II. ARTICLES

DEVELOPMENT OF A SUPPLEMENTARY FOOD MIXTURE (CSM) FOR CHILDREN

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The common occurrence of protein-calorie malnutrition throughout much of the world is well recognized, especially in the post-nursing child under six years of age. Less evident to many, perhaps, is the fact that such dietary deficiencies of protein and energy in young children and pregnant or lactating women are almost always associated with multiple deficiencies of certain essential vitamins and minerals. Protein supplementation alone or addition of the first limiting amino acid to improve the effectiveness of the protein, without concern about total energy intake or adequacy of other essential nutrients, may be of little or no value under most circumstances of calorie-protein malnutrition. In countries where most of the population subsists largely on cereals and plant protein foods, dietary deficiencies in vitamin A, thiamine, riboflavin, niacin, calcium, iron and iodine are found commonly.

It is estimated that each year over three million children die directly or indirectly from malnutrition. Moreover, infants born of malnourished mothers, start life with depleted reserves of protective nutrients essential for normal growth, development, and disease resistance. Some die from malnutrition alone, many others die from gastrointestinal and respiratory infections due to their malnourished state. In some countries, up to 50% of the children die before the age of 15 years. In those millions which malnutrition does not kill, physical growth and subsequent performance may be impaired. Approximately one-half to three-fourths of the children in certain countries fail to grow physically at a rate considered normal. Of even greater consequence is the possible permanent effects of malnutrition on learning ability, mental capacity, and behavior. Regardless of the deficiency disease indicated, malnutrition is, as it almost always occurs, a multiple deficiency syndrome whose correction requires supplementation with all essential nutrients which may be deficient. Several authors and agencies, including the NIH, INCAP, FAO, WHO, UNICEF and the FAO/WHO/UNICEF Protein Advisory Group (PAG) have called attention to the need to consider calories, vitamins and minerals as well as the quantity and quality of proteins in supplementary foods.

The problem of developing protein-rich food mixtures for infants and young children has received much attention by INCAP, FAO, UNICEF and WHO for a number of years. The PAG was established in 1955 by WHO and from 1961 acted as a tripartite WHO/FAO/UNICEF Protein Advisory Group, assisting the three agencies in their joint work on protein-rich foods and related subjects. The work of the international agencies, government institutions and of some industrial firms led to the development of a number of protein food mixtures including Incaparina, Pronutro, Senegal weanling food, Peruvita (Peru), Arlac (Nigeria), Fortifex (Brazil), Algerian weanling food, biscuit meal (Uganda), Indian multipurpose food, India high protein food, bulger - milk - butter mixture (Brazil and Chili), full-fat soy mixtures (Taiwan), and a soybean-chick pea - sesame flour product (Israel). Many of these have been described previously in this Bulletin. To this list during 1966 was added, a child's food supplement for distribution by the US Agency for International Development, Food for Peace. By January 1967, purchases of this supplement had exceeded 50 million pounds, and at the time of this writing, orders for approximately 200 million pounds of formula foods have been placed. It is anticipated that such products will be distributed in significant quantities until suitable local food supplements can be developed from indigenous food resources in each of the countries where such food supplements are needed.

Since the US AID, Food for Peace, Formula Food No. 2, commonly referred to as "CSM" or corn-soy-milk, is likely to assume considerable importance in the nutrition of children in many countries in the immediate future, information concerning the development of this product may be of interest.

In the summer of 1964, Mr. Stewart Rambo of the American Corn Millers Federation, sought guidance from the Interdepartmental Committee on Nutrition for National Defense (now Nutrition Section, NIH), as to how the nutritional properties of corn meal might be improved. Mr. Rambo was referred to the writer and it was recommended that a food supplement suitable for preschool children be made from US surplus commodities plus defatted, heat-processed soy flour as a protein supplement, with vitamins and minerals added as required.

If energy intakes from most cereals are adequate for adults, their protein and amino acid needs usually are met, except for the pregnant and lactating women. However, the needs for amino acids are higher for children than for adults in relation to the total amount of energy consumed (see Table 1). On the other hand, the need for several nutrients including thiamine, riboflavin, niacin, vitamin C, vitamin A, calcium, and iron are very similar for young children and adults when expressed as a function of their calorie allowance (see Table 2). This is true even though the requirements for certain nutrients are related primarily to body size (vitamin A) and for others to energy metabolized (thiamine, riboflavin and

niacin). It was believed then that a formula food which would adequately supplement the diet of children with respect to the potentially limiting essential nutrients, including amino acids, also could be used satisfactorily as a food supplement for other age groups.

In September 1964, an example formula was prepared for the American Corn Millers Federation. This was very similar to the present US AID, Food for Peace Fomula Food No. 1 known as "Ceplapro". The term "Ceplapro", from cereal-plant protein, was suggested by Mr. Rambo. The original formula contained 55% degerminated corn meal, 10% durham wheat flour, 5% non-fat dry milk solids, 27.5% full fat toasted soy flour, 2% of a mineral mix, and 0.5% of a vitamin-antioxidant-soy mix. This product was formulated to contain a sufficient level of all essential nutrients so as to render the total diet of a pre-school age child adequate if consumed at a level to supply approximately 25% of the energy needs. The original formula contained 17.9% protein, 6.3% fat and 355 metabolizable Calories per hundred grams. This formula was submitted to the Nutrition Committee of the American Academy of Pedeatrics for their comments and approval concerning its suitability for feeding young children. It was provided to the Office of Food for Peace in December, 1964, as an example prototype formula for use in overcoming malnutrition in pre-school-age children.

In the spring of 1965, the original formula was revised so as to include defatted toasted soy flour instead of full-fat toasted soy flour and distributed to interested parties by the American Corn Millers Federation. The 10% durum wheat flour in these initial formulas was included to provide an adequate amount of gluten protein to permit shaping of the product into a cereal grain-shaped kernel.

By fall of 1965, the USDA had also developed formulas for food mixtures containing corn meal, soybean flour, and dried skim milk or ground wheat, soybean flour, and dried skim milk. These formulas contained approximately 70% corn meal or ground wheat, 15% defatted toasted soy flour and 15% nonfat dried milk solids plus minerals and vitamins. These formulas were never field tested as the supply of nonfat dried milk solids became seriously low in relation to demand. In the meantime, preliminary chemical and animal feeding studies had been conducted by the Wisconsin Alumni Research Foundation for the American Corn Millers Federation. These tests revealed that the product had a protein efficiency ratio equivalent to milk protein averaging 2.42 and 2.48. Other tests concurrently done by Dr. E.E. Howe of Merck, Sharp & Dohme, revealed that the protein quality of the uncooked product was not improved by additions of methionine or lysine in studies with rats. Moreover, work supported by the American Corn Millers Federation showed that a corn meal diet containing 25% defatted toasted soy flour and 5% nonfat dried milk solids was equal in protein quality to a similar diet containing 15% defatted toasted soy flour and 15% nonfat dried milk solids. This led to further modifications of the Ceplapro Formula in the fall of 1965 for use as a primary food supplement for pre-school children in lieu of using the USDA

formula which contained considerably more milk solids. The durum wheat flour was removed as the product intended primarily for pre-school children did not require shaping and could be supplied more economically in dry mix ground form. Other changes involved further modifications of the mineral and vitamin mixes in an effort to improve stability and to insure a suitable food grade product. Supplemental copper and manganese were removed to improve stability of liable vitamins, especially vitamin A. Vitamin C also was removed due to uncertainity about its stability. (The writer believes that "stabilized-type" ascorbic acid would be reasonably satisfactory as long as the moisture content of the product is kept low. Further studies are needed to determine the stability of added vitamin C in this product so that it can be rendered sufficient in this nutrient). The corn used in the product is pregelatinized by moist heat treatment. This improves the keeping qualities of the product and gives rise to a product which requires only about 1 or 2 minutes of boiling prior to its consumption.

The formula, initially procured by USDA for the Agency for International Development (Food for Peace) costs about 9 cents per lb. Its composition is shown in Table 3. The calculated nutritional composition of this product is given in Table 4, together with the NRC allowances for the 1 to 3 year-old child for comparison. This formula was developed and approved by a committee representing the Nutrition Branch, Office of Technical Cooperation and Research, AID, the USDA, and the Nutrition Section, NIH.

This development is believed to represent a real breakthrough in AID's program to assist developing countries in overcoming malnutrition in the pre-school-age child. This corn-soy-milk supplement is based on the principle of supplying all nutrients which may be critically limiting rather than just supplying additional high quality protein.

As indicated above, if consumed at approximately one-fourth of the caloric intake, the pre-school child will be able to supplement adequately his or her diet, except for vitamin C. It is important to insure that fruits, fruit juices, vegetables, or soups be supplied to provide an adequate intake of vitamin C to children depending upon this mixture for their supplemental nutrients.

Although the corn-soy-milk formula was made of ingredients which had been used in human diets previously, little information is available even now as to the acceptability of this particular product without additional changes in particle size, flavoring, sweetness, etc. Some of this product was airlifted to India in May 1966 for testing in child feeding programs. Other samples were sent to a number of selected countries and all reports indicated its suitability. Since that time, formal feeding trials have been conducted by Dr. George G. Graham and Dr. Juan Baertl of the British American Hospital in Peru, using children 1 to 3 years old who received the corn-soy-milk mixture as a primary source

of protein. Their preliminary results indicate that this product is equivalent to the best cereal-based products. They found that the product, as it has a bland taste, can be easily incorporated into a variety of preparations. The inclusion of sugar materially improved its acceptability, and it was well consumed as a soup or a "mazamoria". A shortcoming found was its bulkiness when prepared with water and flavoring only. A preliminary report from studies being carried out in Taiwan by Dr. Ta Cheng Tung indicates that the acceptability of CSM was not satisfactory without flavoring, but that intakes of up to 90 grams per day were well accepted when flavored with sugar, fish, or meat. Nutritionally, the lack of vitamin C and relatively low caloric content per unit volume appear to be the major problems aside from possible difficulties with flavor and texture. It is hoped that ultimately a full-fat toasted soy product might be tested further as an ingredient in order to upgrade the intake of fat and energy in children receiving this food as a major part of their diet.

At least six US corn millers have been engaged thus far in manufacturing the corn-soy-milk product for the US Government*. Quality control tests to insure its wholesomeness and that it meets nutritional specifications have revealed no problems. Storage tests performed by the US Department of Agriculture indicate that moisture levels must be kept reasonably low in order to maintain stability of vitamin A.

Although more experience will undoubtedly lead to further improvements in this product, it is believed that this infant food packs a real nutritional "wallop". Every effort should be made to help developing countries produce at a low cost a formula food which is acceptable to their taste and is made from indigenous resources as far as possible. As soon as such products are available, their utilization in local nutrition programs could aid materially in preventing severe malnutrition in young children.

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* The USDA May 5, 1967, purchase tender for 35.6 million lbs. of CSM brings to approximately 230 million lbs. the amount of CSM purchased since last October for use in child and maternal feeding programs in some 90 countries.

Table I

MINIMAL REQUIREMENTS OF CRITICALLY LIMITING ESSENTIAL AMINO ACIDS[1/], EXPRESSED IN MILLIGRAMS NEEDED PER METABOLIZABLE MEGACALORY

Essential Amino Acid	Infant (8 kg)	1-3 yr. old Child (13 kg)	Adult Woman (58 kg)	Adult Man (70 kg)
Lysine	870	770	214	241
Methionine	442	-	167	69
Tryptophan	191	193	75	86
Threonine	760	770	145	172

1/ Values from D.M. Hegsted, in Mammalian Protein Metabolism, H.N. Munro and J.B. Allison, Eds., Vol. II, pp. 135-171, Academic Press, New York (1964).

Table 2

NRC ALLOWANCES[1/] FOR SELECTED NUTRIENTS,
EXPRESSED IN AMOUNTS PER METABOLIZABLE MEGACALORY NEEDED

Nutrient	Infant (8 kg)	1-3 yr old child (13 kg)	6-9 yr old child (24 kg)	15-18 yr old boy (61 kg)	Preg. woman 18-35 yr (58 kg) (3rd trimester)	Lact.woman 18-35 yr (58 kg)	Adult woman 18-35 yr (58 kg)	Adult man 18-35 yr (70 kg)
Vitamin A, I.U.	1630.0	1540.0	1670.0	1470.0	2600.0	2580.0	2380.0	1725.0
Thiamine, mg	0.43	0.39	0.38	0.41	0.43	0.38	0.38	0.41
Riboflavin, mg	0.65	0.62	0.62	0.53	0.7	0.61	0.62	0.59
Niacin, mg	6.5	6.9	6.7	5.9	7.4	6.8	6.7	6.6
Vitamin C, mg	33.0	31.0	30.0	24.0	43.0	32.0	33.0	24.0
Calcium, mg	760.0	615.0	380.0	410.0	515.0	420.0	380.0	276.0
Iron, mg	10.9	6.1	5.7	4.4	8.7	6.5	7.2	3.5

1/ NRC Publication 1146 (1964)

Table 3

PERCENTAGE COMPOSITION OF US BLENDED FOOD PRODUCT, DRIED FOOD SUPPLEMENTS

Ingredient	Formula #1 (Ceplapro)	Formula #2 (CSM)
	%	%
Corn meal, processed (gelatinized)	58.05	68.05
Wheat flour (Durham)	10	--
Soy flour, defatted, toasted	25	25
Milk, non-fat, dry	5	5
Calcium phosphate, di-basic, hydrated	0.55	0.55
Calcium carbonate 1/	0.6	0.6
Zink sulfate hepta-hydrate 1/	0.004	0.004
Ferrous fumarate 1/	0.024	0.024
Iodized salt 1/	0.67	0.67
Vitamin-antioxidant premix 2/	0.1	0.1

1/ Supplied as mineral premix.

2/ Vitamin-antioxidant premix supplies the following in amount per pound of final blended food product :

Thiamine mononitrate	1.25	mg
Riboflavin	1.75	mg
Pyridoxine HCl	0.75	mg
Niacin	22.5	mg
CaD-pantothenate	12.5	mg
Folacin	0.25	mg
Vitamin B_{12}	15	mcg
Vitamin A	7500	USP units
Alpha tocopherol acetate	7	IU
Vitamin D	900	USP units
Butylated hydroxy anisole	10	mg
Butylated hydroxy toluene	10	mg

Table 4

CALCULATED NUTRIENT CONTENT OF US BLENDED FOOD PRODUCT,
DRIED FOOD SUPPLEMENT, FORMULA #2 (CSM)

Nutrient	Amount per 100 gm.	NRC allowance (1-3 yrs.)
Proximate Composition		
Metabolizable kilocalories (C)	340	1300
Crude protein, gm	20.5	32
Crude fat, gm	2.0	
Linoleic acid gm	1.0	
Crude fiber, gm	1.2	
Nitrogen Free Extract, gm	64.3	
Minerals		
Calcium, mg	502	800
Phosphorus, mg	420	
Sodium, mg	350	
Potassium, mg	620	
Magnesium, mg	140	
Iron, mg	11	8
Zinc, mg	9	
Iodine, mcg	48	
Manganese, mg	not calc.	
Copper, mg	not calc.	
Vitamins		
Vitamin A, IU	1960	2000
Vitamin D, USP units	198	400
Vitamin E, as added acetate, IU	1.5	
Thiamine, mg	0.65	0.5
Riboflavin, mg	0.6	0.8
Niacin, mg	6.3	9
Pantothenic Acid, mg	3.6	(10)
Pyridoxine, mg	0.35	(0.4)
Folacin, mcg	3.3	
Vitamin B_{12}, mcg	3.3	(3)
Biotin, mg	0.13	
Choline, mg	105	
Vitamin C, mg	none	40
Vitamin K, mg	not calc.	

(continued over)

Table 4 (Continued)

Nutrient	Amount per 100 gm	NRC allowance (1-3 yrs.)
Amino Acids		
Lysine, gm	1.11	
Tryptophane, gm	0.23	
Methionine, gm	0.32	
Cystine, gm	0.32	
Phenylalanine, gm	0.97	
Tyrosine, gm	0.83	
Threonine, gm	0.80	
Isoleucine, gm	1.05	
Valine, gm	1.07	
Leucine, gm	1.86	
Histidine, gm	0.46	
Arginine*,gm	1.18	
Glycine*, gm	0.75	
Proline*, gm	1.51	
Glutamic acid*, gm	3.73	
Alanine*, gm	1.12	
Aspartic acid*, gm	2.36	
Serine*, gm	1.25	

* Dietary non-essentials

1. Recommended Dietary Allowances (6th Ed., 1964), NRC Pub. 1146. Values in parentheses were taken from the text of the publication and are only approximations.

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