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THE DEVELOPMENT OF INFANT AND PRE-SCHOOL FOODS BASED UPON LEGUME PROTEINS

AID/csd-3646

Submitted by: C. O. Chichester
University of Rhode Island
August 1972

THE DEVELOPMENT OF INFANT AND PRE-SCHOOL FOODS BASED UPON LEGUME PROTEINS

Background

The project (AID/csd-3646) has been underway for a number of years concerned with the development of infant and weanling foods based upon oilseed proteins and fish protein concentrate, which are available in the southern Latin American region. This project has utilized protein sources hitherto not utilized for the production of these foods. The project is an integrated one which investigated possible food protein sources in a systematic manner. The protein sources were evaluated nutritionally by both chemical and biological means, and toxicological investigations of the foods were undertaken in two species of animals. The technology of formulation was developed at a laboratory scale, acceptability trials of the formulated foods were made, and the technology for larger scale production was worked out, along with the economic evaluations of the process. Finally, the products were produced on a commercial scale and evaluated in target populations. The sources of food which were initially considered in this project were fish protein concentrate and sunflower meal presscake. Later, rapeseed presscake meal was added to the products that were investigated. At the present time, the sunflower meal presscake is being utilized commercially on a moderate scale and the technology of the detoxification of rapeseed meal by commercial scale is being developed. The work on rapeseed meal has attracted considerable attention world wide.

A third food material has been developed in the last year based upon a specially processed wheat and soy base (wsb) to which other nutrients are added to give an instantly rehydratable weanling food of very high biological value.

The chief achievements of the project outside of the scientific achievements listed can be considered in three areas, as follows:

1) The establishment of an integrated program in applied nutrition which may serve as a model for other areas in the world. This integration has been achieved by training of Chilean and other nationals and the development of linkages between the basic groups and the applied technological groups in foods in Chile. The program has been able to develop a central applied nutrition theme through the efforts of two governmental agencies, four universities and two

business organizations, all of which are pointed to a common aim.

2) The development of national programs for the supplementation of infant diets through the development of food products based upon indigenous protein sources that are targeted at the most vulnerable groups in the Latin populations, that is, the pre-school infants.

3) A research team has been developed in the country which has achieved some very significant results which may be applied world wide. The results of the relationship between mental development and malnutrition in early youth, the demonstration that marine protein concentrate can be utilized in infant feeding successfully, and the development of new protein sources from under-utilized products such as sunflower seed presscake and rapeseed presscake are significant research breakthroughs.

The results of this contract contribute to institution building, the development of interactions between research groups and private industry in Chile, and, obviously, to the development of research results which are significant on a world wide basis.

The overall project involved the Institute of Food Science and Technology of the University of Chile, the Institute for Science and Technology of the Development Corporation of Chile, and the Institute for Fisheries Development (their section on food technology) together with the Catholic University of Santiago. The project in Chile was lead by Dr. Fernando Monckeberg of the Department of Pediatric Nutrition of the University of Chile. These institutions worked together on the overall project, each in its separate area of expertise.

The National Health Sevice of Chile contributed manpower in the portions of the project concerned with the field testing of products on a large scale.

Coordination of the efforts in Chile and the training of individuals from these institutions was undertaken by the United States institution. Portions of the nutritional and chemical analyses were done in the United States, and personnel from the United States worked in Chile between the various institutions on some of the processing and nutritional phases.

It is proposed that the present project employ the same groups since it has been found that, by coordinating the efforts of these institutions and by cooperating with interested commercial groups, significant progress can be made at a fairly rapid rate. Additionally, the inputs of each of these segments are synergistic. The lead group in Chile is the Department of Pediatric Nutrition of the University of Chile and, in the United States, the Department of Food

and Resource Chemistry. In order to promote the regionality in the program, liaison is maintained between the University of Buenos Aires, Department of Nutritional Sciences; the Department of Food Science and Technology of La Molina in Peru, and the Institute of Food Technology Research in Brazil.

Under AID/csd-3646, approximately 32 papers have been published or presented. Appendix I shows the papers that have been presented at international meetings or published during the last two years of the contract.

Introduction

Although a number of products have been developed in Chile which are eminently suitable for weanling foods and foods for pre-school children, the commercial distribution of these materials is not what we believe it should be. Some of the foods are used in the national school lunch program and are produced commercially by a Chilean firm. Marketing of them however has not been extensive. This is due, in part, to the social organization of the country in which many of the food distribution programs are carried out either through the school lunch program or the National Health Service in child care centers, resulting in a minimal incentive to market the food materials commercially. The National Health Service has relied heavily upon powdered milk, a product which currently is in short supply in Chile and in moderately short supply in the world. This has resulted, in the last year, in large scale purchases of 12%-fat powdered milk from the world market by the government of Chile. Prospects for continued importation of powdered milk are not good, and the cost will increase significantly in the next few years. It is therefore important, both from the standpoint of health and economics, to increase the market and manufacture of the food materials which have been developed under this contract. Cooperation has been achieved between the National Health Service and our investigative team to develop an increased effort in the marketing, manufacture and distribution of two of our products - Leche Alim and Fortesan. It is thus possible to combine the efforts of marketing expertise available in Chile and the efforts of two private concerns interested in promoting the increased use of these food materials. It is obvious, however, that cooperation of the National Health Service is urgently needed. This appears to be forthcoming at the present time.

While the number of studies in experimental animals of the nutrient value of beans is extensive, observations on the biological value in humans are few. The legumes are rich in protein, and, in fact, contain several times the protein

content of cereal grains on a solids basis. Beans, as a representative legume, have a protein score which is decreased by the low content of the sulphur amino acids, particularly cystine and methionine. The legumes, however, also contain a significant amount of calcium and iron as well as thiamine and nicotinic acid. The utilization of legume proteins in Latin America, particularly the southern regions, is thus very attractive. Since the major nutritional shortage of the legumes is methionine, it would be economical to fortify with methionine; but an alternate is also attractive. In the southern regions of Latin America there is, as has been pointed out many times, a significant production of sunflower for oil. As is shown in Table 1, sunflower meal is particularly a good source of methionine. The combination, thus, of legume protein with sunflower protein yields a combination which has an excellent nutritional value. Although the legumes (in this discussion excluding soy) are widely used in the Latin American diet, they are not generally considered as food for children or infants. This is probably due primarily to two problems. The first is that, in general, they are toxic in their raw state; and, therefore, considerable preparation is involved before they can be consumed. Beans must be cooked for a long period of time, and in many cases, pre-soaked. All the edible legumes known contain hemaglutins and, therefore, must be subjected to heat treatment to destroy or to modify the protein. This is a problem, of course, in raw soybeans which, in addition, like many other legumes, may contain trypsin inhibitors. All of these toxic materials are destroyed by heating so that, at least in adults, the products are normally consumed without difficulty. In the feeding of children, particularly at home and on demand, the problem of long cooking times is a major one.

In addition to these problems, the utilization of beans in young children presents some difficulty due to the problem of digestive upset caused by a decrease in passage time through the gut. Combined with this, beans may cause flatulence.

While these problems are of considerable significance in the production of children's or weanling foods they are not, by any means, insolvable. It is quite possible to produce products which have been pre-treated to decrease cooking time required by a significant factor and this, in turn, will obviate any toxic factors. These same processes have the possibility of improving flavor and increasing the ways in which these products can be used in various formulated foods.

It has recently been shown that the oligosaccharide stachyose is the major causative factor of flatulence in legumes. The elimination of stachyose by

diastase treatment significantly reduces the flatulence effect of soy milk and, presumably, other leguminous products.

It is thus possible economically to produce products from the legumes which are easily prepared for consumption and contain no toxic or deleterious materials and produce a minimum of flatulence. These products, then, offer an excellent source of protein.

Table 2 illustrates the essential amino acid content of various leguminous seeds. As pointed out before, these products are good sources of lysine but lack methionine and, in some cases, tryptophane. The tremendous world resources of the protein represented by the legumes require a great deal of additional work in order to effect their utilization. There is no question that they could serve as excellent sources for the preparation of protein concentrates or isolates.

The production of protein isolates and concentrates has proceeded at a moderately rapid rate in the developing countries. Generally, these products are utilized as animal protein replacers in formulated foods, although some have been sold as simulated meats. Processes for the production of this type of plant protein are comparatively expensive since they, in most cases, must serve a very specialized market where emphasis is placed upon their functionality in a food material. There are, however, a number of processes which can be utilized in the production of less sophisticated meat or animal protein simulants. An example is the structuring of proteins brought about by high-pressure extrusion techniques. This technology is of extremely low cost and produces an oriented fiber product. In Latin America, much of the animal protein that is consumed by the lower socio-economic classes is consumed in the form of a soup or stew dish. Animal proteins are usually included as chunks or small pieces. In the project referred to earlier, many of the formulated products are being produced utilizing a Wenger expander. By using a longer barrel on such a unit, structural orientation of vegetable proteins can be achieved. In a series of experiments performed in the United States, it was possible to produce proteins from sunflower seed meal concentrates and sunflower protein isolates. These products would withstand cooking and could be tailored to various textural levels. If products of this sort could be introduced into the school lunch program, one would have direct utilization of vegetable proteins in a traditional dish used in the entire Latin American region. Costs of such a product would be considerably lower than those of the animal proteins which they will replace. Additionally, since the products are textured the fortification of the plant protein would be comparatively easy,

and no problems with regard to leaching would be encountered. A structured protein of good balance could be developed utilizing legume protein in conjunction with sunflower or, alternatively, combinations of fish protein concentrate, or fish protein with other plant proteins. Previous experience would indicate that appropriate flavors could be incorporated into the products at low cost.

Rationale

It is believed that the group of institutions outlined earlier (that is, the Department of Pediatric Nutrition of the University of Chile, the marketing group of the Catholic University, the Institute for Science and Technology of Chile, the Institute for the Development of Fisheries and the Department of Food Science and Technology of the University of Chile together with the Department of Food and Resource Chemistry and the Department of Resource Economics of the University of Rhode Island) offer a combination of facilities, personnel, and enthusiasm which is difficult to match elsewhere. Since the project proposed is a broad-based one involving carrying products from the laboratory phases of experimentation through pilot scale production acceptability testing and marketing each unit serves a particular function and each contributes to the overall project. The coordination of all of these efforts has resulted in significant advances in the nutrition of pre-school children in the Chilean region and has, because of its success, developed a great interest and support at governmental levels. It is thus important to continue work in this line for a period sufficient to assure the establishment of commercial production and marketing of the food developed. Each unit is able to work effectively with the others and to make its contribution. One could not dispense with technology, nutrition, toxicology, or consumer acceptance testing, etc. The United States base makes its important contribution by training personnel from the various institutions in the host country, by coordination, and by backstopping the research effort with facilities, equipment and expertise in the various fields.

The specific aims outlined next would be attacked more or less simultaneously, but a major effort will be placed upon the marketing aspects of already developed foods.

Specific Aims

1. The development of marketing information and a subsequent marketing promotion of the products which have been developed previously, e.g. Leche Alim and Fortesan. This program will require liaison between the Catholic University (School of Economics), the University of Rhode Island (Department of Resource Economics), and the groups in INTEC. These groups will also be used to develop the marketing programs for other products produced under the current contract.

Cooperating in market development, because of the nature of the Chilean social situation, will be the National Health Service and the National School Lunch Feeding Program. We have already had cooperation from these groups and they have indicated their willingness to continue work for the actual product marketing aspects of the products. Integrated with these groups will be two private enterprises in Chile, and the international group of Nestles. They have already packaged numerous samples for the acceptability trials in Curico and will participate in the marketing aspects of the present study.

2. The development of high protein, low cost foods based on the utilization of legumes in conjunction with other vegetable protein sources such as sunflower meal. These products would be processed in order to obtain a readily rehydratable product with no toxicity utilizing expansion techniques. In this area, we would also attempt to develop a series of structured proteins of inherent low cost based on supplemented legumes which could be used in traditional Latin American dishes.

Toxicity and nutritional testing would be done at the Department of Pediatric Nutrition of the University of Chile, and in the Department of Food and Resource Chemistry at the University of Rhode Island in the United States. Enzyme studies would be conducted at the Institute for the Development of Fisheries and pilot scale processing would be performed at the Institute for Science and Technology in Chile.

3. The development of low cost co-precipitants of cereal or legume protein with marine proteins. A series of products which would utilize marine proteins to supplement the deficiencies in the amino acid profile of cereal proteins would be developed. These would be processed in the same fashion as those developed in Aim (1) so that the products would not be a mere mixture of two different protein sources, but rather an integral protein of mixed origin. The work on nutritional testing of these products would be performed in the Department of Pediatric Nutrition of the University of Chile and in the United States. Process development would be done at the Institute for the Development of Fisheries and the Institute of Science and Technology in Chile.

4. The training of Chilean nationals in protein processing problems, and market development. This training would be conducted in the United States and initially would focus on the training of an individual in the analysis of micro-toxins, a skill which is badly needed in Chile and for which no personnel are available. The second area of consideration would be the study of methods of producing structured proteins. A third need is for training in the area of market development.

Procedure

1. Marketing. It is apparent that when one seeks to introduce a new product to the market, background information on that market, such as consumer purchasing power, purchasing habits, geographic distributions, size, distribution of retailers and retailing purchasing habits are needed in order to develop general models for the diffusion of innovation to the particular market. This was cited by Wickström in Protein-Enriched Cereal Foods for World Needs (edited by M. Milner). In particular, we will have to determine the marketing instruments that in previous efforts have been shown to have the best effect. This information will not have to be generated de novo since the Catholic University has been studying marketing of food products in Chile for some time and there is available to us the marketing survey done in recent years by General Oceanography. Much of this information can be utilized in the marketing survey and subsequently in the market promotion of Leche Alim and Fortesan, or for that matter, all other types of new food products.

Additional information is available due to the development of markets for protein rich foods, such as Incaparina in Central America, Pro-Nutra in South Africa, Vitasoy in Hong Kong, etc. Case history studies on the marketing of these products (N. Wilkie, Marketing Strategy in Developing Countries to Combat Infant Malnutrition, Third International Congress of Food Science and Technology) will aid in the development of marketing strategy for the products developed in Chile. We will develop specialized data for Fortesan and Leche Alim by presenting the pilot plant samples of the products to respondents in different Chilean cities to determine:

1) Concept evaluation
   a. CRAM score
   b. Key benefits
   c. Product uniqueness
   d. Product negatives

2) Product evaluation

a. Specific product attributes, such as flavor, texture, consistency, color, etc.

b. Key benefits

c. Problem areas - negative attribute analysis

d. Preparation

e. Serving

f. Possible frequency of use

g. Likes and dislikes

h. Interest in purchasing

i. The possible frequency of purchasing

j. Price/demand structure

k. Packaging

These tests consist of two phases: first, a screening/concept/placement interview and secondly, a follow-up interview. In phase one, the families are to be screened for the presence of children. Those qualifying will be exposed to concept advertisement and their reaction to it explored. Phase two involves interviews which will cover the product performance and reaction of the family having been presented with the products themselves. Thus, primary information on acceptability of the product in the market place can be learned and the perspective volume of the available market can be estimated.

Having determined effective marketing information, the distribution channels, be they government or private, can be utilized to launch a limited test of marketing. We will probably use the city of Curico which has been exposed to the products previously. This exercise will provide a method of estimating the real demand at a given price level and at a given promotional level. Once the given optimal feedback from the limited test marketing is established, the possibilities for promotion campaigns for national marketing distribution can be reviewed with the interested private concerns in order to illustrate to them the possible marketing opportunities for such foods. In particular, they are desirous of ascertaining the promotional level which will be needed to develop the market outside of the national feeding organizations.

Within the school lunch program and the National Health Service, there is a desire to utilize these products. This will be necessary in order to develop a base production. We will use the results of our marketing development to convince them of consumer demand. This coupled with the promotional efforts and placement

trials should develop an internal demand for the products, and thus, in turn stabilize the base of production. National television and radio have established a campaign for nutritional education of the public. Groups in Chile have obtained assurances that a portion of this time can be utilized for the introduction of new products, thus, in effect, the Chilean government will assist in the market development of the products.

2. Legume utilization. The operating parameters for pre-cooking Chilean black beans and other legumes in a Wenger expander will be determined. A pre-conditioning and, possibly, a pre-cook step will be used to lower toxicity. The resultant product will be ground to a mash which will give ready reconstituteability. The toxicity as well as the nutritional value will be determined using rats as the test subjects. The product will be compounded with other proteins or fortified to give a requisite FAO pattern. The moisture of sunflower seed and beans will be used in soup-base dishes for which a tradition exists. Acceptability of the mix will be determined in restricted populations (orphanages) in Santiago, using children ages 3-7. The nutritional effectiveness in normal children will be determined using previously described techniques.

Bean slurries will be digested with diastase in order to decrease the stachyose content of the product or processed in a long barrel extruder. The degree of removal of stachyose will be determined chemically, and the flatulence level of the product determined by the method of Criseofareo et al. in adult male rats. If sufficient reduction in stachyose content is achieved, the product will be tested utilizing normal infants.

The method of sprouting prior to cooking and drying to achieve stachyose and raffinose reduction will be compared against the diastase methodology. The economics of both methods of oligosaccharide reduction will be determined.

An expanded barrel for the Wenger X-25 expander will be purchased and installed in Chile and an X-5 for laboratory investigations will be installed in the United States for training and production modification. Training of an individual from INTEC on the use of the equipment will be undertaken in the United States industrial laboratories. The feasibility of producing structured corn, sunflower, and rapeseed proteins will be determined (these are all indigenous to Chile). The products or mixtures of these products will be assayed for nutritional value and acceptability in limited trials. Formulations utilizing these structured proteins in the typical soup or stew dishes will be made. These in turn will be assayed for acceptability in school lunch programs in the Curico area south of

Santiago. Cooperation in the development of these meat substitutes will be maintained between the industrial segment in Chile and, since the processing work will be done under the auspices of the Corporation for Development, it is likely that, if the products are acceptable in the Chilean dietary, their translation into commerical channels will be facilitated. It is likely that they will find a place in the national distribution of lunch programs since at the present time the distribution by the Ministry of Education of luncheon breakfasts approximates $15,000,000 a year in Chile. A significant percentage of this cost involves the use of animal protein, a major portion of which is imported.

Listed below are a number of controllable variables for the extrusion process which control the nutritional qualities and acceptability of products produced. Although these could represent a myriad of experiments, based upon previous research, we can narrow the range of conditions which we will investigate, in other words, each of the variables will not have to investigated independently.

Material types	Material variables	Equipment variables
Legumes	Moisture content	Temperature
Wheat flour	Particle size	Shear rate
Soy flour	Additives	Die configuration
Rapeseed protein	Conditioners	Feed rate
Sunflower protein	Colors	Barrel pressure
Vegetable oils	Flavors	Die pressure
Fish oils	Amino acid fortification	Output rate
Sugars	Homogeneity of raw mix	Secondary drying conditions
Dried skim milk		
Fish protein concentrate		

In total, however, we will investigate three basic methods of processing the proteins, as follows:

Low pressure cold forming

Low pressure cooking and forming

High pressure cooking and forming

In all cases, we will attempt to achieve functional characteristics and apparent characteristics similar to meat by this method which has been very successful when applied to soy proteins. In particular, the products should have the following characteristics:

1. Low cost
2. Good nutritional value
3. Texture similar to meat
4. Meat-like flavor and color
5. Ability to withstand cooking in a typical Chilean dish

3. Development of protein co-precipitants. In the processing of expanded or structured proteins, mixtures of various protein sources (such as milk, sunflower, bean, etc.) can be added to the expander unit. These result in an intimate mixture of the protein sources in such a manner that, even after grinding, the product is not segregatable. Further processing such as drying, coating, etc. results in a more or less homogeneous mixture of protein sources. Thus, in the expanded mixtures it is possible to develop a single protein base. The acceptability trials of these intimate mixtures using different processing parameters will be performed to determine within nutritional limits the processing techniques which result in developing the most desirable characteristics. Such techniques as oil dipping, spray addition of flavors, utilization of incapsulated flavors, toasting, etc., will be investigated.

A technique which will also be considered in this area is the actual co-precipitation of proteins. In previous work we have been able to develop a fish protein concentrate which is soluble at high pH's and is precipitable at its isoelectric point, e.g., approximately 4. Simultaneously, in working with rapeseed and sunflower, protein isolates using either salt extraction or high pH solubilization have been produced. The next logical step which will be investigated in this phase of the contract will be the precipitation of mixed proteins at pH's 2 to 4. This technique should result in a protein isolate which has high nutritional value (better than casein) that can be utilized in other food products as a non-separating protein source. Co-precipitants with the addition of flavoring components and other constituents such as hydrogenated fat will be investigated as to acceptability and nutritional effectiveness.

4. Training of Chilean nationals. The individuals will be brought from Chile to universities in the United States or other institutions where they can obtain training. The stipend in the United States portion of the budget will cover costs incurred while they are here. As a first order, the training will be given for a short period of time to an individual who will be able to determine the aflatoxin or microtoxin and pesticide contents of raw materials

that go into the various food formulations and also that of the finished product. These and the other training areas outlined under the specific aims will be facilitated by cooperation of the United States institution with other institutions in the United States and with government and private sectors.

Budget

The proposed budget is as follows:

BUDGET I

Personnel	% Time	1/1/73-6/30/73	7/1/73-6/30/74	7/1/74-12/31/74
U.S.Personnel				
Prof. Chichester	30	0	0	0
Research Associate (graduate student)	60	4,000	8,400	4,410
Secretary	50	1,500	3,150	1,653
		5,500	11,550	6,063
Cooperating Nationals				
2 Medical Doctors	170	3,600	7,560	3,969
2 Chemists	100	3,600	7,560	3,969
*2 Food Technologists	200	0	0	0
1 Dietitian	100	1,400	2,940	1,544
**4 Technicians	400	1,425	2,992	1,571
***2 Marketing Special.	200	0	0	0
Secretary	100	750	1,575	827
		10,775	22,627	11,880

* 2 Food Technologists will be paid by Chilean Governmental Source
** 3 Technicians will be paid by Chilean Governmental Source
*** 2 Marketing Specialists will be paid by Catholic University

BUDGET II

	1/1/73-6/30/73	7/1/73-6/30/74	7/1/74-12/31/74
Consultants	1,500	1,500	750

Consultants are to be paid $100 per day.
Consultants are required to design and advise extrusion problems, acceptability measurements, dehydration equipment, and analytical techniques.

Dr. Arthur Prater, Dr. William Darby and Dr. Morris Waskow have advised previously and will be continued. Dr. Thomas Weaver, Marketing Specialist at the University of Rhode Island will be used as needed.

BUDGET III

	1/1/73-6/30/73	7/1/73-6/30/74	7/1/74-12/31/74
Employee benefits calculated at 11.2% of U.S. salaries	616	1294	679

BUDGET V

	1/1/73-6/30/73	7/1/73-6/30/74	7/1/74-12/31/74
U.S. Travel			
4 round trips to Washington plus per diem for time	304	608	304
Foreign Travel			
3 round trips to Chile and per diem for U.S. personnel	3,200	3,200	3,200
1 round trip to U.S. for trainees	500	1,000	500
	4,004	4,808	4,004

BUDGET VIII

	1/1/73-6/30/73	7/1/73-6/30/74	7/1/74-12/31/74
Equipment (Cooperating country)			
Centrifuge		3,500	
Evaporator		3,000	
Calculator	700		
Long barrel for Wenger expander and lab unit		16,000	
Equipment (United States)			
Rat cages	500		
Lab equipment for chemical analysis	250	2,000	1,000
SUB-TOTAL	1,450	24,500	1,000
Materials and Supplies			
Lab supplies, beans, amino acids, fish meal, sunflower meal, animals, radioactive lactose	3,400	7,800	4,000
Air Freight to Chile	500	1,000	500
SUB-TOTAL	3,900	8,800	4,500
TOTAL	5,350	33,300	5,500

SUMMARY BUDGET

	1/1/73-6/30/73	7/1/73-6/30/74	7/1/74-12/31/74
(1) Personnel			
U.S.	5,500	11,550	6,063
Cooperating Nationals	10,775	22,627	11,880
(2) Consultants	1,500	1,500	750
(3) Employee Benefits	616	1,294	679
(4) Travel	4,004	4,808	4,004
(5) Equipment and Supplies	5,350	33,300	5,500
TOTAL	27,745	75,079	28,876
Overhead on U.S. personnel (39.2%)	2,156	4,528	2,377
GRAND TOTAL	29,901	79,607	31,253

Personal Data

PRINCIPAL INVESTIGATOR: Clinton O. Chichester

EDUCATION: B.S. 1949 Massachusetts Institute of Technology, Cambridge, Mass. Chemical Engineering
M.S. 1951 University of California, Berkeley, Food Science
Ph.D. 1954 University of California, Berkeley, Agric. Chemistry

PRESENT EMPLOYMENT: University of Rhode Island, Professor of Food and Resource Chemistry; University of California, Professor of Food Science and Technology

PROFESSIONAL SOCIETIES: American Chemical Society; Institute of Food Technologists; Society of Experimental Stress Analysis; Association of Automotive Medicine; New York Academy of Sciences, Spectroscopy Society; American Society of Biological Chemistry; American Institute of Nutrition; American Public Health Association; American Optical Society; American Institute of Chemical Engineers; American Medical Association; American Society of Clinical Nutrition.

PUBLICATIONS: Senior Editor, Advances in Food Research, which is now in the 20th volume

Editor, together with E. M. Mrak and G. F. Stewart, of Monographs in Food Science and Technology

Author of approximately 210 papers and books over the last fifteen years in Food Science and Nutrition

AWARDS: Bernardo O'Higgins Award from the Government of Chile for work on the nutrition of children

National Academy of Czechoslovakia Gold Medal for work on nutrition of children

Ministry of Agriculture (Czechoslovakia) Gold Medal for work on Maillard Reaction

TABLE 1

Amino Acid Content of Several Oil Seed Proteins
(g/16 g N)

Amino acid	Rape (*B. napus*)	Soybean meal	Sunflower meal	Cottonseed meal	Peanut meal
Lysine	5.8	6.5	3.5	3.9	3.0
Methionine	1.8	1.8	2.2	1.7	1.1
Cystine	2.4	1.7	1.8	1.0	1.4
Leucine	6.3	8.1	6.9	6.7	7.6
Isoleucine	3.6	5.0	4.2	3.9	3.8
Valine	4.8	5.1	5.8	6.0	4.7
Phenylalanine	3.5	4.8	5.1	6.3	5.2
Tryptophan	---	1.5	1.4	1.3	1.0
Threonine	3.8	3.7	3.4	3.6	2.0
Arginine	5.6	8.3	9.1	7.4	11.6
Histidine	2.6	3.3	2.8	2.5	2.5

TABLE 2

Amino Acid Content of Pulse Proteins
(gm/16gm N)

Amino acid	Chick pea	Pea	Broad bean	Lentils	Common bean
Arginine	7.45	8.83	7.00	7.63	6.02
Histidine	2.68	2.74	2.94	2.19	2.84
Isoleucine	5.74	5.63	6.27	5.26	5.68
Leucine	7.39	8.27	8.70	7.04	8.59
Lysine	6.896	7.33	5.62	6.11	7.42
Methionine	2.75	2.50	1.12	1.54	2.00
Phenylalanine	8.19	9.07	6.86	7.07	9.37
Threonine	3.55	3.86	3.26	3.58	4.34
Tryptophan	.82	1.06	.93	.86	.93
Valine	4.93	5.60	5.02	5.44	6.06

APPENDIX 1

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APPENDIX 2

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