional government and community costs paid by local government, and community, and private individuals or families. Funding from outside donors will be considered to fall under fiscal costs because grants and loans generally represent financial responsibilities to be borne by government over the long run. Fiscal costs are useful to funders and planners for budgeting purposes and community costs are of relevance to local program design and to estimates of whether programs that succeed in some communities could be afforded by others.

A monetary value has been attached to mothers' time for some calculations. However, a more realistic estimation of the value of time spent in nutrition education and in weaning food preparation would be the ratio of the number of hours spent in these activities to the number of hours required for subsistence activities. If, for example, 12 hours per day were required for subsistence, one hour per day spent in weaning food activities would roughly represent one twelfth of time required for subsistence. Such a realistic calculation would have to weight this expenditure against the benefits of having a healthier infant requiring less special care, of having a lower percentage of infant deaths, and of producing children better capable of assisting the family later. Although information for making these cost-benefit calculations was not gathered, the overwhelming impression of the observers and participants was that the benefits outweighed the costs. An additional benefit of learning to adopt innovation also was gained from the experience of participating in weaning food activities. Because of the lack of precise data and the potential offsetting nature of the benefits, the imputed monetary value of mothers' and monitors' time was excluded from the consideration of cost effectiveness in the conclusions section.

The indicators calculated are annual costs per beneficiary of providing the entire community-level health care package in Yako and of providing nutrition education in both Yako and Koupele; and of costs per mother of teaching an adequate weaning food recipe in Yako, and of costs per child of malnutrition averted by the Yako program. The first two of these indicators measures operating costs, while the second two estimate cost effectiveness.

The cost of achieving a particular nutrition or health outcome by a particular method cannot be calculated by simply dividing the cost of the program by the number of positive outcomes, because some individuals will stay well-nourished or get well with the application of any program or of no program at all. The cost of achieving an outcome by a method or program must be derived and interpreted by comparison with alternative results which would have occurred under alternative circumstances. The calculation generally involves the analysis of a series of program components or subcomponents. In the present case, results of such an analysis are given below, while the procedures used to derive these results are presented in Appendix F.

A. Marginal Costs

Annual fiscal costs for the Yako village-level health and nutrition program are summarized in Table 26. These were the incremental costs of running the community-level program in addition to the typical district health program in approximately one third of Yako District. Estimations of annual fiscal and community costs for the nutrition component of programs in Yako and Koupele, with comparable fiscal costs but different designs, are listed in Table 27. The costs in this table are presented separately by component because different combinations of components may be used in the calculation of cost-effectiveness for the purpose of making different types of decisions. As an example, the cost of the entire village-level health program is included as component C. While the entire program accomplished far more than improvement of nutritional status of preschoolers, it can be argued that improvement of nutritional status could not be guaranteed unless the entire program were functioning. Thus, a planner desiring to improve nutritional status must be aware that marginal cost-effectiveness figures for averting malnutrition that do not take total health costs into consideration are a grave underestimate of actual costs, unless the funds for the rest of the health program are provided from another source.

B. Cost Effectiveness

Fiscal costs per recipient of the entire health package, including simple primary care and emergency referral, were $0.29 per person per year. Cost per preschool, pregnant, or lactating recipient came to $0.68 per person per year. Fiscal costs for the services of the weaning food monitors were $0.02/mother beneficiary/year and $0.026/mother who learned a correct weaning food recipe. If mothers' and monitors' time is given a monetary value of $0.01/hour and monitors' time is included, the cost rises to $0.09/mother beneficiary/year. If mother's time is also included, the figure rises to $0.33/mother/year. As mentioned previously, however, addition of

TABLE 26

ANNUAL FISCAL COSTS OF YAKO
VILLAGE-LEVEL HEALTH AND NUTRITION PROGRAM

	UNIT COST	TOTAL COST
On-going training required to maintain total of 200 primary care workers; 300 traditional midwives, and 300 weaning food monitors		$1,800
New supply box yearly for primary-care workers and midwives	$9/box	$4,500
Medical supplies for primary-care workers (quarterly)	$17	$13,600
Supplies for midwives (quarterly)	$4	$4,800
1 motorbike for each of 7 rehab. centers, lasting average of 5 years	$450/bike	$ 630
gas/bike/year	$50	$ 350
Total		$25,680

TABLE 27

ANNUAL COSTS FOR YAKO AND KOUPELE NUTRITION PROGRAMS INCLUDING WEANING FOODS AND WEANING FOOD PREPARATION

	Yako	Koupele
(N of children)	(18,000)	(1,800)
A. Intermediate worker's time (fiscal)	$ 3,600	$3,600
B. Monitor's training (fiscal)	385	--
C. Entire village-level health package (fiscal)	25,680	--
D. Weaning foods (community)	178,691	6,700
E. Monitor's time (community)	1,260	--
F. Mothers' time to attend nutrition education and to prepare bouillie (community)	9,936	760

TABLE 28

MARGINAL COSTS OF MALNUTRITION AVERTED BY ADDING YAKO PROGRAM TO TYPICAL PROGRAM

(letters are defined in Table 27)

	Difference in Costs	Cost per Case of Malnutrition averted by adding Yako program to typical program		
	Yako - Koupele	wt/age	wt/lth, a.	wt/lth, b.
B	$385	$ 0.07	$ 0.21	$ 0.11
D	$171,991	$32.39	$45.55	$50.19
C	$ 25,680	$ 4.84	$14.27	$ 7.58
B+D	$172,376	$32.46	$95.76	$50.91
C+D	$197,671	$37.23	$109.82	$58.38
B+D+E+F	$182,812	$34.43	$101.56	$53.99
C+D+E+F	$208,107	$39.19	$115.62	$61.46

a monetary estimate of the opportunity costs of the mother's time is artificial because the calculation lacks a corresponding monetary estimate of the benefits to the mother of spending her time preventing her child from becoming malnourished, and because the monetary value does not describe the real value of the mothers' time.

Instead of calculating the marginal cost effectiveness of adding a community-level nutrition program to a pre-existing, typical district health-nutrition program, the cost effectiveness of the nutrition components of a typical health program was compared with the cost effectiveness of a health program which included community-level workers. The fiscal costs for nutrition services per mother per year of a typical program such as the one in Koupele are about $2.00, as compared with $0.22 for the community-level program in Yako.

C. Malnutrition Averted

Two measurements of malnutrition, weight/age less than 75% and weight/height less than 80%, are used for calculating malnutrition averted. Prevalence of malnutrition in Yako, in Koupele MCH participants, Koupele non-MCH participants, and from a national prevalence study are used in the comparisons which are detailed in Appendix F. Tables 28 and 29 give annual costs per case of malnutrition averted, broken down by program components introduced in Table 27. Table 28 gives the marginal cost effectiveness of transforming a presumed typical MCH program, such as exists in Koupele, into a community-level program operating with the efficiency observed in Yako. Table 29, on the other hand, compares the cost effectiveness of the nutrition component of a presumed typical health program, exemplified by the Koupele experience, with the cost effectiveness of the nutrition component of a community-level program, exemplified by Yako. In neither comparison is the attempt made to assess the specific effects of the home economics program in Koupele as distinct from the effects of the Koupele MCH program, because the sample size of children who were not participants of both programs was too small.

Cash cost to the communities of the foods used in preparing bouillie was higher than the cost actually borne by individual families because total costs were divided only by the number of infants who might have become malnourished in the absence of the program. A maximum cost per family for bouillie for one infant came to $23/year for families who had to purchase enrichment ingredients. This is $0.06/day, which still was high if a woman earned only about $0.01/hour.

By the calculations of Table 28, annual fiscal costs varied between $0.07 and $4.84 for each additional case of malnutrition averted by adding a community-level health and nutrition program to the typical program. The lower figure includes only the fiscal costs of the nutrition component of the community worker program, whereas the higher figure includes the costs of the entire health program. By the calculations of Table 29, annual fiscal costs per case of malnutrition averted by adopting the Yako model as contrasted to the typical model varied similarly from $0.71 to $5.25, depending on whether the entire health program is included.

TABLE 29

ANNUAL COST PER CASE MALNUTRITION AVERTED: COST-EFFECTIVENESS CALCULATED BY DIFFERENT COST COMBINATIONS

(letters are defined in Table 27)

	Yako				Koupele			
	cost	cost-effectiveness			cost	cost-effectiveness		
		wt/age	wt/lth,a.	wt/lth,b.		wt/age	wt/lth,a.	wt/lth,b.
A+B (fiscal nutrition only)	$3985	$ 0.71	$ 2.01	$ 1.11	$3,600	$13.33	$20.00	$16.82
D (only)	$178,691	$32.02	$ 90.25	$49.64	$6,700	$24.81	$37.22	$31.31
A+C (fiscal)	$29,280	$ 5.25	$ 14.79	$ 8.13	$3,600			
A+B+D	$182,676	$32.74	$ 92.26	$50.74	$10,300	$38.15	$57.22	$48.13
A+C+D	$207,971	$37.27	$105.04	$57.77	$10,300			
A+B+D+E+F	$193,872	$34.74	$ 97.92	$53.85	$11,060	$40.96	$61.44	$51.68
A+C+D+E+F	$219,167	$39.28	$110.69	$60.88	$11,060			

The lowest annual fiscal cost per case of malnutrition averted by the typical program is calculated in Table 29 as $13.33. Thus it is possible to say that use of the village-level worker program reduced the annual cost of averting malnutrition by a factor ranging from 2.5 to 19 depending on how much of the cost of the health program is included. In reality this factor probably was much larger for a number of reasons, including the impact of the village-level program on mortality, which was not studied.

Community-level preschool child nutrition and health programs have been shown to reduce infant and young child mortality rates by up to one half more rapidly than they improve nutritional status (Alderman, Wise, and Ferguson 1977). The really comparable figures for malnutrition prevalence might be claimed to include infants in each program who died during the year and their degree of malnutrition at the time of death.

VI. CONCLUSIONS

Despite the limitations of the data and the small sample of mothers surveyed, it appears reasonable to conclude that the Yako program succeeded in preventing weaning age malnutrition in a significant percentage of infants. The impact of the Koupele home economics program is less clear. Although participation in the Koupele MCH program was associated with significantly better weight/length than nonparticipation, the MCH group still showed an appreciable degree of malnutrition.

Conforming to the goals of the case study, this section will present successful approaches of the Yako program, apparent constraints limiting the effectiveness of weaning food development (together with ways in which these constraints might be reduced), and further research required to solve basic problems. The section will close with policy guidelines.

Successful approaches of the Yako program can be subdivided into the village-level delivery system for nutrition education and health care, and the message content and methods of presentation of nutrition education teaching weaning food development.

A. Village-Level Services Cost Effectiveness

The overwhelmingly favorable cost-effectiveness figures for the village-level delivery system leave no question about its desirability. As shown in the cost-effectiveness section, the system has provided in Yako simple primary care and nutrition services which include home-based weaning food development to about ten times the population covered by the traditional system, without additional middle-level personnel and at an incremental external cost of only $0.29 per year per beneficiary covered. The system appears to avert malnutrition successfully at a fiscal cost of about $0.70 per year per case (or a maximum of about $5 per case if the entire costs of the community-level health system are divided by the number of cases of malnutrition averted). This is from 1/2 to 1/19 the cost per case of malnutrition averted by the typical district health and nutrition program, without taking into account any middle-level worker

training costs (or the amount which would be required to train ten times the present number of middle-level workers to extend their coverage to match the present coverage scale of the village-level program).

B. Teaching Weaning Food Development Through Village-Level Workers

In addition to operating more cost effectively, weaning food monitors living in the village have the following advantages as nutrition educators over middle-level workers who visit the village:

- the monitors are permanent members of the community accountable to the village, rather than outsiders who are accountable to outside supervisors and who are transferred at frequent intervals.

- they are more readily available to give advice when a problem or crisis arises.

- they can conduct nutritional surveillance by observing and giving advice on the practices of their neighbors, at the same time as they and their neighbors perform their normal daily household and farming chores; thus they can transmit nutrition information informally within the normal village communications network, with far fewer logistical problems (transport into the village or trying to convene all mothers at fixed meeting times).

- as peers of the women they monitor, they may understand the problems of their neighbors better than an outsider of a different social class, and may function more credibly as role models than outsiders.

- the "echo" system of nutrition education which enlists opinion leaders of the community (the monitors) builds formally on the natural informal diffusion process, and induces learners to take on the role of teachers. These are two established methods of producing attitude and behavior change (Rachman 1970).

C. Integrated Village-Level Health and Rural Development

The need for constant surveillance and referral of weanling infants who are not faring well is indicated by several findings of the study. About 25% of infants in both locations had initial problems with bouillie. The future nutritional state of an infant who refuses the weaning food, starts to lose weight, or develops a digestive disturbance after eating it depends on an adequate response to the problem. While the weaning food monitor can counsel a mother to continue coaxing a reluctant baby to eat and can correct a deficient recipe, she cannot cope with severe diarrhea and vomiting. The sick infant who can be referred to a local primary-care worker is at a distinct nutritional advantage.

Time and resource constraints and nutritional need are real in Upper Volta and vary greatly by family. The adaptation that results in good nutritional status and good health for one household may be quite different from that of another. The presence of three or more categories of village workers who reinforce each other increases the probability that the individual family's problems will be diagnosed and solved creatively and on a continuing basis as need arises. With a marginally adequate weaning food such as bouillie, a recipe which is adequate for one infant, for example, may not be rich enough in protein and calories for another, or a preparation schedule that is sufficiently sanitary for one may cause diarrheal infection in another. The individualized care required probably can be provided better by a team than by a single individual.

Further integration of weaning food development with food production activities will be the answer that permits some families to make a nutritionally adequate adaptation to the environment, and is also important for a variety of additional reasons.

D. Message Content and Method of Presentation

The majority of mothers in both Yako (94%) and Koupele (78%) were able to give a weaning food recipe. However, the recipes given in Yako were nutritionally adequate in quantity and quality, whereas the recipes given in Koupele were deficient. A reason why the Yako recipes were adequate was that they had been tested in the rehabilitation centers and found satisfactory for rehabilitating severely malnourished infants. Yako mothers gave a variety of appropriate recipes and geared the recipe to the toddler, whereas Koupele mothers tended to give a single recipe for the 6- to 12-month-old infant. The variety and the greater age range for bouillie in Yako made it more likely that the food would be adopted for more than one preschooler living in the household, thus adding to the variety of an otherwise relatively monotonous family diet. These factors also increased the usefulness of the food to the mother, since for the same amount of fuel and effort she could satisfy several children (and possibly adults) in addition to the infant.

Presentation of the group nutrition talks that accompany the weaning food demonstration in question form is a simple method of accomplishing several desirable goals: cutting down on lecturing, insuring audience participation and encouraging group discussion, and offering the opportunity to consider arguments for both the innovative and old methods. Proverbs and songs are also successfully used in teaching nutrition in Yako, with the result that the meetings of mothers and monitors are festive occasions.

E. Constraints to Effectiveness

It is clear from the survey results and from individual impressions and interviews that mothers in Upper Volta are living close to subsistence limits in terms of the quantities of food, cash income, fuel, and water available to them. The survey results suggest that all of these resources are constraining factors which affect nutritional status. For

the planner, these findings suggest that a broad range of development projects are likely to have some positive impact on nutritional status on the condition that they improve the package of resources available to the village mother. For the nutrition educator, they imply that weaning foods that require the least amount of fuel and time to prepare and the fewest number of purchased or labor-intensive ingredients will be most successful.

The largest unsolved problem, in this respect, appears to be to establish weaning regimes that minimize cooking time and maternal effort and at the same time provide a nutritionally adequate food which does not cause infection or displace breast milk. To the extent that this problem varies individually by family, it should yield to diagnosis and solution by a village-level health/nutrition team, with the assistance of outside supervision and referral services. To the extent that it is a generalized problem which requires new nutrition education message content to be developed, it requires additional research.

Because of the apparently high cost to the mothers of preparing bouillie, an alternative to be explored is whether feeding the infant more to and protein-enriched sauce from an early age might accomplish the same goals as feeding bouillie, without requiring extra firewood and cooking time. This possibility was proposed by Canadian nurse Armande Petillon (1978), working with the IDRC to establish a similar program to the north in Gorom-gorom. Foreseeable problems in using to and sauce exclusively are the infrequent intervals at which they are prepared and the low protein content of the to - sauce combination when eaten in the usual proportions. However, the amount of sauce given to the child probably could be increased, and the practice among some families of using sauce as a first weaning food suggests that this procedure would be culturally acceptable.

F. Further Research Required to Solve Basic Problems

The mechanism by which repeated serving of bouillie after cooking negatively affects nutritional status requires investigation to answer the following questions: How long can bouillie, to, and sauce safely be kept for infant feeding? Can some local methods of storage or preparation keep the food safe for a longer period than others - for example, lowering the pH appreciably by using sorghum which has been allowed to sour by fermentation (used as a weaning food in Nigeria) or by adding tamarind? Is the bouillie, which can be afforded on a regular basis by most families, nutritionally adequate? As a supplement to breast milk? As a substitute for breast milk? Does bouillie as used actively displace and thus reduce the amount of breast milk consumed, or are mothers who overuse bouillie attempting to compensate for a lack of milk? Are there potential bouillie-enrichment ingredients that are not currently in use? If more efficient use of to and sauce can substitute for bouillie, then from what age? In what proportions and quantities? And fed on what schedule?

On the basis of answers to these questions, explicit nutrition education messages should be devised. These might include, for example, a message not to reduce frequency of breast-feeding after introducing bouillie, or messages on how long it is safe to keep bouillie based on local methods of gauging time.

G. Policy Guidelines for Weaning Food Development and Nutrition Education

Policy guidelines based on the foregoing conclusions are as follows:

(1) Existing health care and home economics programs should be extended by recruitment and training of village-level workers. These workers should include the three categories currently in service in Yako, and should also include a new category of female village-level agricultural and home economics extension agents to extend the present outreach of the rural development home economics programs.

(2) The "echo" method used in Yako should be used to teach weaning food development through village-level monitors.

(3) Weaning food recipes should:

(a) be nutritionally adequate (as proved by laboratory tests and successful use in rehabilitating malnourished infants);

(b) be varied, by the use of alternative locally available protein-enrichment ingredients and flavorings;

(c) be geared to the toddler and older preschool child in addition to the 6- to 12-month-old infant; and

(d) minimize preparation time and fuel without sacrificing safety or nutritional adequacy.

(4) Further research in a food laboratory is required:

(a) to determine the time bouillie, to, and sauce can be kept for use in infant feeding; effects of spoilage; and ways to delay spoilage; and

(b) nutrient adequacy and lack of toxicity of newly proposed ingredients or recipes.

(5) Further nutritional field research is required to determine interactions between:

(a) frequent feeding of bouillie and breast feeding; when frequent bouillie feeds reduce the amount of breast milk consumed, and when mothers who overuse bouillie attempt to compensate for a primary lack of milk.

(b) fuel, resource and child-care constraints; bouillie storage patterns, consumption, spoilage, and child growth;

(c) resource constraints and nutrient adequacy of recipes prepared regularly; and

(6) Field research also should explore:

(a) whether potential bouillie enrichment ingredients that are not currently in use exist; and

(b) whether more efficient use of to and sauce can substitute adequately for bouillie and if so, from what age, in what proportions and quantities, and fed on what schedule.

CHAPTER FOUR FOOTNOTES

[1]Most ages were calculated from birthdates recorded on MCH cards, although some were estimated in months by the local events calendar, and a few were roughly estimated in years. A question of whether birthdates were registered accurately arises because of a trend toward relatively taller infants with increasing birth order, which could be explained if mothers with several children delayed registering the birth of a new infant longer than mothers of first children, for example. Three children below six months and eight children above 24 months in age were accidentally included in the sample, and were included in the sociodemographic but not in the nutritional analyses (with the exception of three infants between 24 and 27 months who were kept in the sample). Fourteen children whose ages were given by year only were excluded from most analyses involving weight for age or length for age, whereas all children within the age range were included in weight-for-length calculations.

[2]This is a Mossi proverb in the More language: "Pubh pidyâ, baög lwèyâ." French translation: when the stomach is filled, misery is strangled.

APPENDIX A

FORMULATED WEANING FOODS

CURRENT AND TERMINATED PRODUCTS

The following table is a compendium of producers functioning as of May 1978, followed by a table of products that have terminated. The data have been extracted from a diversity of sources, some of which may be outdated. In particular, some products classified as current may have terminated production, and prices and quantities produced are subject to error. For many products, only the major ingredients are included, and percentages may not add to 100. The table is presented merely to provide an approximation of the scope of this intervention. Where data are not available, the abbreviation N.A. has been inserted. The authors would appreciate receiving corrections from readers.

FORMULATED WEANING FOODS - NORTH, CENTRAL, AND SOUTH AMERICA

COUNTRY	PRODUCT	PRODUCER	INGREDIENTS	PROTEIN (%)	P.E.R.	CALORIES (per 100g.)	FORM	PRICE ($/kg)	PRICE OF STAPLE ($/kg)	DISTRIBUTION	ANNUAL PRODUCTION (metric tons)	ANNUAL SALES (MT)
ARGENTINA	ARGENTIRINA	N.A.	sorghum wheat peanut white bean flour vit. & min.	27.8	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
BRAZIL	CEREALINA	CPC	soya corn DSM vit. & min.	20.0	2.29	425	powder	0.63	N.A.	Retail (100%)	N.A.	N.A.
	GOLDEN ELBOW MACARONI (NUTRIBOM)	GENERAL FOODS currently MATARAZZO CO.	soya corn wheat germ min. methionine	30.0	N.A.	350	macaroni	0.33	N.A.	N.A.	50	N.A.
	MACARRAO GEMINI PROTEICO	PASTIFICIO ANHANGUERA	soybeans	20.0	N.A.	340	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	SOLEIN	LATICINIOS MOCOCA	soya(23)[1] DSM(10) sugar oil	33.0	N.A.	469	powder	1.52	N.A.	N.A.	irregular	N.A.
CHILE	FORTESAN	private co.	soy oil WSB DSM	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	Retail:	FORTESAN+ 1,000	SUPERCHIL 16,000 (1975)[2]
	SUPERCHIL	private co.	soya DSM	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	Subsidized	15,000	
	LECHE ALIM	U. of Chile	FPC DSM wheat sunflower	27.0	N.A.	N.A.	powder	0.30	N.A.	Insti.[3]	80 tons per day (1972)	
COLOMBIA	BIENESTARINA	INSTI. OF TECHNOLOGICAL RESEARCH (ICBF)	soy flour(37) wheat flour(14) corn flour(42) DSM methionine	28.0	2.5	398	powder	0.52	N.A.	N.A.	5,000 (1975)	N.A.
	COLOMBIHARINA	MOLINOS SANTA RITA	precooked soya flour(30) rice flour(70)	19.0	N.A.	355	powder	0.27	N.A.	N.A.	500 (1969)	N.A.

[1]Numbers in parentheses are percentage of dry weight, given where known.
[2]Number in parenthesis is year for which data are available.
[3]Insti. is abbreviation for institutional.

COLOMBIA (con't.)	DURYEA	MAIZANA (CPC SUBSIDIARY)	soy flour corn flour DSM	28.3	2.36	345	powder	0.59	N.A.	Retail (100%)	2,250 (1974)	N.A.
	PROVESOL	INST. DE INVESTIGACIONES TECNOLOGICAS	soy protein(44)	N.A.	N.A.	N.A.	reconstituted beverage	N.A.	N.A.	N.A.	N.A.	N.A.
	VITALIA	INSTI. DE INVESTIGACIONES TECHNOLOGICAS	wheat seminola soy corn derivatives rice	17.8	N.A.	N.A.	macaroni	0.22	N.A.	N.A.	6,000	n.a.
EL SALVADOR	FRESCAVIDA	PILLSBURY (U.S.A.)	sesame seeds wheat germ sugar vit. & min. flavors	11.0	1.8	N.A.	reconstituted beverage		N.A.	N.A.	N.A.	N.A.
GUYANA	PUMA	QUAKER OATS	soybeans vit. sugar	2.0	2.0	N.A.	beverage	0.30	N.A.	N.A.	N.A.	29 million 6.5 oz. bottles
GUATEMALA	INCAPARINA	ALIMENTOS	cottonseed flour(38) corn flour(58) torula yeast vit. & min.	27.5	2.4	370	powder	0.53	0.20 (corn)	Retail(87) Insti. (13)	N.A.	2,000 (1974)
MEXICO	NUTRIMPI	CONASUPO	soy(30) kidney bean or chick pea(70)	31.0	N.A.	N.A.	N.A.	0.27 (1966)	N.A.	N.A.	N.A.	N.A.
	PROTEA	PROTEINAS	N.A.	24.0	N.A.	418	N.A.	1.00	N.A.	Insti. & Retail	N.A.	N.A.
PERU	PROTAL	N.A.	cottonseed rice or corn	N.A.	N.A.	N.A.	added to bread	N.A.	N.A.	N.A.	N.A.	N.A.
VENEZUELA	PL	INSTITUTO NACIONAL DE NUTRICION	DSM sugar vit. & min. methionine	27.0	N.A.	N.A.	reconstituted beverage	N.A.	N.A.	Gov't. Insti.	N.A.	N.A.
U.S.A.	CEPLAPRO	AMERICAN CORN MILLERS EXPORT INSTITUTE	corn flour(58) wheat flour(10) soy(25) DSM(5) vit. & min.	20.0	N.A.	N.A.	N.A.	N.A.	N.A.	mostly Vietnam	N.A.	N.A.
	CORN-SOY-MILK (CSM)	KRAUSE; ADM; LAUHOFF; QUAKER OATS	precooked corn meal(68) soy flour(25) DSM(5) sugar, oil vit. & min.	20.0	2.48	N.A.	powder	0.19	N.A.	N.A.	300 per day	1,000,000 (1966-1972)

FORMULATED WEANING FOODS - NORTH, CENTRAL, AND SOUTH AMERICA (con't.)

COUNTRY	PRODUCT	PRODUCER	INGREDIENTS	PROTEIN (%)	P.E.R.	CALORIES (per 100g.)	FORM	PRICE ($/kg)	PRICE OF STAPLE ($/kg)	DISTRIBUTION	ANNUAL PRODUCTION (metric tons)	ANNUAL SALES (MT)
U.S.A. (con't.)	INSTANT CORN-SOY-MILK (ICSM)	ADM MILLING CO.	gelatinized cornmeal(63) soy flour(23.7) soy oil(5.5) DSM(5.0) vit. & min.	20.0	2.4	380	powder	N.A.	N.A.	N.A.	N.A.	N.A.
	WHEAT PROTEIN CONCENTRATE/ SOY FOOD BLEND (WPC-SOY)	ADM MILLING CO.	Full fat soy flour(38.9) wheat protein concentrate(40.6) corn syrup liquids(8.95) soy oil(12) vit. & min.	22.5	2.14	468	powder	N.A.	N.A.	N.A.	N.A.	N.A.
	WHEAT-SOY BLEND (WSB)	ADM MILLING CO.; LAUHOFF GRAIN CO.	wheat protein concentrate, soy flour soy oil wheat flour vit. & min.	20.0	2.40	360	powder	N.A.	N.A.	Insti. mostly external to U.S.	100 per day	100,000 (1966-1972)

FORMULATED WEANING FOODS - AFRICA (con't.)

COUNTRY	PRODUCT	PRODUCER	INGREDIENTS	PROTEIN (%)	P.E.R.	CALORIES (per 100g.)	FORM	PRICE ($/kg)	PRICE OF STAPLE ($/kg)	DISTRIBUTION	ANNUAL PRODUCTION (metric tons)	ANNUAL SALES (MT)
ALGERIA	SUPERAMINE	SEMPAC (state enterprise)	chickpea(38) lentil(19) wheat flour(28) DSM(10) sugar(5)	20.2	2.19	414	N.A.	0.54	N.A.	Subsidized (75) Retail(12) Institu-tional(13)	800 (1975)	523 (1970)
EGYPT	SUPRAMINE	NILE CO. FOR PHARMACEUTICALS	wheat flour(25) chick pea flour(25) lentil flour(25) DSM(5) sugar(18) vit. & min.(2)	N.A.	N.A.	N.A.	N.A.	0.73 (1976)	N.A.	Retail(60)	300 (1976)	N.A.
	WEANING FOOD	NILE CO. (state enterprise)	wheat(25) chickpea(25) broad beans(25) DSM(10)	20.0	N.A.	320-400	N.A.	0.73	N.A.	N.A.	N.A.	N.A.
	BALADI BREAD	EGYPTIAN GENERAL BAKERIES	wheat flour chickpea premix or cottonseed flour	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
ETHIOPIA	FAFFA	ETHIOPIAN NUTRITION INSTITUTE (+SWEDISH GOV'T.)	wheat or teff(57) soya(18) legume(10) DSM(5) sugar(8) salt(2) vit. & min.	22.8	2.89	340	powder to make gruel or put in unleavened bread	0.43	N.A.	Retail(99) Insti.(1)	1,500 (1975)	160 (1975)
KENYA	SIMBA	MERCAT (local)	corn(85) DSM(15)	12.0	N.A.	N.A.	N.A.	0.24	N.A.	Retail (maj.) Insti.	N.A.	300 (1969)
	SUPRO	STEEL/PROTEIN ANSTALT (internat'l.)	corn or barley (50) yeast(25) DSM(15)	24.0	N.A.	380	N.A.	N.A.	N.A.	Insti. (100%)	N.A.	N.A.
MADAGASCAR	WEANING FOOD	N.A.	soya(38) rice(40) DSM(5)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
MALAWI	LIKUNI PHALA	LIKUNI HEALTH CENTER	corn(50) white beans(25) groundnuts(25)	17.5	N.A.	412	N.A.	0.29	N.A.	N.A.	200 pounds per day	N.A.
MOZAMBIQUE	SUPER MAEU	NUTRESCO	corn(61) soya(10) DSM(8)	23.4	N.A.	350	N.A.	0.39	N.A.	Retail Insti. Industrial canteens	2,400 (1976)	N.A.
NIGERIA	SOY OGI	N.A.	corn soy	20.0	N.A.	400	N.A.	N.A.	0.05 (cas-sava)	N.A.	N.A.	N.A.

FORMULATED WEANING FOODS - AFRICA (con't.)

COUNTRY	PRODUCT	PRODUCER	INGREDIENTS	PROTEIN (%)	P.E.R.	CALORIES (per 100g.)	FORM	PRICE ($/kg)	PRICE OF STAPLE ($/kg)	DISTRIBUTION	ANNUAL PRODUCTION (metric tons)	ANNUAL SALES (MT)
RHODESIA	NUTRESCO (FORMULA 3XN3)	NUTRITIONAL RESEARCH & FOOD PRODUCTS, LTD.	precooked corn meal millet sorghum soya meal groundnut meal FPC DSM	23.4	NPU= 62%	361	powder	0.33	N.A.	Retail Insti. Industrial canteens	1,200 (1973)	N.A.
	NUTROVITE SOUP POWDER	NUTR. RESEARCH & FOOD PRODUCTS, LTD.	wheat soy groundnut FPC	32.0	N.A.	335	N.A.	0.25	N.A.	N.A.	600 (1973)	N.A.
SENEGAL	ALIMENT DE SEVRAGE	N.A.	millet groundnut DSM sugar vit. & min.	20.0	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
SIERRA LEONE	BENNIMIX	Household preparation; Communit, cooperatives	Benniseed (sesame) rice groundnuts	N.A.	N.A.	N.A.	meal	N.A.	N.A.	N.A.	N.A.	N.A.
SOUTH AFRICA	KUPUGANI INSTANT BREAKFAST	KUPUGANI	mealie meal milk powder egg solids	11.0	N.A.	380	powder	0.52	N.A.	N.A.	N.A.	N.A.
	KUPUGANI BISCUITS	PYOTT, LTD.	wheat meal soya meal DSM fnt sugar vit. & min.	7.9	N.A.	N.A.	N.A.	0.25	N.A.	N.A.	N.A.	N.A.
	PRONUTRO	FOOD CORP. LTD.	soy corn groundnuts DSM wheat germ fish flour yeast	22.0	NPU= 63%	413	powder	0.66	N.A.	Retail(96) Industrial canteens(4)	4,000 (1973)	4,000 (1975)
	PROTONE SOUP POWDER	SUNGOLD PROD. LTD.	cereal products DSM yeast protein concen. vit. & min.	24.4	BV= 79%	N.A.	powder	N.A.	N.A.	Insti. Retail	3,000 (1973)	N.A.

TCHAD	VITATCHAD	BUREAU OF PROMOTION INDUSTRIELLE DU TCHAD	millet flour rice niebe beans cottonseed cake oyster shell	N.A.	N.A.	250	N.A.	N.A.	N.A.	Insti. Retail	100	N.A.
TUNISIA	ACTAMINE-5	SEPO	wheat flour(23) chickpea flour (23) lentil flour(23) NFDM(15) sucrose(15) vit. & min.	18.5-20.0	2.08	N.A.	N.A.	1.65	.20 (bread)	N.A.	N.A.	N.A.
UGANDA	SOYA PORRIDGE (other soya products)	AFRICA BASIC FOODS	corn(42) soya meal(38) DSM(5) sugar salt	20.0	N.A.	N.A.	N.A.	N.A.	N.A.	Insti. (maj.) Retail	450-1,000 (1973)	N.A.
ZAMBIA	AUSTRALIAN MILK BISCUIT	DAIRY PRODUCE BOARD (gov't.)	wheat(27.4) soya(7.1) casein(13.3)	20.0	N.A.	460	biscuit	0.66	N.A.	Retail (major) Insti.	N.A.	N.A.

FORMULATED WEANING FOODS - MIDDLE EAST

COUNTRY	PRODUCT	PRODUCER	INGREDIENTS	PROTEIN (%)	P.E.R.	CALORIES (per 100g.)	FORM	PRICE ($/kg)	PRICE OF STAPLE ($/kg)	DISTRIBUTION	ANNUAL PRODUCTION (metric tons)	ANNUAL SALES (MT)
IRAN	SHADAMIN WEANING FOOD	N.A.	wheat chickpea DSM sugar	20.0	N.A.	400	N.A.	1.60	0.15 (bread)	Insti. Retail	N.A.	N.A.
	YOO-HOO HIGH PROTEIN BEVERAGE	YOO-HOO CHOCOLATE BEVERAGE CORP. (U.S.A.)	milk sugar flavoring vegetable protein	3.3	N.A.	N.A.	bottled beverage	0.16	N.A.	N.A.	N.A.	N.A.
LEBANON	LAUBINA	AMERICAN UNIVERSITY OF BEIRUT	wheat chickpea DSM vit. & min.	16.8	2.3	N.A.	powder	N.A.	N.A.	N.A.	N.A.	N.A.
TURKEY	SEKMAMA	Sut Inst. Kurumu (gov't. milk processors)	wheat flour(37) rice flour(19) soy flour(19) DSM(12) sugar(12) vit. & min.(1)	19.0	2.0	380	powder	1.71 (1975)	0.45 (wheat)	Retail(60) Insti.(40)	500 (1975)	N.A.
	WEANING FOOD	gov't.	soya(20) wheat(40) legume(20) DSM(10)	25.0	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

FORMULATED WEANING FOODS - ASIA (con't.)

COUNTRY	PRODUCT	PRODUCER	INGREDIENTS	PROTEIN (%)	P.E.R.	CALORIES (per 100g.)	FORM	PRICE ($/kg)	PRICE OF STAPLE ($/kg)	DISTRIBUTION	ANNUAL PRODUCTION (metric tons)	ANNUAL SALES (MT)
HONG KONG	VITASOY	HONG KONG SOYA BEAN PRODUCTS	soybean extract sugar vit.	3.0	N.A.	N.A.	bottled beverage	0.27	N.A.	N.A.	N.A.	120 million bottles (6.5 oz.) (1970)
INDIA	BAL AHAR	FOOD CORPORATION (gov't.)	groundnut(25) wheat(65) legume(10)	22.0	1.8	300	powder	0.18	N.A.	Insti.	40,000 (1976)	N.A.
	BAL AMUL	KAIRA DIST. COOP MILK PRODUCERS UNION, LTD.	soya (20-25) DSM(15) legume(20) cereal(25) sugar	22-25	2.4	350	powder	1.44	N.A.	Insti. Retail	N.A.	N.A.
	FORTIFIED ATTA	private flour mills	wheat peanut flour vit.	13.5	N.A.	N.A.	powder	N.A.	N.A.	Gov't. subsidy covers fortification	N.A.	N.A.
	HYDERABAD MIX	INSTITUTE OF CHILD HEALTH, HYDERABAD	wheat or sorghum Bengal gram groundnut sugar	14.3	N.A.	371	powder	0.57	N.A.	N.A.	N.A.	N.A.
	KIF (KERALA INDIGENOUS FOOD)	local research insti.	cassava groundnut flour to replace CSM	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	MILTONE (milk extender)	MUNICIPAL DAIRIES	groundnut isolate buffalo milk vit. & min.	4.0	N.A.	N.A.	N.A.	0.12 per liter	0.16 per liter for whole milk	Mass feeding programs	364,000 liters	N.A.
	MPF (MULTI-PURPOSE FOOD) (CHANDRA)[1]	CHANDRA ORGANIZATION	groundnut(75) chickpea(25)	42.0	N.A.	N.A.	grits or powder	0.72	N.A.	N.A.	irregular 300	23 (1969)
	MODERN BREAD	Modern Bakeries (public sector co.)	wheat lysine(0.2%) vit. & min.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	Retail	N.A.	10,000 (1969)

[1]Also produced by Agrawal Oil Mills and Central Food and Technological Research Institute (CFTRI).

FORMULATED WEANING FOODS - ASIA (con't.)

COUNTRY	PRODUCT	PRODUCER	INGREDIENTS	PROTEIN (%)	P.E.R.	CALORIES (per 100g.)	FORM	PRICE ($1kg)	PRICE OF STAPLE ($1kg)	DISTRIBUTION	ANNUAL PRODUCTION (metric tons)	ANNUAL SALES (MT)
INDIA (con't.)	Multimix developed by Chaudhuri, Calcutta Sch. of Tropical Med.	household	bengal gram flour(50) fresh green leaves(25) jaggery(25)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	NUTRIMIX	CINI (Child in Need Insti.)	DSM wheat/rice pulse	20.0	N.A.	360	powder	N.A.	0.25 (rice or wheat)	Insti.	N.A.	N.A.
	NUTRI NUGGET	SOYA PROD. & RESEARCH ASSOC.	N.A.	50.0	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	NUTRO BISCUITS	BRITANNIA BISCUIT CO.	groundnut(25) wheat(40)	16-17	N.A.	N.A.	Biscuit	0.69	N.A.	Insti. (100%)	N.A.	N.A.
	POSHAK	name originally used for ICSM in India. Indigenous product under development.	See ICSM	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	PROTAMIN	J.B. PROTEIN IND.	groundnut(75) chickpea(25)	45.0	N.A.	N.A.	N.A.	0.33	N.A.	Insti. (major) Retail	300	100 (1969)
	PROTEIN PLUS	SOYA PROD. & RESEARCH ASSOC.	N.A.	21.0	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	PROTESNAC	SOYA PROD. & RESEARCH ASSOC.	N.A.	12.0	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	SEV	CARE	CSM rice flour Bengal gram flour oil	15.0	N.A.	N.A.	fried noodle snacks	N.A.	N.A.	N.A.	pilot test	N.A.
	SUKHADA	local research inst. Maharastra	CSM/local grains(60) oil(10) jaggery(30)	12.1	N.A.	430	granular	N.A.	N.A.	Insti.	6,000 (1973)	N.A.
	STAMINO FERMSTRATE	N.A.	cottonseed protein isolate	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

INDIA (con't.)	SWM	CHRISTIAN MEDICAL COLLEGE; BROWN MEM. HOSPITAL	soy(50) wheat(25) corn(25)	27.0	N.A.	360	powder	N.A.	N.A.	Insti.	N.A.	N.A.
	UNI-PROTEIN BISCUITS	UNICHEM LAB	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	WINFOOD	Tamil Nadu State	legume	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	Insti.	N.A.	N.A.
MALAYSIA & SINGAPORE	VITABEAN	YEO HIAP SENG	soybean vit. sugar	2.75	N.A.	N.A.	beverage	0.21	N.A.	N.A.	N.A.	N.A.
PHILIPPINES	NUTRI-NOODLE	Gov't.	flour(75) DSM(25)	14.0	N.A.	445	noodle	0.62	0.25 (rice)	Insti. Retail	N.A.	N.A.
	NUTRIPAK	Gov't.; home preparation	minishrimp or anchovies or mongo bean grits rice oil DSM (optional)	15.0	N.A.	450	powder	1.00	0.25 (rice)	Insti. Retail	N.A.	N.A.
SRI LANKA	THRIPOSHA	HEALTH DEPT. & CARE	WSB(80) sorghum(20) vit. & min.	20.0	N.A.	423	ready to eat	0.31	0.14 (rice)	Insti. Retail	N.A.	N.A.
TAIWAN	WEANING FOOD	WEI CHUAN	soy(30) DSM(20) rice(20)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
THAILAND	BEANSTALK, FERM SOY, SANDWICH SPREAD, TEXTURED VEGETABLE PROTEIN	APPLIED SCIENTIFIC RESEARCH CORPORATION OF THAILAND	variety of ingred. centered around soy; some FPC	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	KASET INFANT FOOD (& OTHER PRODUCTS)	INSTITUTE OF FOOD & RESEARCH & PRODUCT DEV.; KASETSART UNIVERSITY	rice flour(70) soy flour(12.5) sugar (15) vit. & min. methionine	11.0	N.A.	385	puffed snack; mix with water to form porridge	0.70	0.25 (rice, bananas)	Insti. Retail	N.A.	N.A.
	POLUK MILK	NEW MEMBO	soy DSM	N.A.	N.A.	N.A.	beverage	0.04 per 200 cc	N.A.	N.A.	864,000 bottles (200 cc)	432,000 bottles (200 cc) (1969)
	VITAMILK	GREENSPOT	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

FORMULATED WEANING FOODS

TERMINATED PRODUCTS

FORMULATED WEANING FOODS - TERMINATED PRODUCTS

COUNTRY	PRODUCT	PRODUCER	INGREDIENTS	PROTEIN (%)	P.E.R.	CALORIES (per 100g.)	FORM	PRICE ($/kg)	PRICE OF STAPLE ($/kg)	DISTRIBUTION	ANNUAL PRODUCTION (metric tons)	ANNUAL SALES (MT)
AMERICA:												
BRAZIL	FORTIFEX	NESTLE	soy(47.5) corn(46.3) vit. & min. methionine	30.0	N.A.	365	N.A.	0.64	N.A.	N.A.	Irreg.	N.A.
	INCAPARINA	QUAKER OATS	soy(38) corn(58)	23.74	N.A.	N.A.	powder	N.A.	N.A.	N.A.	N.A.	N.A.
	MULTI-PURPOSE FOOD (MPF)	MPF PRODUCTOS ALIMENTIELES	N.A.	50.0	N.A.	N.A.	powder	0.53 (1964)	N.A.	N.A.	N.A.	N.A.
	SACI	COCA-COLA	soy cocoa vit.	3.0	N.A.	N.A.	beverage	N.A.	N.A.	N.A.	N.A.	N.A.
COLOMBIA	INCAPARINA	QUAKER OATS	soya(20.9) cottonseed(20) corn(58)	27.5	2.2	370	powder	0.21	N.A.	Retail(85) Insti.(15)	1,000 (1972)	N.A.
	INCAPARINA BLANCA	N.A.	soy flour(30) rice flour(70)	N.A.	N.A.	N.A.	powder	N.A.	N.A.	N.A.	N.A.	N.A.
	POCHITO	ALIMENTOS, S.A.	rice flour(70) soy flour(25) sesame flour(5)	20.0	N.A.	335	powder	0.34 (1968)	N.A.	N.A.	N.A.	N.A.
EL SALVADOR	INCAPARINA	PRODUCTOS ALIMENTICIOS	cottonseed flour (38) sorghum(29) torula yeast(3) corn(29)	27.5	N.A.	370	powder	N.A.	N.A.	N.A.	190 (1968)	N.A.
MEXICO	INCAPARINA	CONASUPO	corn flour cottonseed flour	27.5	N.A.	N.A.	N.A.	0.28	N.A.	N.A.	N.A.	N.A.
NICARAGUA	INCAPARINA	ALIMENTOS INFANTILES	cottonseed(38) corn(58)	27.5	N.A.	370	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
PANAMA	INCAPARINA	CENTRAL AGRICOLA	cottonseed(38) corn(58)	27.5	N.A.	370	N.A.	0.40	N.A.	N.A.	N.A.	N.A.
PERU	PERUVITA (savory)	NESTLE	cottonseed(52) DSM(4) Quinoa(28)	35.0	N.A.	338	powder	0.84 (1964)	N.A.	N.A.	N.A.	N.A.
	PERUVITA (sweet)	NESTLE	cottonseed(47) DSM(4) Quinoa(23)	30.0	N.A.	363	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
VENEZUELA	INCAPARINA	QUAKER OATS	soy(19) cottonseed(19) maize(58)	N.A.	N.A.	N.A.	powder	0.45 (1966)	N.A.	N.A.	N.A.	N.A.

FORMULATED WEANING FOODS - TERMINATED PRODUCTS (con't.)

COUNTRY	PRODUCT	PRODUCER	INGREDIENTS	PROTEIN (%)	P.E.R.	CALORIES (per 100g.)	FORM	PRICE ($/kg)	PRICE OF STAPLE ($/kg)	DISTRIBUTION	ANNUAL PRODUCTION (metric tons)	ANNUAL SALES (MT)
AFRICA:												
NIGERIA	AMAMA	GLAXO	groundnut casein	51.0	N.A.	N.A.	N.A.	0.93 (1961)	N.A.	N.A.	N.A.	N.A.
	ARLAC	NIGERIAN CREAMERIES	groundnut(75) DSM(25) vit. & min.	42.0	N.A.	387	powder	0.34	N.A.	Insti. Retail	N.A.	N.A.
SENEGAL	LADYLAC	SOFRAL	groundnut(15) DSM(20) millet flour(45) sugar(20)	18-20	N.A.	N.A.	N.A.	0.97 (1967)	N.A.	N.A.	N.A.	N.A.
ASIA:												
INDONESIA	SARIDELE	P.N. Sarihusado	sesame soy vit. & min.	18-19	2.57	N.A.	powder	0.66	N.A.	N.A.	N.A.	N.A.

APPENDIX B

PAG STATEMENTS AND GUIDELINES

PAG STATEMENTS

NEW SYMBOL	NO.	TITLE	
13/1	1	PAG Definition of Some Basic Principles Concerning Protein Food Supplements	E1 3*
13/2	2	Recommendation on Aflatoxin	D 581
13/3	3	Nature and Magnitude of the Protein Problem	F 749
13/4	4	Single Cell Protein	C2 2237
13/5	5	Marketing and Distribution of Protein-Rich Foods	G 397
13/6	6	Milk Substitutes	E1 5
13/7	7	Recommendation on Prevention of Food Losses and Protein-Calorie Malnutrition	B 109
13/8	8	Plant Improvement by Genetic Means.....	D 123
13/9	9	Amino Acid Fortification of Foods	B 367
13/10	10	A Systems Approach to the Formulation and Evaluation of Nutrition Intervention Programs	G 547
13/11	11	Leaf Protein Concentrate	C2 2049
13/12	12	The World Protein Problem: Research and Development Needs	F 755
13/13	13a	Review of the Specific Proposals Contained in ACAST Report "International Action to Avert the Impending Protein Crisis," United Nations, 1968	F 769

*Letters and numbers in this column refer to volumes and page numbers in the PAG Compendium.

PAG STATEMENTS (continued)

13/14	14	Marketing of Conventional Foods	C 403
13/15	15	Popular Participation and Community Involvement in Nutrition Improvement Programs	F 783
13/16	16	The Potential of Fish Protein Concentrate for Developing Countries	C1 431
13/17	17	Low Lactase Activity and Milk Intake	E1 349
13/18	18	Relationship of Pre- and Postnatal Malnutrition in Children to Mental Development, Learning, and Behavior	E1 619
13/19	19	Maintenance and Improvement of Nutritional Quality of Protein Foods	B 111
13/20	20	The "Protein Problem"	F 785
13/21	21	Specifications for Solvents	D 599
13/22	22	Upgrading Human Nutrition through the Improvement of Food Legumes	D 127
13/23	23	Promotion of Processed Protein Foods for Vulnerable Groups	E1 623
13/24	24	The Green Revolution and Protein Supplies .	D 171
13/25	25	The Global Maldistribution of Protein: A Growing Trend	F 795
13/26	26	Food and Nutrition Considerations in National Economic Planning	F 799

PAG GUIDELINES

NEW SYMBOL	NO.	TITLE	
14/2	2	Preparation of Food Quality Groundnut Flour	C2 1519
14/4	4	Preparation of Edible Cottonseed Protein Concentrate	C1 1137
14/5	5	Edible, Heat-Processed Soy Grits and Flour	C2 1945
14/6	6	Preclinical Testing of Novel Sources of Protein	D 785
14/7	7	Human Testing of Supplementary Food Mixtures	D 933
14/8	8	Protein-Rich Mixtures for Use as Supplementary Foods	E1 631
14/9	9	Fish Protein Concentrates for Human Consumption	C1 469
14/10	10	Marketing of Protein-Rich Foods in Developing Countries	G 405
14/11	11	Sanitary Production and Use of Dry Protein Foods	D 1041
14/12	12	Production of Single Cell Protein for Human Consumption	C2 2249
14/13	13	Preparation of Milk Substitutes of Vegetable Origin and Toned Milk Containing Vegetable Protein	E1 637
14/14	14	Preparation of Defatted Edible Sesame Flour	C2 1625

APPENDIX C

SOCIODEMOGRAPHIC DATA ON YAKO AND KOUPELE

OCCUPATIONS OF FATHERS OF SIX TO 24-MONTH-OLD CHILDREN IN YAKO AND KOUPELE

	Yako		Koupele	
	N	% *	N	% *
Subsistence farming only	18	29	4	10
Market gardening	1	2	15	38
Raises poultry	2	6	0	0
Raises livestock	2		0	
Weaves cloth	6	40	7	36
Weaves mats	6		0	
Weaves baskets	9		0	
Shoemaker	1		1	
Well digger	0		2	
Potter	0		3	
Repairs houses	1		1	
Other crafts	2		0	
Butcher	1	2	0	0
Mechanic	5	8	0	0
Trader	4	10	3	10
Sells cloth	1		1	
Sells kola nuts	0		1	
Sells wood	1		0	

TABLE C-1 (continued)

	Yako		Koupele	
	N	% *	N	% *
Absent in Ivory Coast	6	10	0	5
Absent from Gabon	0		1	
Absent from Ouagadougou	0		1	
Chief, chief's family	1	2	2	5
Dead	0		1	3

*Percentages total more than 100 because 8% in Yako and 10% in Koupele listed two occupations.

TABLE C-2

OCCUPATIONS OF MOTHERS OF SIX TO 24-MONTH-OLD

CHILDREN IN YAKO AND KOUPELE

	Yako		Koupele	
	N	% *	N	% *
Household work only, including farming, spinning cotton, etc.	45	73	26	65
Weaver	0		2	
Potter	1	3	0	5
Repairs houses	1		0	
Beer maker	10	16	1	3
Trader	1		5	
Market gardens	1		1	
Sells peanuts and soumbala	2		3	
Sells wood	0	10	1	28
Sells rice	0		1	
Sells bean cakes	1		0	
Sells millet and soumbala	1		0	

TABLE C-3

ANSWERS TO QUESTION: WHAT WOULD YOU LIKE THIS CHILD TO BE WHEN HE/SHE GROWS UP?

	Yako	Koupele
Farm	4	4
School	22	20
School, then farm	3	9
School first, then decide	2	-
Help me, work for me	7	-
Same as us (me), be a good wife like all women	10	1
Better off than us	-	4
Support him/herself, have a good job	2	-
Agricultural agent	1	1
Nurse	2	-
Doctor	1	-
Whatever he/she wants	2	-
Be a good cook	1	-
Be an adventurer, go to Ivory Coast	1	-
Be a good person	2	-
Don't know	1	1
Total traditional sector	26 = 42% (.005)*	5 = 13%
Total: school mentioned or required	31 = 50% (.025)*	30 = 75%

*Level of significance of differences between Yako and Koupele.

APPENDIX D

YAKO AND KOUPELE SURVEY RESULTS

TABLE D-1

SUMMARY OF WEANING PRACTICES IN YAKO AND KOUPELE

	Yako		Koupele	
Still breast-fed*	55 (89%)		39 (98%)	
Weaning age of weaned children in months	20 (6.2)		19 (N=1)	
Age of introducing supplementary foods in months	7.1 (2.3)	(.1)**	8.0 (2.9)	
No. introducing by 6 months	35 (56)	(.1)**	15 (38)	
First food: N (%) not yet	2 (3)		5 (13)	
Protein-enriched bouillie	50 (81)		3 (8)	
Nonprotein-enriched bouillie	6 (10)		15 (38)	
Rice, maize, bouillie, or rice	--		3 (8)	
Sauce of baobab and soumbala	--		13 (33)	
To	2 (3)		--	
Other	2 (3)		--	
Age of starting to	8.8 (1.9) (N=25)		10 (N=2)	
No. meals bouillie yesterday	2.1 (1.8)	(.01)**	1.1 (1.5)	
No. tbsp. bouillie eaten yesterday	4.8 (2.6) (N=17)		Not obtained	
No. meals to yesterday	1.5 (1.0)	(.0001)**	0.7 (0.9)	

*Children over 27 months were included in the Yako analysis of questions not directly related to growth status.

**Level of significance of differences between Yako and Koupele.

TABLE D-1 (continued)

	Yako		Koupele
No. tbsp. *to* eaten yesterday	3.5 (2.0%) (N=18)		Not obtained
Sauce eaten by infant yesterday:			
had no sauce	12 (19)	(.05)*	16 (40%)
had sauce one meal only	17 (27)		10 (25)
had sauce two meals	33 (53)		14 (35)
Other foods eaten by infant yesterday:			
to dissolved in water**	15 (24)		6
rice	3		10 (25)
mango	--		2
Total meals eaten yesterday	3.7 (2.2)	(.0006)	1.9 (1.6)

	Yako		Koupele	
Sauce	Sauce 1	Sauce 2	Sauce 1	Sauce 2
None	12	29	16	26
Gombo	10	3	5	1
Soumbala	4	4	0	0
Kapok	3	1	0	0
Baobab	2	1	3	2
Fish and vegetables	5	2	0	0
Other vegetables	1	1	0	1
Missing values			6	6
Ate sauce (kind unspecified)	25	20	10	4

*Level of significance of differences between Yako and Koupele.
**This left-over *to* dissolved in water and sweetened may have been eaten by more children but may not have been recorded separately from fresh *to* by some interviewers.

TABLE D-2

AWARENESS OF BOUILLIE; ANSWERS TO QUESTION: WHAT IS BOUILLIE?

	Yako	Koupele	
Never heard of it	0	8	(22%)
Heard of it, no definition	16	9	
A good food	4	-	
A food for children	4	9	
A food for growth, strength, health	18	-	
A good food for children	12	-	
A food made with flour, etc.	1	10	
A food to make children strong and healthy	6	-	

Note: In answer to the question, "Who is bouillie for?" 55 (89%) of the Yako sample and 27 (68%) of the Koupele sample answered that it was for children.

TABLE D-3

INGREDIENTS USED IN COOKING BOUILLIE

Ingredient	Yako N Used Ingredient		Yako N Specified Amount (Tbsp)	Yako Mean	Yako SD	Koupele N Used Ingredient		Koupele N Specified Amount (Tbsp)	Koupele Mean	Koupele SD
Sorghum flour	57	(71%)	28	2.7	1.1	21	(45%)	9	1.3	.5
Millet flour	1	(2)	1	3.3		9	(30)	2	1	0
Maize flour	15 (always mentioned second after sorghum and in same amount)	(24)				2		(see Yako)		
Rice flour	1		1	3	-	2	2	1.5	.7	
Sugar cubes	31	(50)	17	3.4	1.6	28	(70)	17	2.4	1.2
Tamarind	5		-	-	-	10	(25)	-	-	-
Lemon	-		-	-	-	12		-	-	-
Soumbala balls	52	(84)	38	1.8	.8	7	(28)	2	1	0
Groundnut cake	30	(52)	27	3.7	2.6	-		-	-	-
Groundnut butter	16	(26)	5	2.0	0	-		-	-	
Tomato	16	(26)	4	1	-	-		-	-	-
Powdered fish (tsp)	22	(35)	17	1.7	1.0	1		0	-	-
Milk powder	6	(10)	4	2.0	0	1		1	2	-
Nere powder	6	(10)	4	1.3	.5	-		-	-	-
Eggs	1		4	-	-	-		-	-	-
Baobab fruit	4		-	-	-	-		-	-	-
Dried meat	2		-	-	-	-		-	-	-
Baobab leaves and beer	-		-	-	-	1		-	-	-
Bean flour	3		-	-	-	-		-	-	-

TABLE D-4

NUTRIENT VALUES OF BOUILLIE RECIPES

Recipe	N	Mean	sd	N	Mean	sd
sorghum soumbala						
calories	28	244	78	1	112	--
" w/o sugar	18	225	--	--	--	--
" with sugar	10	278	89	--	--	--
protein	28	10	3	1	6	--
millet soumbala						
calories	2	293	--	--	--	--
protein	2	9	--	--	--	--
sorghum groundnut cake						
calories	20	213	90	--	--	--
" w/o sugar	14	182	--	--	--	--
" with sugar	6	284	104	--	--	--
protein	20	9	5	--	--	--
sorghum groundnut butter						
calories	2	382	--	--	--	--
protein	2	13	--	--	--	--
sorghum tomato						
calories	4	173	95	--	--	--
protein	4	4	2	--	--	--
sorghum milk						
calories	4	214	66	1	206	--
protein	4	9	3	1	10	--

TABLE D-4 (continued)

Recipe	N	Mean	sd	N	Mean	sd
flour, flavoring						
and sugar only						
calories	0	--	--	12	104	45
protein	0	--	--	12	1.7	.68
all recipes						
calories	74	214	88	14	112	49
protein	74	9.0	4	14	2.6	2.5
% protein calories		17%				

Source: Calculated from tables by Jardin (undated).

TABLE D-5

FOOD TABOOS FOR INFANTS

	Yako		Koupele	
None	15	(24%)	30	(75%)
Chicken forbidden to eldest child so long as father lives	21		0	
Meat of boa constrictor	15		2	
Eggs	9		1	
Beignets (like doughnuts)	2		0	
Mangoes	0		1	

Note: Eleven families in Yako mentioned both chicken and boas and two mentioned chicken and eggs.

TABLE D-6

ACCEPTABILITY OF BOUILLIE

	Yako		Koupele	
Infants who had problems with bouillie				
none	43	(75%)	21	(78%)
vomiting	2	(4%)	3	(11%)
diarrhea	2	(4%)	2	(7%)
child refuses	10	(18%)	1	(4%)
Overcome problems	9	(69% of those with problems)	1	(17% of those with problems)
Did not overcome	4	(31% ")	5	(13% ")
Attitudes towards bouillie				
child:				
likes	55	(95%) (0.5)	23	(77%)
doesn't like	3		7	
mother:				
likes	57	(97%)	27	(90%)
doesn't like	2		3	
Reasons for liking				
sugar	17	(31% of mothers liking)	14	(52% of mothers liking)
tamarind	2		2	
lemon	--		1	
soumbala	--		1	
fish	1		--	

TABLE D-6 (continued)

	Yako	Koupele
well seasoned, good taste	19	5
good for my child	--	3
because my child likes it	1	--

Note: Four Yako mothers who had overcome problems with bouillie stated they had done so by continuing to feed the child with patience. Two said they had forced the child to eat it, and one had taken the child to the hospital. The Koupele mother had taken the child to the dispensary.

TABLE D-7

ANSWERS TO QUESTION: HAVE YOU NOTICED ANY CHANGES IN THE CHILD SINCE YOU STARTED FEEDING BOUILLIE?

	Yako		Koupele	
	N	%	N	%
No change	1	2%	5	19%
Fatter	24	77% (of those answering)	3	
Bigger	10	71% (of total sample) say fatter or bigger	2	27% (of those answering) say fatter or bigger
Bigger and fatter	8		0	
Good health	3		6	31% (of those answering) say good health
Fatter and healthier	2	11% (of those answering) say good health	1	
Bigger and healthier	1		1	
Bigger, fatter, and healthier	-		-	
Plays well, doesn't cry	2		1	
Develops, walks early, is strong	1		1	
Negative changes	1	2%	3	12%
Diarrhea, vomiting	1			
Got sick	1			
Always sick	2			
Got thin	1			
Never ate	4		3	12%
Total positive change	51	89% 82% of total sample)	15	58% (38% of total sample)
Total no change or negative change	2	4% (3% of total sample)	8	31% (20% of total sample)

TABLE D-8

ANSWERS TO QUESTION: WHY DON'T YOU PREPARE BOUILLIE REGULARLY?

	Yako		Koupele	
	N	%	N	%
Do prepare regularly	41	65%	13	38%
Child doesn't eat yet	2	11 (of those not preparing)	3	20 (of those not preparing)
Used to, but child grown	3	17 "	2	13 "
Child eats to instead	8	44 "	1	7 "
Think it would make child sick	0	--	5	33 "
Lack means, ingredients	3	17 "	2	13 "
Child doesn't like it	1	6 "	2	13 "
Too busy	1	6 "	0	--
Total respondents	26		30	
Child doesn't eat yet	2	8	2	7
Child eats to/adult foods	13	50	3	10
Can't afford condiments	2	8	3	33
Lack means, flour, cereal	--		7	
Child wouldn't eat more	3	12	6	20
Too busy	5	19	5	17
Hasn't heard of it	0	0	2	7
Think child will become sick	0	0	1	3

TABLE D-9

PREPARATION AND USE OF BOUILLIE

	Yako	Koupele
No. times mother cooks bouillie/ week		
0	5	12
1-5	8	7
7	19	9
10	2	1
14	24	3
21	3	3

(difference between % cooking once a day or more in Yako vs. Koupele is significant at .005 level)

No. times bouillie is served after cooking					
once		30		14	
twice		20		7	
3 times		3		5	
Where bouillie is kept after cooking					
not kept/eaten as soon as cooled		18	(31%)	8	(27%)
plate (assiette)	1	9	(15%)	9	(30%)
plate (dish)	2	7	(12%)	7	(23%)
calabash	3	17	(29%)	0	--
pot (marmite)	4	2	(3%)	6	(20%)

TABLE D-9 (continued)

		Yako			Koupele		
cup	5	5	(8%)		0	--	
recipient	6	1	(2%)		0	--	
mother mentions covering container		30	(50%)		4	(13%)	
When bouillie is cooked							
not cooked		4	(7%)		10	(26%)	
a.m. only		31	(51%)		16	(41%)	
p.m. only - once a day		1	(2%)	53%	0	(0%)	49%
noon only		0	(0%)		3	(8%)	
a.m. and p.m.		21	(34%)		5	(13%)	
a.m. and noon - 2x/day		1	(2%)	36%	0	(0%)	16%
noon and p.m.		0	(0%)		1	(3%)	
a.m., noon, p.m.-3x/day		3	(5%)	5%	4	(10%)	10%
How long bouillie is cooked							
never prepare		4			7		
short time		21			2		
well-cooked, leave a while on fire		11			1		
5 minutes					1		
10-20 minutes		17			1		
1/2-1 hour		2			7		
until cooked		2			1		
					15		

TABLE D-9 (continued)

	Yako	Koupele
Who eats bouillie		
don't prepare bouillie	4	10
baby only	17 (29% of those preparing)	10 (37% of those preparing)
baby first, then siblings	13 (22% ")	11 (41% ")
the younger children	24 (41% ") (.1)*	6 (11% ")
baby first, then adults	4 (7% ")	1 (4% ")
No. hours bouillie is kept after cooking		
not kept	28 (52%)	10 (45%)
1-2 hours	8 (15%)	0
3-4 hours	4 (7%)	2 (10%)
10 hours	11 (20%)	10 (45%)
12-24 hours	2 (4%)	0
Age bouillie should be stopped		
when child eats adult food or no longer wants it	47 (89%)	18 (69%)
N, mean, Sd. of those giving precise age	6, 15 mo., 5.3	8, 11 mo., 3.9
No. years cooking bouillie		
N, mean, Sd.	17, 4.4, 1.2 (range = 2-6)	not asked

APPENDIX E

ANALYSIS OF FACTORS SIGNIFICANTLY RELATED TO NUTRITIONAL STATUS

The following hypotheses were examined:

(a) that the age of introducing supplementary foods is negatively correlated with nutritional status;

(b) that the amount of good-quality bouillie eaten by the infant is positively correlated to nutritional status;

(c) that keeping bouillie for several hours in tropical heat is negatively correlated to health and nutritional status; and

(d) that other variables, such as morbidity and wealth, correlate with nutritional status in the same direction as indicated in other studies.

A major problem in the analysis arises with regard to hypothesis (b), because neither quantity or quality of bouillie eaten are satisfactorily recorded in the 24-hour dietary recall (recipes given were not necessarily those cooked the previous day). This lack of accurate information made it necessary to substitute a series of indirect and highly intercorrelated measures, such as times bouillie is cooked per day, times bouillie is cooked per week, and number of meals bouillie eaten yesterday, each of which has limitations as a surrogate measure of intake.

The analytic methods used both have limitations. The first, nonparametric correlation, is appropriate for the nominal and ordinal variables in the study but cannot be used to control for the effects of some factors while looking at others. These correlations give true levels of significance for relationships which may be partially masked by other factors. The second procedure, using partial correlations, is not fully accurate in controlling for the binary and highly intercorrelated variables in the study, and thus gives somewhat dubious levels of significance for relationships after the masking effects of other factors have been removed (for example, what is the correlation between health status and weight/length when the effects of the programs and the ages of the infants are controlled). In spite of these limitations, experience with previous studies suggests that important relationships will prove highly significant in both types of analysis and that relationships that appear to be moderately significant in either type of analysis are valuable for formulating new hypotheses.

Results are presented and discussed in the order in which the hypotheses and questions are listed. They are summarized and their implications for program planning are discussed in the conclusions section. Table E-1 presents variables that were significantly correlated to the

TABLE E-1

NONPARAMETRIC CORRELATIONS BETWEEN NUTRITIONAL STATUS INDICATORS AND OTHER VARIABLES IN YAKO, KOUPELE, AND BOTH SAMPLES COMBINED

	Yako	Koupele	Both
Weight/age			
Age introducing supplementary foods	-.307	-.029	-.037
Times bouillie cooked/day	+.229	-.053	+.484
Times bouillie served after cooking	-.005	-.038	-.002
Illness	-.109	-.015	-.004
Age	-.314	-.200	-.114
Sex	+.006	+.482	+.022
Aspirations for child's future	+.131	+.003	+.056
Length/age			
No. meals bouillie eaten yesterday	-.006	-.043	-.001
Times bouillie served after cooking	-.001	-.006	-.001
Time to collect firewood	-.005	-.252	-.009
Age	-.219	-.063	-.039
Sex	+.006	-.096	+.003
Weight/length			
Age introducing supplementary foods	-.187	-.102	-.067
Times bouillie cooked/week	+.064	+.391	+.096
No. meals bouillie eaten yesterday	+.033	+.304	+.021
Illness	-.066	-.037	-.003
Aspirations for child's future	+.063	+.001	+.018

three outcome measurements of nutritional status using Spearman's rank order correlations (SPSS 1975), either within the Yako sample, within the Koupele sample, or within the two samples combined.

Age of introducing supplementary foods was negatively correlated with weight/age and marginally negatively correlated with weight/length as hypothesized (the strength of these correlations increased, when the effects of other variables such as age and sex were controlled by partialing). Surrogate measures of bouillie consumption, testing hypothesis (b), turned out to be positively correlated with weight/length only and only in Yako. The fact that a significant positive relationship occurred in Yako only was not surprising in view of the poor nutritional quality and small quantity of the recipes given by the Koupele mothers, and also it was possible that other factors, such as the high incidence of illness in Koupele at the time of the survey, affected these results. The strong negative relationships that occurred between length/age and number of meals bouillie served yesterday are best explained in a consideration of hypothesis (c). Number of hours bouillie was kept was significantly negatively related to nutritional status, but not nearly so strongly as was the number of times bouillie was usually served after cooking. The hours kept question was relatively disregarded in the analysis because it was sometimes asked hypothetically as "How long do you think bouillie can be kept without spoiling?" rather than "How long do you usually keep it?" Table E-2 helps to quantify the effects of serving the food more than once by showing a breakdown of mean values of weight/age, length/age, and weight/length by program and by whether bouillie was served only once, at the time of cooking or whether it was kept and served over a period of time (further breakdown of the data by number of times served did not yield additional insight).

In both locations average length/age of children eating the food repeatedly fell below the cut-off point (95%) for first-degree malnutrition (Waterlow 1972), which at this early age indicated stunting in linear growth that should be taken seriously. In Yako, weight/length remained the same between the two groups. In Koupele, average weight/length of infants who ate the food once per cooking lay at the tenth percentile (NCHS 1976), as compared with the fifth percentile for those eating it more than once (although the difference was not statistically significant at this sample size). The apparent difference in effects on weight/length between the locations was not surprising, because of the low calorie and protein density and smaller quantities of the bouillie recipes given in Koupele.

Number of times bouillie was served was not significantly related to health status; thus, there was no clear evidence to support the hypothesis that spoilage caused illness, which in turn retarded growth. On the other hand, since 22 mothers claimed the food could be kept for 10 hours or more, microbial contamination and some toxins undoubtedly developed, which might affect growth through a variety of mechanisms. Another hypothesis was that bouillie displaces breast milk when given frequently and that stunting was caused by the lower protein quality (and possibly phytate

TABLE E-2
MEAN VALUES OF WT/AGE, LTH/AGE, AND WT/LTH IN YAKO AND KOUPELE BROKEN DOWN BY WHETHER BOUILLIE IS SERVED TO INFANT ONLY ONCE AFTER COOKING OR IS SERVED MORE THAN ONCE

	Yako			Koupele		
	N	Mean	sd	N	Mean	sd
Weight/age						
served once	27	87.2	11.0	13	84.8	11.3
		(p=.1 t=1.97)			(p=.01)	
served more than once	24	81.9	7.7	15	71.8	15.7
Length/age						
served once	26	99.0	4.7	13	98.1	4.1
		(p=.000 t=3.57)			(p=.05 t=2.16)	
served more than once	24	94.6	3.9	15	93.3	7.0
Weight/length						
served once	26	89.2	9.4	13	88.9	10.8
		N.S.				
					(p=.2 t=1.28)	
served more than once	24	89.9	6.4	15	83.4	11.8

content) of the flour-based diet. If bouillie was served only once per cooking, even if it was cooked three times per day, it could not become a comfort food and thus replace the frequent comfort breast-feeds commonly given to Mossi toddlers. These frequent feeds presumably helped to maintain a supply of breast milk which would fall off if bouillie snacks replaced nursing. The previously noted negative correlation between weight/age and number of times bouillie was cooked per day in Koupele supported the hypothesis that bouillie sometimes substituted for breast milk, because frequent cooking should decrease rather than increase risk of spoilage. The negative correlations between number of meals bouillie and length/age in both locations probably simply reflected that the number of meals was partially estimated from the number of times the food was served after cooking.

While in some cases frequent feeds of bouillie may have been a causal factor in reducing breast milk production, in others a lack of breast milk may have been a reason for giving more bouillie. In fact, two mothers of poorly nourished infants explained to the interviewers that they fed bouillie frequently because they lacked milk. Even if an infant ate bouillie as a primary food all day, the stimulation of nursing on breast milk production should not have been entirely eliminated because infants normally slept with their mothers and breast fed on demand during the night.

Variables included in hypothesis (d) were illness, age, birth order, occupation, number of huts, and number of months practicing rationing. A strong negative relationship between illness and weight/age did occur in Yako, but was not statistically significant because only six Yako infants had either fever or diarrhea that could be expected to affect nutritional status. The mean weight/age of these six was five percentage points below average, as would be expected. Age of infants should be negatively correlated with length/age and weight/length in this age range. The fact that neither of these correlations was significant in Yako may be a measure of the success of the program in preventing malnutrition. Birth order was not negatively correlated to nutritional status as expected, but was positively correlated to length/age, as mentioned earlier, which raised the possibility that births of later-born children may not have been registered promptly.

Parental income or wealth usually was positively correlated with nutritional status of infants. In the present survey, questions concerning parental occupation were weak surrogate measurements for income or wealth. Nonetheless, the mean values of weight/age and weight/length by occupation category of fathers in Table E-3 and of mothers in Table E-4 were of interest in interpreting the data. In Table E-3 the sample sizes of subcells were too small for most comparisons, although in Yako a significant difference in nutritional status favored the children whose fathers farmed and practiced traditional crafts above those whose fathers farmed only. Table E-4 indicates that the average nutritional status of infants did not improve if their mothers had a source of cash income. The reason for this finding may lie in constraints on the mothers' time, which are explored later in partial correlations, together with number of huts and months rationing food.

TABLE E-3
NUTRITIONAL STATUS OF VOLTAIC INFANTS BY FATHER'S OCCUPATIONAL CATEGORY

	Yako				Koupele			
	N	%	wt/age	wt/lth	N	%	wt/age	wt/lth
Farming only	16	31	84.6(7.6)	87.8*(5.4)	4	12	96.8(7.9)	95.0(9.6)
Farming plus traditional crafts	18	35	87.3(10.1)	93.0*(9.6)	9	29	76.6(17.2)	87.2(11.4)
Market gardening, poultry, livestock	3	6	78.0(6.5)	88.3(13.3)	12	39	77.9(15.3)	85.9(10.6)
Tradesman	5	10	86.4(9.0)	88.8(6.4)	5	15	85.6(8.7)	93.6(7.7)
Mechanic	4	8	80.5(12.1)	88(10.7)	--	--	--	--
Absent	5	10	89.8(6.5)	93.0(7.0)	3	9	71.3(3.5)	76.0(6.0)

*Difference significant at .05 level.

TABLE E-4

NUTRITIONAL STATUS OF VOLTAIC INFANTS BY MOTHER'S OCCUPATIONAL CATEGORY

	Yako				Koupele			
	N	%	wt/age	wt/lth	N	%	wt/age	wt/lth
Household and farming duties only	36	71	85.1(10.0)	90.0(8.0)	13	54	81.2(16.6)	88.2(12.8)
Beer making	9	18	85.7(8.4)	90.0(9.9)	1	4	80	88
Trade, crafts, or market gardening	6	12	83.2	88.5(6.7)	10	42	79.8(13.4)	86.6(12.7)

Sex has been found to be correlated to nutritional status in some poorly nourished groups with a strong preference for male children (Levinson 1974). Sex differences in nutritional status and in weaning patterns appeared to occur in both Yako and Koupele. These are presented in Table E-5. In both locations the number of months that mothers claimed they had been feeding bouillie to the infant was significantly longer for girls than for boys. In Koupele, the age given for introducing supplementary foods averaged 8.5 months for boys versus 6.8 months for girls, while in Yako the average age for both boys and girls was 7.0 months. In Koupele the average number of meals of bouillie eaten per day was two for girls and one for boys. The difference in nutritional status favoring girls in Yako was significant at the .01 level, while the apparently larger mean difference favoring boys in Koupele was not statistically significant and no longer existed when children with imprecisely recorded ages were included in the sample.

These findings are difficult to interpret without additional anthropological information. One hypothesis is that the right moment for introducing supplementary foods may traditionally have occurred later for boys than for girls, but that this tradition no longer affected behavior in Yako. Another is that mothers were more willing to take risks with girls than with boys, because male children were necessary to support the mother in old age, whereas girls married out of the family. Thus mothers could be more willing to adopt innovation, namely bouillie, with girls than with boys. If the weaning food were of good quality and carefully used as a supplement, it could improve nutritional status as in Yako. If, on the other hand, it were of low quality and used as a breast milk substitute, it could have a negative effect on nutritional status, as may have occurred in Koupele.

An unexpected variable correlating strongly with nutritional status was aspiration for the child's future. Table E-6 shows that nutritional status was significantly related to whether or not the mother aspired for the child to have a modern-sector occupation. The significance of this relationship increased when other variables were partialed out. The relationship may indicate that the mother with a visibly weak child felt that it was realistic not to put forth high aspirations for it, which would imply her recognition that modern-sector activities required superior health and strength in order to achieve success. It could also mean that families who aspired to the modern sector enjoyed better socioeconomic circumstances, which nutritionally benefited the child. This second interpretation is in accord with other studies of the diffusion of innovation (Rogers and Shoemaker 1971).

Interrelationships between the variables affecting nutritional status were explored through partial correlation coefficients. (It was decided that the attempt to quantify the proportion of variance of each variable explained by other variables by means of path analysis would lend the analytic exercise an air of false accuracy and therefore should not be attempted. Controlled variables include program, age, sex, health status, and times bouillie was served after cooking. The particular subset

TABLE E-5
DIFFERENCES IN WEANING PRACTICES
AND NUTRITIONAL STATUS BY SEX

	Yako			Koupele			
Age	N	Mean	sd	N	Mean	sd	
Boys	26	15.6	5.5	19	16.5	7.0	
Girls	30	15.6	5.2	18	14.8	6.5	
Age Starting Supplementary Feeding							
Boys	24	7.0	2.5	15	8.5	3.4	
							(t = 1.7)
Girls	29	7.0	2.1	15	6.8	2.3	
No. months eating Bouillie							
Boys	14	4.7	5.6	14	2.2	3.8	
Girls	19	6.7	5.3	14	6.4	6.6	
Weight for age							
Boys	23	82.0	8.6	11	85.8	10.9	
Girls	28	87.4	9.8	13	76.6	16.5	
Lth for age							
Boys	23	95.7	4.3	11	96.5	5.4	
Girls	27	98.3	4.2	13	96.5	5.1	
Weight for length							
Boys	23	88.9	8.9	11	92.2	7.5	
Girls	27	90.7	7.4	13	83.5	14.2	

TABLE E-5 (continued)

	Yako			Koupele		
Age	N	Mean	sd	N	Mean	sd
Meals Bouillie eaten yesterday						
Boys	21	2.0	1.4	8	1.0	1.6
Girls	26	2.1	2.1	11	2.0	1.4
Total Meals						
Boys	24	3.3	2.0	10	1.9	1.6
Girls	27	3.9	2.3	13	2.1	1.8

TABLE E-6
DIFFERENCES IN NUTRITIONAL STATUS OF INFANTS
BY WHETHER OR NOT THEIR MOTHERS
INTEND THEM TO ATTEND SCHOOL

		Yako			Koupele		
		N	Mean	sd	N	Mean	sd
Weight/age	school	29	86.6	7.3	31	81.8	13.6
	no school	27	83.1	11.3	6	65.3	126
Length/age	school	28	96.5	4.3	31	96.0	5.8
	no school	27	96.9	5.1	6	94.2	6.1
Weight/length	school	28	91.6	8.2	31	88.8	10.8
	no school	27	88.4	8.3	6	75.0	6.9

controlled during the calculation of each coefficient between two variables was chosen according to a judgment of whether or not a primary relationship between variables might be masked by the effects of each control variable. Because of the imprecision inherent in partialing procedures using dichotomus variables, correlation coefficients are not presented. However, significant relationships are described in the following sections.

The time use of the mother who had a cash income, the number of fields farmed personally by the mother, and the amount of time needed to collect firewood per meal were explored. Although the mother with a cash income had the money to purchase a protein supplement and sugar for making bouillie, it appeared that she might not have time to prepare weaning food. Having a cash income marginally delayed the introduction of solid foods; decreased the number of times bouillie was cooked per day; decreased the probability that the infant ate bouillie yesterday; and marginally increased the number of times bouillie was served to the child after it was cooked and the probability that it was stored in a covered container. Having a cash income also decreased the number of personal fields farmed by the mother and increased the amount of time she spent gathering fuel for cooking.

The amount of time required to gather fuel per meal was shown in Table E-1 to be negatively related to nutritional status. The partial correlation analysis showed it to be highly correlated positively to the number of times bouillie is served after cooking, which in turn was correlated negatively to nutritional status. It would theoretically be an oversimplification, however, to assume that shortage of fuel affected nutritional status only by decreasing the frequency with which fresh bouillie was cooked. Shortages of firewood also could strain the mother's energy resources in other ways affecting child care or breast milk quantity.

A woman with more personal fields needed less time to gather fuel (perhaps she could bring firewood or millet stalks for cooking back from her farming fields) and was more likely to have fed bouillie to her child yesterday, was less likely to have served bouillie several times after cooking, and was more likely to have mentioned more ingredients for cooking bouillie. However, she was not likely to have a significantly better nourished child, perhaps because she lacked the cash income to buy protein-enrichment ingredients for bouillie.

Another constraint on time and energy, namely distance from the family home to the well was also examined. Distance from water was negatively correlated to weight/length and marginally negatively correlated to weight/age of the infant. Mothers living farther from the well had more children, more child care for the infant, more help in fetching water, and marginally more family meals per day. The number of family meals was strongly negatively correlated to nutritional status of the infant for reasons which should be investigated. Help in fetching water was associated with better nutritional status of the infant, and greater use of bouillie, with marginally greater frequency of cooking bouillie per week, and the probability that the infant ate bouillie yesterday, that bouillie would be served more than once after cooking, and that bouillie would be eaten by

more members of the household than the infant only. Thus some aspects of household structure appeared conducive to the use of weaning food. Mothers with younger infants may have tended to live closer to the well to make it easier to give hot-water baths and massages, customarily given to Mossi infants during the first months of life.

We also looked at number of huts and number of months that the family rationed food as wealth indicators relating to nutritional status. Number of rationing months was negatively correlated to health status of the infant and to length/age, suggesting that severe preharvest scarcity may leave a residual effect on height growth even in seasons when food is plentiful enough for weight/length not to be affected. A greater number of huts is associated with fewer months of rationing, with more family meals per day, more wives, and more children per mother.

The fact that having more wives in the family was negatively correlated with health status of the infant might be explained by suggesting that mothers with co-wives were less likely to assert that their infant is doing well for fear of appearing immodest or inciting jealousy. The fact that numerous wives was also negatively correlated with weight/age and length/age of the infant, however, suggests that the relationship between number of wives and health status may be a real one. The reasons for these relationships are not obvious, although it could be that resources coming from the father of the family were insufficient to meet the needs of an increasing number of wives and their children, particularly in view of the cash cost of protein ingredients for bouillie.

Having more huts was associated with greater frequency of cooking bouillie per day and a greater number of children sharing the weaning food. Number of family meals cooked was highly correlated with number of times bouillie was cooked per day. This could be because the beginning stage of preparing to involved the making of a flour porridge or bouillie, some of which could be transferred to another container and sweetened to feed the baby. Unless the porridge of this stage were put back on the fire, however, most types of protein-enrichment ingredients could not be added, so that an infant primarily nourished with bouillie extracted from the pot would be receiving a nutritionally inferior food. Number of huts was also correlated with the amount of sugar used in preparing bouillie, which could indicate that people with more huts could afford to buy more sugar. More children might desire to eat the food if it were sweeter.

Finally, we explored again relationships between sex of the infant and other variables. Apparently mothers of male infants were more likely to have a child care helper, and presence of child care was negatively correlated with nutritional status, possibly because the child cared for by someone else could not breast-feed as frequently as the child cared for by its mother. Girl infants were more likely to have eaten bouillie yesterday and to have been eating bouillie over a long period of time, as noted earlier. Number of months eating bouillie was positively correlated with weight/age, after controlling for program and age (including infants without precise age specifications in the analysis).

APPENDIX F

TECHNICAL APPENDIX ON COST-EFFECTIVENESS CALCULATIONS

This appendix is designed to take the reader step by step through the calculations presented in the cost-effectiveness section and to discuss the types of assumptions and decisions made along the way. It is hoped that each step has been presented in sufficient detail to permit the reader to adapt the same procedure to the calculation of cost effectiveness of his or her own nutrition program.

If I is the program or method for which cost effectiveness is being estimated and J...N are alternative programs or situations, the cost effectiveness of adding program or method I to program or method K is calculated by the formula:

$$\text{Marginal cost effectiveness (I)} = \frac{\text{Cost (I + K) - Cost (K)}}{\text{Effectiveness (I+K)-Effectiveness (K)}}$$

The relative cost effectiveness of choosing program component I versus component I versus program component J in addition to K requires the same process of calculating:

$$\text{Cost effectiveness (J)} = \frac{\text{Cost (J + K) - Cost (K)}}{\text{Effectiveness (J+K)-Effectiveness (K)}}$$

and then comparing the costs of achieving the same effects by the two methods I and J.

The calculation will differ on the basis of the decisions to be made. If the choice is whether to add a single new component to an infrastructure which is already in place, then calculation of marginal cost effectiveness will give the incremental cost per incremental unit of effectiveness. On the other hand, if the choice is between alternative methods, components, or programs to be added to a baseline situation, then the relative costs of achieving the same effectiveness by the alternative options should be compared. The effectiveness outcome of having no program at all, as a baseline situation, must also be considered in the K position for most health-related effectiveness indicators, because a significant percentage of individuals recover or never become affected in the absence of any program.

The reason for not simplifying the above formula to $\frac{\text{Cost (I)}}{\text{Effectiveness (I)}}$ is that I rarely exists in isolation. I + K should ideally be two functional program units which have separate and real existence, so that the effectiveness and costs of K are not extrapolated by hypothetical considerations. In practice, however, we may be interested in estimating the cost effectiveness of components that are so closely interrelated with other components that the distinctions between the costs and effects of

different units border on the speculative and artificial. This situation arises, for example, in the attempt to calculate the separate cost effectiveness of health versus nutrition services in averting infant deaths in an integrated program. In the Upper Volta case, separate effectiveness estimates for community-level health and midwifery versus nutrition services in averting malnutrition would similarly be difficult to determine meaningfully.

Five alternative situations, I...M are presented below for the Upper Volta Case. As can be seen, the entire Yako program is represented by the letters I + J + K + L, whereas the typical district health and nutrition program is represented by K + L. In general, K + L is taken to be the equivalent of the Yako program minus the village-level health system. Figures from Koupele are used to estimate costs and outcomes for K + L for some calculations. Although this procedure is open to question, it tends to err on the side favoring the typical program because most infants considered in Koupele were recipients of a double intervention, both from the MCH program and from the home economists of the Ministry of Rural Development.

I. The nutrition component of the Yako village-level health and nutrition program.

J. The Yako village-level health care program excluding the nutrition component of the package.

K. The preschool nutrition component of the typical district health program with the same number of middle-level workers as in Yako, but lacking village-level workers.

L. The typical district health program with the same number of middle-level workers as Yako but without village-level workers and without a preschool nutrition component.

M. No program at all.

Each of these alternative situations will be assumed for some calculations.

Further assumptions are: (1) that middle-level preschool nutrition activities do not require buildings or supplies beyond those already provided for health services; and (2) that the value of alternative time use of middle-level workers when not engaged in nutrition activities or in supervising village-level workers need not be calculated. Ongoing costs of middle-level worker training in nutrition should be but are not included because they were not collected.

Regarding the first assumption, nutrition activities of typical district health programs often make use of infant weighing scales and donated foods, neither of which are used in Yako. While scales could be considered necessary for nutritional status surveillance, the necessity of donated foods is disputed. The typical costs of scales and of imported or program-purchased foods for a district of Yako's size should be considered. Since these costs were not collected, it must be noted that

incremental costs of the Yako scheme could easily become negative (that is, savings) in comparison to programs delivering substantial amounts of donated foods.

The reason for the second assumption is that alternative time use would necessarily focus on curative treatment of ills that could probably have been prevented by middle-level nutrition activities and by village-level health programs.

Many of the assumptions made in the calculation and use of cost-effectiveness cannot be fully justified. The most dubious of all assumptions may be that of replicability. The use of cost-effectiveness analysis in planning rests on the assumption that the same package of inputs can be expected to produce the same results when applied by different individuals in a different location. Personal leadership plays such a strong role in the success of nutrition programs everywhere that the assumption that the Yako model is applicable without the leadership of Dr. Gourier may in fact not be realistic. However, the fact that programs attempting to replicate the model have not yet shown great signs of success does not answer the question of replicability one way or the other, because none of them has been in operation for the period of time that was required for the Yako program to become established.

I. COSTS PER BENEFICIARY

The first calculation compared I + J + K + L (the whole Yako program) with K + L (the typical program). Annual fiscal costs for the entire village-level health and nutrition program, excluding a small amount of milk powder used for rehabilitating orphans and twins, spoons and drinking cups provided by UNICEF to the rehabilitation centers, and the cost of improving village wells, are given in Table 26 in Chapter 4. The construction of rehabilitation centers is not presented because new centers are being built of mud and thatch at no fiscal cost. Costs of the hospital and middle-level workers are not considered because they are lost in the subtraction (of K + L from I + J + K + L).

An estimate of the maximum number of beneficiaries who could be served directly with primary-care, midwifery, and nutrition services by 20 middle-level workers is derived from claims by Dunlop (undated) that only 10% of the population currently receives health care. Division of 10% of the population by the total number of middle-level workers yields a working figure of 10,000 who could be covered by the 20. Thus, the total incremental number served by the Yako system is 90,000 (100,000 - 10,000), including 16,200 preschool children and their mothers (of whom 9,000 mothers are assumed to be lactating) and 3,000 pregnant women.

Fiscal costs per recipient of the entire health package, including a simple primary care and emergency referral, are $0.29/person/year. If the vulnerable group, estimated to include about 16,200 preschool children and about 12,000 pregnant and lactating women, is assumed to require 75% of the care provided, cost per vulnerable recipient comes to $0.68/person/year. Community costs are not included in this particular global calculation because the time use of the primary-care workers and midwives was not investigated by the survey.

Calculation of the marginal cost of nutrition education in Yako compares I + J with J. Fiscal costs for the weaning food monitors come to approximately $385/year for training (one week only) or to $0.02/year/mother beneficiary. For the calculation of community costs for the monitor's time, it was estimated by an anthropologist working with women's program in Upper Volta that rural women make an income of approximately 200 CFA, or about U.S. $1.00/week from trading, marketing gardening, or crafts which might occupy up to 50 hours per week (Hoskins 1978). Since this income tends to be highly seasonal, the opportunity costs of time are valued here at $0.50/week. Considering that rural Voltaic women work long hours in all seasons, and thus basing the calculation on a 50-hour work week, opportunity costs of monitors' and mothers' time are both valued monetarily at $0.01/hour (although use of an external monetary figure for an internal time cost is not a useful descriptor of the value of the mother's time to the well-being of her family, as will be discussed later). If the monitor spends an average of seven hours/week at her job, the total community cost per year for the 300 monitors is $1,092 or $0.07/mother. This comes to a total of $0.09 per mother beneficiary to deliver the nutrition education. If opportunity costs of the mother for about two hours/month spent attending nutrition talks are added, the total comes to $0.33/recipient/year for nutrition education.

A second way of looking at the costs per beneficiary of nutrition education is by comparing I + K with L and K with L, in order to be able to compare the costs per beneficiary of delivering nutrition education by the Yako versus the traditional method. In this calculation, middle-level workers in situation K are assumed to spend 30% of their time in nutrition education-related activities (direct nutrition education and consultantions with mothers coming for curative service), and an equivalent 30% of intermediate-level worker time in Yako is assumed to be spent in supervising village-level nutrition activities. If the intermediate workers' annual wages average $600/worker, then $3,600/year goes to nutrition education in both programs. In the typical program K, serving 1,800 mother-child pairs, the cost per year per mother is $2.00 in fiscal costs or $2.24 including opportunity costs of mothers' time. Including the same $3,600 in the Yako costs (and dividing by total rather than incremental number of beneficiaries) yields an external cost of $0.22/mother/year, a cost of $0.28 including the value of the monitors' time and $0.54 including the value of the mothers' time. This shows that the Yako program is about five to ten times as cost effective as the traditional program in delivering nutrition education.

II. COST FOR KNOWLEDGE AND ATTITUDE CHANGE IN YAKO

Returning to the I + J with J comparison, if it is assumed that 94% of mothers, as in the Yako survey, learn how to make weaning food as proved by the fact that they are able to give a correct recipe and describe how to make the food, then the cost for teaching women how to make weaning food can be estimated at $0.026/mother/year fiscal cost, $0.07/mother/year monitor's cost, and $0.34/mother/year total cost, including opportunity cost of the mother's time.

Attitude change appears to be less important among Mossi mothers than for other groups who have traditional food and health beliefs which conflict with good nutritional practices. It was not possible from the survey to separate Yako mothers who did not prepare bouillie because of negative attitudes, if such existed, from those who did not prepare it for a variety of other reasons, including time and resource constraints and the fact that the infant already was eating adult foods.

Primary care workers and midwives also probably had an impact on nutritional knowledge and attitudes, although their role could more likely be one of referring the mother to the weaning food monitor and urging her to implement the weaning food advice or the dietary advice given for pregnant women. The attempt has not been made to include these workers in the educational calculation, because they were not studied in the survey and their role is assumed to be more one of urging behavior change rather than providing knowledge.

III. COSTS OF MALNUTRITION AVERTED

A number of calculations in this section will compare internal and fiscal costs of I + K + L and I + J + K + L with K + L.

Two measures of nutritional status are used to calculate malnutrition averted. One is percentage of infants falling into second- or third-degree malnutrition by the Gomez scale (Gomez et al. 1956) or less than 75% weight/age; the other is percentage falling into second- or third-degree malnutrition by weight/length, or less than 80% weight/length (Waterlow 1972). As mentioned earlier, however, weight/age is the more accurate measurement of nutritional status of infants under age two, and will therefore be considered in the conclusion. Children with MCH cards in Koupele are considered here as a comparison group representing beneficiaries of the typical health program K + L. Children without MCH cards in Koupele provide a rather poor estimate of prevalence of malnutrition in children not receiving program services because of the small sample size, but will be considered, nonetheless, for lack of alternative data. Both groups in Koupele are further untypical in that most of them are beneficiaries of the home economics intervention.

The following chart gives estimates of malnutrition prevalence in the groups considered:

	Below 75% Weight/Age	Below 80% Weight/Length
Yako	12%	11%
Koupele	29	12
Koupele non-MCH	43	22
Seaman and Holt (1973)		31

Cases of malnutrition averted and calculations used to derive these figures are presented in the following table:

Number of Cases of Malnutrition Averted

Formula	Yako	Koupele	Yako-Koupele
Weight/age	(.43-.12)* x 18,000 = 5,580	(.43-.29) x 1,800 = 270	5,310
Weight/ length (Koupele comparison)	(.22-.11) x 18,000 = 1,980	(.22-.12) x 1,800 = 180	1,800
Weight/ length (Seaman and Holt 1973)	(.31-.11) x 18,000 = 3,600	(.31-.12) x 1,800 = 214	3,386

*Decimal figures from previous chart.

Table 27 in Chapter 4 presents annual costs for Yako and Koupele programs by calculating I + J + K + L (Yako) and K + L (Koupele) in comparison to L. The ingredients and firewood for cooking one meal of bouillie are calculated in the following way: sugar at CFA 2.5 (two cubes), flavorings CFA 0.5, protein-rich ingredient at CFA 2.5 (some is produced at home and some would otherwise be fed to the child), and fuel at CFA 1.5, or a total of about CFA 7 in Yako, and CFA in Koupele (without the protein enrichment but with more fuel purchased). Cost of the flour is not included because it is assumed that the infant would probably have eaten the equivalent to or in other foods. The cost of total meals eaten per program is calculated by the formula: (percent who ate bouillie yesterday) x (average number of times bouillie cooked per week) x (cost per bouillie meal) x (52 weeks) x (recipient) x (child population) divided by dollar/franc conversion rate. Cost of mothers' time for cooking bouillie is estimated at (0.5 CFA/meal) x (percent who ate yesterday) x (average number of times bouillie cooked per week) x (52 weeks).

Table 28 shows the results in a cost-effectiveness analysis, and Table 29 presents the same results in a slightly different manner, by looking at the difference in costs between the two programs divided by the difference in numbers of cases of malnutrition averted. The anomalously large figure in these calculations is the cost of weaning foods in Yako. Division of the costs of all home-prepared weaning foods by the number of cases of malnutrition averted produces a cost figure per case that is paid neither by any outside agency nor by any individual family, but by the rural community as a whole.

A real estimate of this cost would have to take into consideration the ways in which these foods would have been utilized if they hadn't been eaten by infants and the effects of supply and demand. The point to note here is that these costs are private costs which are being afforded at the level stated within the rural community, and that a maximum cost per family of actually preparing bouillie two times/day, 365 days/year comes to no more than $23/child/year (two times is considered enough because other foods can be given from the family meals).

As was explained earlier, weight/age is the indicator of choice for measuring malnutrition over the age range of the sample children. Therefore, although the weight/length figures also are of interest, weight/age figures are used here for drawing conclusions.

By the calculations of Table 29 annual fiscal costs per case of malnutrition averted by adopting the Yako model as contrasted to the typical model vary between $0.71 and about $5.25 depending on how much of the costs of village-level health worker programs are attributed to malnutrition prevention. The reason for including all of the costs of the community-level health programs in the calculation is that the nutrition component probably would not function in isolation, so that it is unrealistic to think of erecting the nutrition component of the community structure alone. Therefore, this total amount of money would have to be provided from some source in order to keep nutrition prevention in operation. If the calculations of Table 29 are used, costs vary between $0.07 and $4.84 for additional cases averted by adding the community-level to the typical program. An exact figure for marginal costs for the nutrition component is not calculable because the effects of good midwifery on producing infants of adequate birthweight and of primary care for treating diarrhea and malaria cannot be estimated from the present survey.

The lowest annual cost for averting malnutrition in the typical program is calculated at $13.33/case from Table 29. Thus, it is possible to say that use of the village-level worker program reduces the annual cost of averting malnutrition by a factor ranging from 2.5 to 19, depending on how much of the cost of the community-level health program is included.

REFERENCES

Abbott, J.C. Economic factors affecting the distribution of world food protein resources. In Protein-enriched cereal foods for world needs, ed. Max Milner. St. Paul, Minnesota: American Association of Cereal Chemists, 1969.

Ackels, A.A., Gaylord, R.E. and Kuphal, E.E. Evaluation of low-cost extrusion cooking in Sri Lanka. Special Report. Fort Collins, Colorado: Colorado State University, 1977.

Agriculture Abroad. Research and education - the bennimix solution. 23(2):46, 1977.

AID. Food for peace p.l. 480 title II commodities reference guide. Washington, D.C., 1977.

AID/CDC. Disease and demographic survey project status report. Atlanta, Georgia: AID/CDC (January) 1975.

AID/Colombia. Vegetable protein mix subproject, Colombia nutrition loan. Project Paper. Washington, D.C., 1976.

Akinrele, I.A. and Edwards, C.C.A. An assessment of the nutritive value of a maize-soya mixture, "soya-ogi," as a weaning food in Nigeria. Br. J. Nutr. 26:177-84, 1971.

Alderman, M., Wise, P. and Ferguson, R. Reduction of young child malnutrition and mortality in rural Jamaica. New York: Cornell University Medical College. (Mimeographed.) 1977.

Allison, J.B. The nutritive value of dietary proteins. Pp. 41-86 in Mammalian protein metabolism. Vol. 2. New York: Academic Press, 1964.

Asfour, R.Y., Tannous, R.I., Sarry, Z.I., and Cowan, I.W. Protein rich food mixtures for feeding infants and young children in the Middle East. II. Preliminary clinical evaluation with Laubina mixtures. Am. J. Clin. Nutri. 18:148, 1965.

Austin, J.E. and Mock, C. High protein product development in Thailand. Harvard Business School case no. 9-374-301. Boston, Massachusetts: Harvard University, 1974.

Barja. I., Munoz, P., Solimano, G., Vallijos, E., Radrigan, M.E., and Tagle, M.A. Infant formula based on chickpea (Cicer arietinum), its use as the sole food in healthy infants. Indian J. Nutr. Diet. 11:335, 1974.

Beghin, I., de Mello, A.V., Costa, T., Monteiro, E., Lucena, M.A., and Varela, R. Assessment of biological value of a new corn-soy-wheat noodle through recuperation of Brazilian malnourished children. Am. J. Clin. Nutr. 26:246-58, 1973.

Behar, M. Evaluation of commercial distribution of vegetable mixes. PAG Nutrition Document R. 10/Add 94. New York: United Nations, 1966.

Berg, A. The nutrition factor. Washington, D.C.: Brookings Institution, 1973.

Bodenheimer, T.S. The political economy of malnutrition: generalizations from two Central American case studies. Arch. Latoam. Nutr. 22:4, 1972.

Bourne, M.C. What is appropriate/intermediate food technology? In overview, outstanding symposia in food science and technology. Food Tech. 32:4, 1976.

Bressani, R. Formulation and testing of weaning and supplementary foods containing oilseed proteins. In Protein-enriched cereals foods for world needs, ed. Max Milner. St. Paul, Minnesota: American Association of Cereal Chemists, 1969.

Bressani, R. and Behar, M. The use of plant protein foods in preventing malnutrition. In Proceedings of sixth international congress of nutrition. Edinburgh, 1964.

Bressani, R. and Elias, L. Legume foods. In New protein foods, vol. 1A, technology, ed. A. Altschul. New York: Academic Press, 1974.

Bressani, R., Valiente, A.T., and Tejada, D.E. All-vegetable protein mixtures in human feeding. VI. The value of combinations of lime-treated corn and cooked beans. J. Food Sci. 27:394, 1962.

Bressani, R. and Viteri, F. Metabolic studies in human subjects. In Proceedings, SOS/70, Third International Congress on Food Science and Technology. Chicago: Institute of Food Technologists, 1971.

Brown, E. Weaning foods in developing countries. A position paper for the Workshop on Effective Intervention to Reduce Infections in Malnourished Populations. Haiti, 1977.

Buffa, A. Food, technology and development. A special UNICEF report. Reprinted from Food Eng. (November-December) 1971.

Cameron, M.E. Method of relating protein requirements to protein value of food and its application to improvement of meals for infants and young children, 1968. PAG Compendium. The collected papers issued by the protein-calorie advisory group of the U.N. system, 1956-1973, ed. M. Sachs. New York: Worldmark Press, Ltd., 1976.

Cameron, M. and Hofvander, Y. Manual on feeding infants and young children. Second edition. New York: U.N., 1976.

Campbell, J.A. and McLaughlin, J.M. Applicability of animal assays to humans. In Proceedings, SOS/70, Third International Congress on Food Science and Technology. Chicago: Institute of Food Technologists, 1971.

Capone, C. Integrating Title II programs with locally operated nutrition, socioeconomic, and humanitarian activities. Field Bulletin No. 27. Nairobi: Catholic Relief Services, 1977.

CDC (Center for Disease Control). AID/CDC disease and demographic survey project status report for Upper Volta. Rockville, Maryland (January 19) 1975.

Chaudhuri, R.N. Home-made vegetable protein food in the treatment of Kwashiorkor. J. Indian Med. Assoc.. 42(120):560-564, 1964.

Cinquieme Congres du Magrebe. a malnutrition proteino-calorique chez l'enfant algerien. Algiers, 1976.

Comite de Sante Infantile, Secteur No. 10 de Yako. Causerie du mois de fevrier 1976, la nutrition. Yako District Hospital, 1976.

Comite de Sante Infantile, Secteur No. 10 de Yako. Demonstration culinaire no. 1, bouillie simple individuelle, Yako District Hospital, undated.

Cordaro, J.B. and Call, D. Nutritional protection of vulnerable groups through protein-rich mixtures, a critical review. In Proceedings, nineth international congress of nutrition, Mexico, 1972, vol. 4, eds. A. Chavez, H. Bourges, and S. Basta. Basel, Switzerland: S. Karger, 1975.

CRS (Catholic Relief Services). CRS/Upper Volta 'FY 1968. Nutrition intervention program. Ouagadougou, 1978.

den Hartog, A.P. Unequal distribution of food within the household. Food Policy and Nutrition Division, 1972.

Devadas, R.P. Problems and prospects in alleviating protein malnutrition in India. Paper presented at 8th Pugwash Symposium, Frankfurt, Germany (May 12-23) 1970.

Devadas, R.P., Chandrasekhar, U. and Lalitha, M. Nitrogen retention in preschool children on a vegetable protein mixture supplement. Am. J. Clin. Nutr. 26:415-19, 1973.

Dunlop, D.W. Alternatives to modern health delivery systems in Africa: issues for public policy consideration on the role of traditional healers. In Traditional healers: use and nonuse in health care delivery, eds. I.E. Harrison and D.W. Dunlop. East Lansing, Michigan: Michigan State University, The African Studies Center. Rural Africana, No. 26, undated.

El-Shazali, H. Homemade weaning foods for Sudanese children. Sudan Med. J. 10(2), 1972.

FAO. Amino acid content of foods and biological data on proteins. FAO Nutritional Studies No. 24. Rome: FAO, 1970.

FAO. Production yearbook. Vol. 28-1. Rome: FAO, 1974.

FAO. Handbook on human nutritional requirements. Rome: FAO, 1974.

FAO. Rapport intermediarie sur l'etat d'avancement du project strategie pour l'alimentation TF-INT. 210 (SWE), composante Haute-Volta a l'issue de la premiere phase division des politiques alimentaires et de la nutrition. Rome: FAO, 15 (September 30) 1976.

FAO. FAO community review and outlook, 1977-79. FAO economic and development series no. 4. Rome: FAO, 1978a.

FAO. FAO production yearbook, 1977. FAO statistical series no. 15, vol. 31. Rome: FAO, 1978b.

FAO/WHO Ad Hoc Expert Committee. Energy and protein requirements. FAO nutrition meetings report series no. 52. Rome: FAO/WHO, 1973.

Fomon, S.J. Infant nutrition. Philadelphia: W.B. Saunders, 1974.

Fox, H.C. and Waterlow, J.C. Nutritive value of leafe protein concentrates for children. In Proceedings of the seventh international congress of nutrition, Hamburg, 1966, vol. 3. London: Pergamon Press, 1967.

Gershoff, S.N., McSandy, R.B., Suttapreyasri, D., Promkutkao, C., Nondasuta, A., Pisolyabutra, U., Tantiwongse, P., and Viravaidhaya, V. Nutrition studies in Thailand. II. Effects of fortification of rice with lysine, threonine, thiamin, riboflavin, vitamin A, and iron on preschool children. Am. J. Clin. Nutr. 30:1185-95, 1977.

Goodhart, R.S. and Shils, M.E. Modern nutrition in health and disease. Philadelphia: Lea and Febiger, 1975.

Gomez, F., Galvan, R.R., Franke, S., Munoz, J.C., Chavez, R., and Fazquez, J. Mortality in second- and third-degree malnutrition. J. Trop. Pediatr. 2(2):77-83 (September) 1956.

Gopalan, C. Vegetable mixtures as protein sources for young children. In Proceedings of the seventh international congress of nutrition, Hamburg, 1966, vol. 3. New York: Pergamon Press, 1967.

Gopaldas, T., Varadarajan, I., Grewal, T. and Shingewekar, A.G. Development of indigenous multimixes for the preschool child. Indian pediatr. (11(7):501-9 (July) 1974.

Gopaldas, T., Srinivasan, N., Varadarajan, I., Shingwekar, A.G., Seth, R., Mathur, R.S., and Bhargava, V. Project Poshak. Vol. I and II. New Delhi, India: CARE, 1975.

Graham, G.G. Nutritional quality of vegetable protein in young children. In Proceedings of the seventh international congress of nutrition, Hamburg, 1966, vol. 3. New York: Pergamon Press, 1967.

Graham, G.G. and Baertl, J.M. Nutritional effectiveness of soy cereal foods in undernourished infants. J. Am. Oil Chem. Soc. 51(1):152A-155A, 1974.

Graham, G.G., Baertl, J.M., Placko, R.P., and Cordano, A. Dietary protein quality in infants and children. VIII. Wheat- or oat-soy mixtures. Am. J. Clin. Nutri. 25:875-80, 1972.

Graham, G.G., Baertl, J.M., Placko, R.P., and Morales, E. Dietary protein quality in infants and children. IX. Instant sweetened corn-soy-milk blend. Am. J. Clin. Nutri. 26:491-6, 1973.

Graham, G.G., Morales, E., Acevedo, G., Baertl, J.M. and Cordano, A. Dietary protein quality in infants and children. II. Metabolic studies with cottonseed flour. Am. J. Clin. Nutr. 22(5):577-87, 1969.

Graham, G.G., Morales, E., Acevedo, G., Placko, R.P., and Cordano, A. Dietary protein quality in infants and children. IV. A corn-soy-milk blend. Am. J. Clin. Nutr. 24:416-422, 1971.

Grewal, T., Gopaldas, T., Hartenberger, P., Ramakrishnan, I., Srinivasan, N., and Devgun, D.P. Acceptability trials with instant CSM: taste and flavor preferences of a rural community of India. Ind. J. Nutr. Diet. 11(6):350, 1974.

Habicht, J.P., Schwedes, J.A., Arroyave, G., and Kline, R.E. Biochemical indices of nutrition reflecting ingestion of a high protein supplement in rural Guatemalan children. Am. J. Clin. Nutr. 26:1046-52, 1973.

Harper, J., Jansen, G., Wilson, D., and Stumpf, P., eds. Low cost extrusion cookers. International workshop proceedings. Fort Collins, Colorado: Colorado State University. June 2-5, 1976.

Hemming, G. Doctoral thesis in anthropology, in progress, Yale University.

HIID. World survey of nutrition interventions. Unpublished report. Cambridge, Massachusetts: Harvard Institute for International Development, 1976.

HIID. Interviews with UN, WHO, and FAO officials conducted by Catherine Overholt. Geneva and Rome, 1978.

Hitt, C. and Austin, J.E. Africa protein products (A) - Harvard Business School case no. 4-576-193, Boston, Massachusetts: Harvard University, 1976a.

Hitt, C. and Austin, J.E. Africa protein products (B) - Harvard Business School case no. 4-576-194, Boston, Massachusetts: Harvard University, 1976b.

Holden, C. Fish flour: protein supplement has yet to fulfill expectations. Science 173-410-2, 1971.

Hoskins, M. Personal communication, 1978.

Icaza, S.J. The Incaparina project in case histories in mass communications. PAG Bulletin 6(1):35, 1976.

INCAP. Informe de actividades del periodo guadrienal 1971-1975. Division de Nutricion Aplisoda, Guatemala, 1976.

Indo Dutch Project for Child Welfare. Fighting malnutrition with Hyderabad mix. Promotional pamphlet, undated.

Irwin. M.I. and Hegsted, D.M. A conspectus of research on protein requirements of man. J. Nutr. 101:385-43, 1971.

Jardin, C. List of foods used in Africa, 2nd edition. A joint publication of the Food Consumption and Planning Branch, Nutrition Division, FAO, Rome and the Nutrition Program, Regional Medical Programs Service, U.S. Department of Health, Education and Welfare, Bethesda, Maryland, undated. (Note: First edition was published in February 1967.)

Jelliffe, D.B. Approaches to village-level infant feeding, (1) Multimixes as weaning foods. J. Trop. Pediatr. 13(1):46-48, 1967.

Jelliffe, D.B. Cajanus 3:148, 1970.

Jelliffe, E.F. A new look at multimixes for the Caribbean. Envir. Child Health 136-50, 1971.

Jett, J. The role of traditional midwives in the modern health sector in West and Central Africa. Report. AID contract no. REDSO/WA-76-81, 1977.

Johansson, A. Food and nutrition in social and economic change in Upper Volta: implications for planning. Unpublished research proposal (January) 1978.

Jones, P.O. Letter to Mrs. M. Wilins-Crosta, Project Management Division, World Food Programme. Rome (May 4) 1977.

Kapsiotis, G.D. History and status of specific protein-rich foods; FAO/WHO/UNICEF protein food program and products. In Protein-enriched cereal foods for world needs, ed. Max Milner. St. Paul, Minnesota: American Association of Cereal Chemists, 1969.

Kapsiotis, G.D. Report on food production for infants and children in Malawi, 27 February-5March 1977. Consultancy report. Rome: Food policy and nutrition division, FAO, 1977a.

Kapsiotis, G.D. Report on food production for infants and children in Swaziland. 7-11 March 1977. Rome: Food Policy and Nutrition Division, FAO, 1977b.

Kracht, U. Marketing unconventional protein-rich foods - one form of nutrition intervention. In Nutrition, national development and planning, eds. A. Berg, N.S. Scrimshaw, and D.L. Call. Cambridge, Massachusetts: MIT Press, 1973.

Kuiken, K.A. Effect of other processing factors on vegetable protein meals. In Processed plant protein foodstuffs, ed. A. Altschul. New York: Academic Press, 1958.

LIFE (League for International Food Education). Files on formulated foods. Washington, D.C., 1973.

Levinson, F.J. Morinda: an economic analysis of malnutrition among young children in rural India. Cornell/MIT International Nutrition Policy Series, 1974.

Liener, I.E. Effect of heat on plant proteins. In Processed plant protein foodstuffs, ed. A. Altschul. New York: Academic Press, 1958.

Lowe, C.U., Coursin, D.B., Heald, F.P., Holliday, M.A. et al. Proposed changes in Food and Drug Administration regulations concerning formula products and vitamin-mineral dietary supplements for infants. Pediatrics 40:5, 1967.

Martin, C. Letter to Harvard Institute for International Development from Find Your Feet, Ltd. Abington (February 4) 1977.

Martin-Santos, F. La sante publique en Haute Volta, profil sanitaire. Report to USAID. 118-121, 1976.

Martin-Santos, F., Stabile-Wolcan, S., and Kersauze, R. Apercu informatif sur sante-eau-nutrition dans les pays du Sahel. (Draft) (Essai d'analyse des donnees globales relatives aux huit pays membres du CILSS). Commission "Sante-Eau-Nutrition" Reunion Pleniere de l'Equipe "Ressources Humaines." Dakar, Senegal (March 28-31) 1977.

Mathur, Y.C. and Madhavi, V. Village-level production of supplementary food, Indo-Dutch project for child welfare, Hyderabad, India. Trop. Doct. 6:84-86, 1976.

Mauron, J. Protein-enriched foods: facts and illusions. In Proceedings of the ninth international congress of nutrition, Mexico, 1972, vol. 3. New York: Karger, 1975.

McLaren, D.S., Asfour, R.Y., Cowan, J.W., Pellett, P.L., and Tannous, R.I. Further development of Laubina mixtures in the Middle East. In Proceedings of the seventh international congress of nutrition, Hamburg, 1966, vol. 3. New York: Pergamon Press, 1967.

Milner, M. Status of development and use of some unconventional protein. In Protein-enriched cereal foods for world needs, ed. Max Milner. St. Paul, Minnesota: American Association of Cereal Chemists, 1969.

Milner, M. History of the UAR protein-rich weaning foods project. PAG Bulletin (May 6) 1970.

Mock, C. and Austin, J.E. CARE-Sri Lanka - Harvard Business School case no. 4-375-243. Boston, Massachusetts: Harvard University, 1975.

Naismith, D.J. Kwashiorkor in western Nigeria: a study of traditional weaning foods, with particular reference to energy and linoleic acid. Br. J. Nutr. 30:567, 1973.

NAS/NRC. Evaluation of protein quality. Publication No. 1100. Washington, D.C.: National Academy of Sciences/National Research Council, 1963.

NCHS (National Center for Health Statistics). Monthly vital statistics report, health examination survey data, HEW, HRA, Rockville, Maryland 76-1120, vol. 25, no. 3, supplement (June 22) 1976.

Nermark, C.H. Product testing methodologies. In Report on FAO/SIDA Interregional seminar on food promotion, Food and Agriculture Organization of the United Nations, Rome, 94-100, 1972.

Nicol, B.M. Dietary bulk as a factor influencing protein and caloric intakes. PAG Document 10/116. New York: United Nations, 1967.

Nutrition Center of the Philippines. Trainer's manual on the new direction of the Philippine nutrition program (Course 1). Makati, Rizal (September) 1975.

Ogbeide, O. Nutritional hazards of food taboos and preferences in mid-west Nigeria. Am. J. Clin. Nutr. 27:213-16, 1974.

Orr, E. The use of protein-rich foods for the relief of malnutrition in developing countries: an analysis of experience. London: Tropical Products Institute, 1972.

Orr, E. The contribution of new food mixtures to the relief of malnutrition, a second look. Food and Nutrition 3(2)2-10, 1977.

PAG Compendium. The collected papers issued by the protein-calorie advisory group of the U.N. system, 1956-1973, ed. M. Sachs. New York: Worldmark Press, Ltd., 1976.

PAG Guideline No. 7. Human testing of supplementary food mixtures. P. D933 in PAG Compendium, ed. M. Sachs. New York: Worldmark Press, Ltd., 1976.

PAG Guideline No. 8. Protein-rich mixtures for use as weaning foods. P. E1-631 in PAG Compendium, ed. M. Sachs. New York: Worldmark Press Ltd., 1976.

PAG Guideline No. 12. Production of single cell protein for human consumption. In PAG Compendium, ed. M. Sachs. New York: Worldmark Press Ltd., 1976.

PAG Statement No. 4. Single cell protein. In PAG Compendium, ed. M. Sachs. New York: World Mark Press Ltd., 1976.

PAG Statement No. 20. The protein problem. In PAG Compendium, ed. M. Sachs. New York: Worldmark Press Ltd., 1976.

PAG Statement No. 25. The global maldistribution of protein: a growing trend, 1973. P. F795 in PAG Compendium, ed. M. Sachs. New York: Worldmark Press Ltd., 1976.

PAHO/INCAP. Recommendations for human trials on new protein-rich foods. PAG Nutrition Document R. 10/Add. 61. New York: United Nations (July) 1965.

Pak, N., Bermer, L., Duffau, G., Macaya, J., Soriano, H., Munoz, R., Hidalgo, R., Soto, A., Zerene, N. and Tagle, M.A. Infant feeding formula based on chickpea (Cicer Arietimum). Its use in the treatment of acute diarrhea with dehydration, preliminary communication. Indian J. Nutr. Diet. 12:42-46, 1975.

Pariser, E.R., Wallerstein, M.B., Corkery, C.J., and Brown, N.L. Fish protein concentrate. Panacea for protein malnutrition?? Cambridge, Massachusetts: MIT PRess, 1978.

Patodi, R.K., Tiwari, S.C., and Mathur, L.K. Infant feeding practices in urban and rural areas in Madhya Pradesh. Indian J. Pediatr. 43:333-8, 1976.

Pereira, S.M. and Sundararaj, R. The effect of a high energy food supplement on the growth of preschool children. Indian J. Med. Res. 63(1): 156-61, 1975.

Petillon, A. Personal communication, 1978.

Pike, R.L. and Brown, M.L. Nutrition: an integrated approach. Second edition. New York: Wiley & Sons, 1975.

Pirie, N.W. Thirty years progress with leaf protein. Cajanus 3(5):279-87, 1970.

Popkin, M. and Latham, M.C. The limitations and dangers of commerciogenic nutritious foods. Am. J. Clin. Nutr. 26:1015-23, 1973.

Rachman, S. The modification of attitudes and behavior. In Malnutrition is a problem of ecology. (Bibl. Nutri. Dieta. 14). Basel/New York: Karger, 1970.

Rajahyaksha, V.G. Rural marketing in India. PAG Document 2.22/15. New York: United Nations, 1969.

Rao, G.P. and Ramchandran, P. Experience with cottonseed protein in the therapy of Kwashiorkor. Indian Pediatr. 8(8):380-4, 1971.

Rawson, I. and Berggren, G. Family structure, child location and nutritional disease in rural Haiti. J. Trop. Pediatr. 19(3):288, 1973.

Republique de Haute Volta. Plan quinquinnal de developpement economic et social, 1972-1976. 2 volumes. Government of Upper Volta, Ouagadougou, 1972.

Reutlinger, S. and Selowsky, 1976. Malnutrition and poverty, magnitude and policy options. Baltimore, Maryland: Johns Hopkins University Press, 1976.

Rha, C. Evaluation of the feasibility and relative cost of the industrial production of 2 protein mixes - Fortesan and FLT. Contract no. PERR-14976-PAHO. Cambridge, Massachusetts: Massachusetts Institute of Technology, 1974.

Robinson, D. A systems approach to marketing new foods in report on FAO/SIDA interregional seminar on food promotion, Food and Agriculture Organization of the United Nations, Rome, 61-93, 1972.

Rogers, E.M. and Shoemaker, F.F. Communication of innovation: a cross-cultural approach, New York: Free Press, 1971.

Ropes, G.H., Nutrition in the Philippines: policies, programs and politics. Masters thesis. Cambridge, Massachusetts: Massachusetts Institute of Technology, 1978.

Scrimshaw, N.S. Nutritional considerations in food aid. P. 37 in International food policy issues, a proceedings. Foreign Agricultural Economic Report No. 143. Washington, D.C.: USDA, 1978a.

Scrimshaw, N.S. Through a glass darkly. Nutr. Today. 14-34 (January/February) 1978b.

Scrimshaw, N.S., Wang, D.I., and Milner, M. Protein resources and technology: status and research needs, research recommendations and summary. NSF-RA-T-75-037, Washington, D.C., NSF (December) 1975).

Seaman, J. and Holt, J. Report on an enquiry on the drought situation in Upper Volta. Westport, Connecticut: London Technical Group and Save the Children Fund(July 10-31) 1973.

Selinus, R. Homemade weaning foods for Ethiopian children. J. Trop. Pediatr. 16(4):188, 1970.

Shah, P.M. Feeding practice in rural community, Palghar. Indian Pediatr. 12(1):73, 1975.

Shah, P.M., Udani, P.M., and Aphale, R.V. Domiciliary management of Kwashiorkor in a rural set up: a longitudinal study of clinical, economic, and social aspects. Indian Pediatr. 3(12):805-813, 1971.

Shaw, R.L. Incaparina in Central America. PAG Document 2.19/18. Rome: United Nations, 1969.

Sr. Trinitas. Personal communication and information sheet on Likuni Phala. Malawi (May) 1978.

SPSS (Statistical Package for the Social Sciences). Second edition. New York: McGraw-Hill, 1975.

Swaminathan, M. Supplementary foods based on oilseeds for infants and children. J. Scientific Industrial Research 34:329 (June) 1975.

Tannenbaum, S.R., Stillings, B.R., and Scrimshaw, N.S. eds. The economics, marketing, and technology of fish protein concentrate. Cambridge, Massachusetts: MIT Press, 1974.

Tannous, R.I., Cowan, J.W., Rinner, F., Asfour, R.J., and Sabry, Z.I. Protein-rich food mixture for feeding infants and preschool children in the Middle East; development and evaluation of Laubina mixture. Am. J. Clin. Nutr. 17:144 (September) 1965.

Tavill, F. and Gonik, A. Use of fish protein concentrate in the diets of weanling infants. Am. J. Clin. Nutr. 22(12):1571-6 (December) 1969.

Trinitas, Sr. Personal communication, 1978.

U.N. Economic and Social Council. Edible protein. A strategy statement on action to avert the protein crisis. Report of the Secretary General to the U.N. Economic and Social Council, 51st Session. New York: United Nations, 1971.

UNU/WHP. Nutritional evaluation of protein foods. United Nations University/ World Hunger Program Publication No. 2. Tokyo, Japan (in press).

U.S. Department of Agriculture. Composition of foods, agriculture handbook No. 8. Washington, D.C.: U.S. Government Printing Office, 1963.

U.S. Department of Agriculture. The annual report on activities carried out under public law 480, 83rd congress, as amended during the period July 1, 1974 through June 30, 1975. Washington, D.C.: USDA, 1977.

Wallerstein, M. Personal communication (April) 1978.

Waterlow, J.C. Classification and definition of protein calorie malnutrition. Brit. Med. J. (September 2) 1972.

Weil, Jr., R.J. Compendium, approaches to improve the nutritional status of the preschool child. Washington, D.C.: Economic Research Station, USDA, 1972.

WFP (World Food Programme). Interim evaluation summary report, Arab Republic of Egypt. WFP/CFA: 2/12-A Add. C14 (September) 1976.

White, P.L. and Fletcher, D.C., eds. Nutrients in processed foods: proteins. Acton, Massachusetts: Publishing Sciences Group, 1974.

WHO (World Health Organization). Report on the seminar on protein problems with particular reference to weaning foods, Cairo (November 4-8) 1974.

WHO. WHO Publication: AFR/NUT/77. Geneva: WHO (October) 1976.

Wicks, A.C.B. and Whittle, H.C. A comparison of dried skimmed milk and Nutresco as a protein supplement for the treatment of kwashiorkor. Centr. Afr. J. Med. 14(7):144-47, 1968.

Wickstrom, B. Cost revenue projection for Faffa. L(¢(. In PAG Compendium, ed. M. Sachs. New York: Worldmark Press Ltd., 1976.

Wickstrom, B. Marketing of protein-rich foods in developing countries. PAG Guideline No. 10. 1971. In PAG Compendium, ed. M. Sachs. New York: Worldmark Press Ltd., 1976.

Wickstrom, B. Purchasing power of African and Asian consumers in relation to meeting the nutritional needs of the child through commercial channels. PAG Document 2.22/23. New York: United Nations, 1972.

Wiese, H.F., Hansen, A.E. and Adam, D.J.D. Essential fatty acids in infant nutrition. J. Nutr. 66:345, 1958.

Wilkie, N.A. The market development programme for protein-rich foods in Algeria. PAG Document 2.22/8. Marketing Meeting. Rome: United Nations, 1969.

Winterbottom, R. Personal communication, 1978.

Wise, R.P. The case of Incaparina in Guatemala. Unpublished (July 17) 1978.

Young, V.R. Recent advances in evaluation of protein quality in adult humans. In Proceedings ninth international congress of nutrition, vol. 3. Basel: Karger, 1975.

Young, V.R. and Scrimshaw, N.S. Nutritional evaluation of proteins and protein requirements. In Protein resources technology, eds. M. Milner, N. Scrimshaw, and D.I.C. Wang. Westport, Connecticut: Avi, 1978.

Zeitlin, M. Trip report to Algeria. HIID, 1976a.

Zeitlin, M. Trip report to Upper Volta. HIID (November 23-6) 1976b.

Zeitlin, M.F. Breast-feeding and growth status in two preschool child populations; reference standards for maximum thigh circumference from 0-5 years; thigh circumference - an age-independent screening index for preschool nutrition interventions. Ph.D. thesis. Massachusetts Institute of Technology, Department of Nutrition and Food Science, 1977.

Zeitlin, M. Personal communication, May 1978.

NUTRITION INTERVENTION IN DEVELOPING COUNTRIES

Prepared by the Harvard Institute for International Development
for the U.S. Agency for International Development
James E. Austin, Project Director; Marian F. Zeitlin, Assistant Project Director

NUTRITION INTERVENTION IN DEVELOPING COUNTRIES: AN OVERVIEW
Edited by James E. Austin and Marian F. Zeitlin
0-89946-077-1 ca. 350 pages $25.00

THE SUPPLEMENTARY STUDIES

Volume 1
Study I: Supplementary Feeding
Mary Ann Anderson, James E. Austin, Joe D. Wray, and Marian F. Zeitlin
0-89946-081-x 224 pages $30.00; $125.00 for 5-volume set

Volume 2
Study II: Nutrition Education
Marian F. Zeitlin and Candelaria S. Formacion
0-89946-082-8 368 pages $30.00; $125.00 for 5-volume set

Volume 3
Study III: Fortification
James E. Austin, Thomas K. Belding, David Pyle, Florentino S. Solon, Thomas L. Fernandez, Michael C. Latham, and Barry M. Popkin
Study IV: Formulated Foods
Jerianne Heimendinger, Marian F. Zeitlin, and James E. Austin
0-89946-083-6 304 pages $30.00; $125.00 for 5-volume set

Volume 4
Study V: Consumer Food Price Subsidies
Beatrice Lorge Rogers, Catherine A. Overholt, Eileen Kennedy, Federico Sanchez, Adolfo Chavez, Thomas K. Belding, C. Peter Timmer, and James E. Austin
Study VI: Agricultural Production, Technical Change, and Nutritional Goals
Richard H. Goldman and Catherine A. Overholt
0-89946-084-4 224 pages $30.00; $125.00 for 5-volume set

Volume 5
Study VII: Integrated Nutrition and Primary Health Care Programs
James E. Austin, Thomas K. Belding, Richard Brooks, Richard Cash, Jonathan Fisher, Richard Morrow, Nancy Pielemeyer, David Pyle, Joe D. Wray, and Marian F. Zeitlin
0-89946-085-2 272 pages $30.00; $125.00 for 5-volume set

0-89946-083-6