5-1971

Protein Needs Throughout the Life Cycle

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PROTEIN NEEDS THROUGHOUT THE LIFE CYCLE

by

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A report submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Food and Nutrition

Plan B

UTAH STATE UNIVERSITY
Logan, Utah

1971

ACKNOWLEDGMENT

The author wishes to express sincere appreciation to Dr. Ethelwyn B. Wilcox for her activity, intellectual ability, and her encouragement, patience, and assistance, in preparing and accomplishing this thesis. Special appreciation is extended to Mrs. Frances Taylor and Dr. Eldon Drake, members of my committee, for their support, advice, and approval of this thesis.

The author also wishes to thank her parents for their encouragement, support and consideration throughout the study.

Mei-You Tsai

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ABSTRACT

Protein Needs Throughout the Life Cycle

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In most countries in Africa and in South and East Asia the foods which are produced do not provide adequate diets, or in some areas, not enough food for the population. In most areas, it is not the severe shortage of food supplies, but inequality of food distribution and the quality of the diet as influenced by deficiencies of individual nutrients. One of the most severe deficiencies is in protein because of the poor quality and imbalanced diets due to lack of nutritional knowledge and ignorance of the special needs of large groups of people such as pregnant and lactating women, and children. The solution to this problem is to help these developing countries in techniques to produce more food, make better use of their present food, provide acceptable high protein foods at a reasonable cost, and educate the people with ways to apply the principles and modern knowledge of nutritional requirements to obtain better health.

Various methods which are used often for estimating the nutritional value of protein are discussed. Estimations of minimal protein and amino acids, and the suggested intakes for adequate protein and amino acids needs are given. In developing countries, animal protein products may not be available or expensive. Mixtures of vegetable or cereal proteins should be used. Many local available foods or new forms of protein-rich foods should be properly introduced to the developing countries to be accepted and used as desirable foods.

The protein needs of many diseases are discussed. Education plays an important role in the program of improving world nutritional problem. In developing countries, sanitation for storage, preparation and service may be first concepts that are taught as they are very important.

(100 pages)

INTRODUCTION

The impact of the very rapidly growing population on the hunger and starvation problem continues to be more and more serious. Even in the United States of America, where food supplies are on the whole abundant, there are instances of hunger and malnutrition. In the developing countries, between 300 to 500 million persons do not get enough food and as many as 1,500 million do not receive an adequately balanced diet (Lives in Peril, 1970). According to the President's Science Advisory Committee reports (Pearlberg, 1969), kwashiorkor and marasmus have ranged from 1-10 percent since 1952 in preschool children of the developing countries. Extremely high mortality rates in the 1-4 year age group (Tables 1 and 2) in these countries has suggested that moderate protein-calorie malnutrition affects at least 5 percent of these children (Aykroyd, 1970). At least 20 percent of the population of less developed countries was undernourished and some 60 percent received diets inadequate in nutritional quality. Deficiency of a good quality protein was the most severe problem.

Three other groups of the population in which malnutrition is apt to be prevalent in the United States of America as well as in the developing countries are the mothers, teenage daughters and senior citizens. Many studies show that the large group of the pregnant and lactating mothers suffer from an imbalanced diet or insufficient total food intake which is often a protein or

Table 1. Mortality in infants and in age group 1-4 years in certain countries[a]

Country	Year	Infant Mortality (deaths under 1 year per 1000 live births)	Deaths per 1000 Population Ages 1-4 Years
Egypt	1961	139.0	33.8
Guatemala	1963	92.9	23.9
Philippines	1961	72.1	8.8
Portugal	1961	77.5	6.9
Canada	1961	25.2	1.0
England and Wales	1961	21.4	0.9

[a]Taken from Akyroyd, 1970, p. 58.

Table 2. Mortality rates in the first five years of life in certain countries, by one-year age group[a]

Country or Territory	Date	Deaths per Thousand per Year in the Following Age Group				
Punjab, India	1957-59	186.9	72.2	21.0	8.1	3.9
Grenada, West Indies	1961-62	79.2	33.3	7.0	3.0	1.0
USA	1959	25.2	1.7	1.0	0.8	0.7
England and Wales	1961	21.4	1.5	1.0	0.7	0.6
England and Wales	1901	151.3	41.7	17.1	11.4	8.4

[a]Taken from Aykroyd, 1970, p. 59.

protein-calorie deficiency owing to their lack of knowledge in nutrition and the use of food taboos. In the United States of America, improper dieting and lack of nutritional knowledge lead a high percentage of the teenage girls to a state of malnutrition, especially in protein and calorie. Low income, impoverished condition in housing and in cooking facilities, poor health and lack of good dentures are the major factors which cause protein deficiency among the majority of the senior citizens.

It is more difficult to satisfy the world's protein needs than to satisfy its needs for the other nutrients. Protein sources are more expensive than other parts of the diets. Many studies and much research have been done to increase the crop yield and to improve the quality of their protein. For instance, plant breeding has increased the quality and content of protein and at the same time obtained high yielding varieties of corn and maize, rice, and wheat. Other grains and legumes such as pulses that are staple foods for some countries are being improved by plant breeding. The introduction of new genes into corn, for example, has resulted in increasing the lysine by as much as 70 percent and also increasing tryptophan and methionine. Breeding programs are also being made to increase yield of meat and milk per animal and food consumed. Use of more varieties of fish or edible fish protein concentrate gives promise of a better protein supply to people in all countries. Effort must be and is being made to educate the people to use local available foods for adequate and balanced protein food.

Protein

Protein originated from the Greek word meaning to "take the first place." Protein is a constitute of all living cell and tissue. All enzymes are protein in nature. Many hormones are either proteins or protein derivatives. The only body compounds that normally contain no protein are urine and bile. Protein is necessary in growth and tissue replacement, regulation of body processes, maintenance of body neutrality, and stimulation of antibody formation. Proteins which contain the essential amino acids in sufficient amounts for maintaining life, and a normal rate of growth are classified as complete proteins. All animal proteins except gelatin are complete proteins. Incomplete proteins are those that lack one or more essential amino acids which can not be synthesized in the body, hence, are unable to replace or build new tissue and can not maintain life nor growth. Most vegetable and cereal proteins are incomplete proteins. Soybeans rank higher than other plant proteins. It is possible to simulate a complete protein by combining two or more plant proteins that complement one another or to supplement an incomplete protein with a small amount of animal protein. Following this principle, many low cost high quality protein foods have been produced successfully.

Amino Acids

Rose, according to Hegsted (1964a), defined an essential amino acid as one which could not be synthesized by the body fast enough from material ordinarily available in the diet to meet the needs for growth and maintenance.

Isoleucine, leucine, methionine, phenylalanine, threonine, tryptophan, and valine are eight essential amino acids for adults. Histidine should be added to the list for the children. Nonessential amino acids are those which can be synthesized by the body and need not be supplied by the diet. All amino acids are equally important in terms of protein synthesis, and all must be supplied adequately and simultaneously in one way or another at the site of protein synthesis.

METHODS OF ESTIMATING THE NUTRITIVE VALUE OF PROTEIN

Many methods have been suggested for determining the quality of dietary protein. Biological evaluation is the only reliable method for testing of protein quality since it is the ability of a protein to support growth and maintenance that determines its utlimate value. Therefore, most methods for evaluation of protein quality are based on the retention of nitrogen in the body.

Biological Value

Protein efficiency ratio

The protein efficiency ratio (PER) was used as early as 1917 by Osborn and Mendel (Pike and Brown, 1967). PER is the ratio of the gain in body weight and the gram of protein consumed. The PER and the weight gain should be measured under standard condition: The calorie and the protein must be fed at an adequate level for a specific period of time. This method has been used chiefly in studies on small animals and human infants. Obviously, it is the simplest method for evaluating protein quality since it requires only the measure of the dietary intake and the weight gained. The greatest source of error in the PER method lies in the use of weight per se as sole criterion of protein value (Pike and Brown, 1967). Weight gain may not be proportional to gain in body protein under all conditions. The PER value might become negative if weight loss happened. Also, the measurement of food intake is time-consuming and expensive.

Nitrogen balance

Allison (1951) has illustrated the relationship between maintenance and growth using the concept of nitrogen balance which is shown in this equation:

$$B = I - (U+F+S)$$

Where I is dietary nitrogen intake, U is urinary nitrogen, F is fecal nitrogen, and S is skin nitrogen.

Nitrogen balance by far is the best method for evaluating humans. It has been shown that biological value is directly related to the nitrogen balance when different amounts of a protein are fed. Mitchell and associates have done more than any other group about the quantitative determination of this value.

Allison in 1964 reported that as early as 1909, Thomas defined biological value (BV) of a dietary protein as the fraction of absorbed nitrogen that was retained in the body for maintenance and growth. Mitchell, Hamilton, and Beadles (1945) made improvement on Thomas' method which is commonly used now.

Endogenous nitrogen (U_o) = urinary nitrogen when a nitrogen-free diet is fed.

Metabolic nitrogen (Fo) = fecal nitrogen when no nitrogen is fed.

Dietary nitrogen (D) = nitrogen fed during test.

Urinary nitrogen (U) = urinary nitrogen during test.

Fecal nitrogen (F) = fecal nitrogen during test.

$$\text{Absorbed nitrogen} = D - (F - Fo)$$

$$\text{Percent digestibility} = \frac{\text{absorbed nitrogen}}{\text{dietary nitrogen}} \times 100 \qquad (1)$$

Similarly,

$$\text{Retarded nitrogen} = \text{absorbed nitrogen} - (U - Uo)$$

$$= D - (F - Fo) - (U - Uo)$$

$$\text{Biological value} = \frac{\text{retained nitrogen}}{\text{absorbed nitrogen}} \times 100$$

$$= \frac{D - (F - Fo) - (U - Uo)}{D - (F - Fo)} \qquad (2)$$

Mitchell fed rats a diet containing a small amount of egg protein rather than a nitrogen-free diet. This has a minimum effect on endogenous and metabolic nitrogens, but allows a more stable and reproducible biological test subject.

In the measurement of BV, it is important that the protein should be fed at or below the level needed for maintenance, so that it is utilized with maximum efficiency.

Carcass analysis

It is more accurate to estimate nitrogen retention by determining carcass nitrogen instead of body weight. The nitrogen and water ratio of the carcass is essentially constant in a short assay.

Net protein utilization (NPU) is used to describe the relationship between the protein eaten and the increased nitrogen in the carcass. This can be expressed in the following equation (Miller and Payne, 1961):

$$NPU = \frac{Cp - Co}{I}$$

Cp is carcass nitrogen of animal fed the diet containing protein, Co is the carcass nitrogen of animal fed a protein-free diet, and I is the nitrogen of animal fed the diet containing protein. NPU can be calculated arithmetically from Mitchell's equations (1) and (2) as listed above to express in a single index both the digestibility of protein and the biological value of an amino acid mixture absorbed from the intestine by the following equations:

$$\text{NPU} = \frac{\text{retained nitrogen}}{\text{intake nitrogen}}$$

$$= \frac{\text{retained nitrogen}}{\text{absorbed nitrogen}} \times \frac{\text{absorbed nitrogen}}{\text{intake nitrogen}}$$

$$= \text{BV x digestibility}$$

<u>Nitrogen balance index</u>

Nitrogen balance index is basically the same as BV (Allison, 1955). It is a measure of dietary nitrogen retained. Thus,

$$\text{Nitrogen balance index} = \frac{B - Bo}{A}$$

Where B is nitrogen balance, Bo is nitrogen balance when nitrogen intake is zero, and A is absorbed nitrogen.

The inter-relationships among PER, NPU, BV, and nitrogen balance index are shown in Figs. 1 and 2. NPU represents the proportion of food nitrogen retained, whereas both BV and nitrogen balance index represent the proportion of absorbed nitrogen retained. If nitrogen intake is used in place of absorbed nitrogen, the value of nitrogen balance index is equivalent to the net protein utilization.

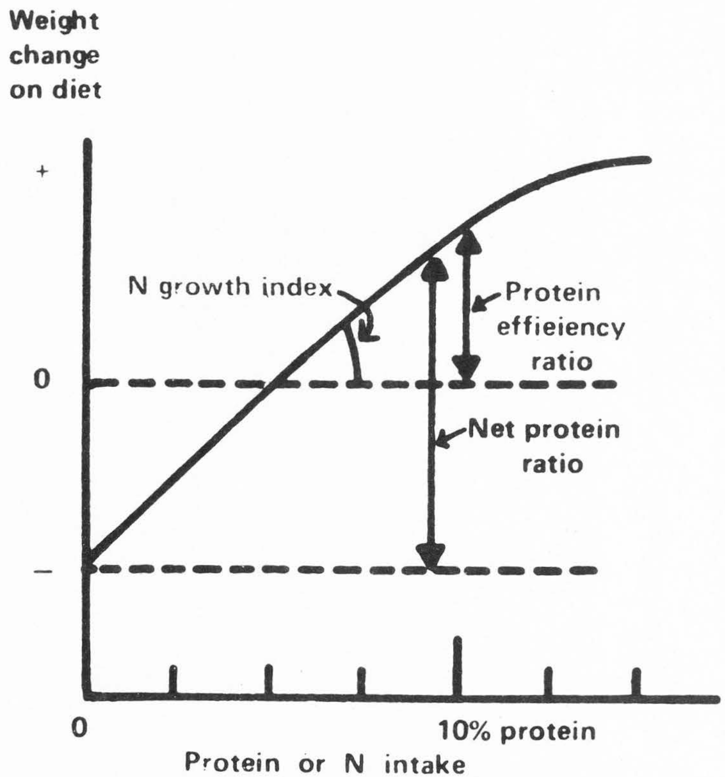

Figure 1. Indices based on weight changes (Allison, 1964, p. 44).

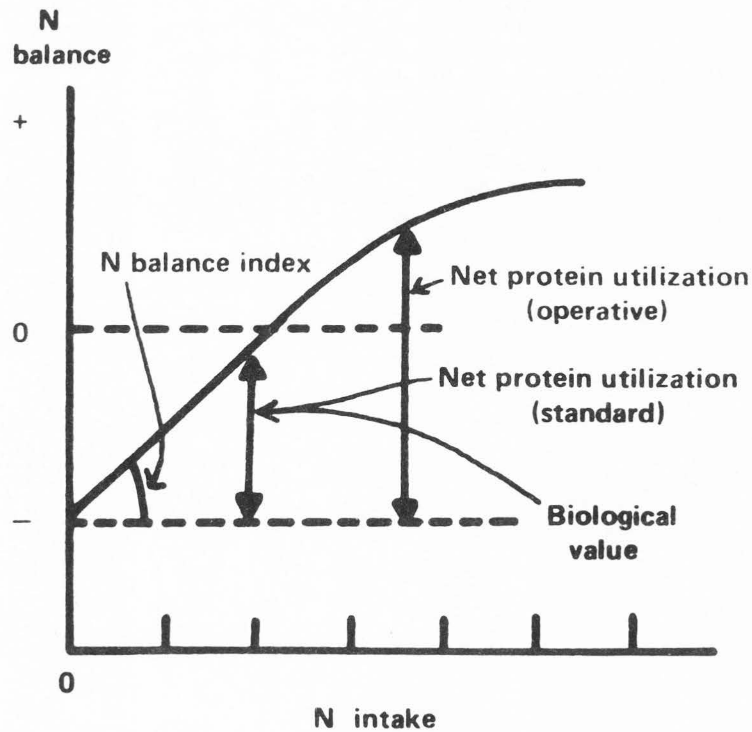

Figure 2. Indices based on body nitrogen changes (Allison, 1964, p. 44).

Depletion and repletion

Adult animals are fed a standard depletion diet, low or devoid in protein, until a certain amount of weight is lost. Test proteins may be compared by the weight gain during the repletion period. The body does not store protein or create reserves in the same way as fat is metabolized. However, there is evidence that some tissue proteins can be reversibly depleted and repleted by a variation in the quantity and quality of dietary proteins. These proteins can contribute to the amino acid metabolic pools, and help maintain essential structures and functions involving amino acids when intake is deficient.

This method is good for an amino acid imbalance test. The same animal can be reutilized in this method. However, after one or two tests, the nutritional background of the test animals may be sufficiently changed to affect the assay.

Other biological methods

Microbiological methods for estimation of specific amino acids are widely used. Their use as measure of biological value applicable to man, would require an organism having quantitative amino acid requirements identical to man. Young, et al. (1971) have discussed the use of plasma amino acid levels as a measure of dietary protein quality. Hegsted and Chang (1965) have described a bioassay procedure which has advantages in testing biological potency of proteins in terms of a standard protein. Akeson and Stahmann (1964) proposed enzymatic hydrolysis of dried protein as a simple and valid method for determining the relative amounts of amino acids liberated by test proteins as compared with egg protein and conversion of these data into a measure of BV. The latter method is especially advantageous because results can be obtained rapidly without resorting to animal feeding experiments.

Relationship Between Biological Value and Chemical Composition

Chemical score

The content of each essential amino acid in a food protein is expressed as a percentage of the content of the same amino acid in the quantity of a protein selected as a standard. The essential amino acid of protein that shows the greatest percentage deficit in comparison with the same amino acid contained in the same quantity of another protein selected as a standard is called the limiting amino acid and this percentage is the chemical score. Whole egg protein had a biological value of 100 according to the Thomas method and each amino acid in egg protein was in exactly the amount required. The score is given by the deficit of the most limiting amino acid as compared with the pattern of the essential amino acids of whole egg. From the practical point of view, it is encouraging that the chemical score predicts nutritive value with reasonable accuracy when the biological value is above 50.

Net dietary protein value

In a practical evaluation of diets, efficiency and concentration of protein may be combined in a single index (Platt and Miller, 1959), which has been called the net dietary protein value (ND_pV). Thus,

$$ND_pV = \text{protein concentration x NPU.}$$

Net dietary protein calories percent ($ND_pCal\%$)

The nitrogen intake may be diverted into three directions, for maintenance, for growth, and oxidized for energy (Miller and Payne, 1961). As the level of dietary protein is increased, the proportions which follow these pathways change, the amount being oxidized inevitably increasing. Net dietary protein calories percent is protein content that can be utilized in a diet in terms of calories expressed as a percentage of total metabolizable calories:

Thus,

$$ND_pCal\% = \frac{\text{protein calories x 100}}{\text{total metabolizable calories}} \text{ x NPU}$$

Allison (1964) suggested that in the presence of adequate dietary protein, the rate of growth of rat tissue is a function of caloric intake. A competition may develop between the need for growth or maintenance and for energy. $ND_pCal\%$ is one of the most recent methods proposed for the evaluation of dietary protein. This method appears to be especially useful in the human diets in which the relation of protein to total calories may vary markedly. For the human adult, a diet which contains only 5 percent of calories in the form of available protein will not meet his protein needs and is lower than should be used for any experimental subjects; children must have at least 8 percent (FAO/WHO, 1965a).

PROTEIN REQUIREMENTS

Estimates of Minimal Protein Needs

Human protein requirements have been studied for over a hundred years. Irwin and Hegsted (1971a) recently made a comprehensive review of this topic. They concluded that the determination of protein requirements is still elusive owing to the lack of precise and adequate methods for evaluating the status of nutrition, especially with regard to protein. Many studies did not relate the retentions to changes in body size or tissue mass. Human studies have not been made over broad enough ranges of intakes to explain the data obtained on high protein intakes. Interrelationships between protein and other nutrients are also factors, especially protein and calories.

Adult men and women are the groups which have been studied most thoroughly. However, only limited little data are available on the adolescent, pregnant, and aged groups who need special consideration from a nutritional aspect. Long term performance as judged by clinical practice, longitudinal studies, etc., are important and must be given consideration in interpretation of laboratory findings.

Protein Recommended Allowance

Although each healthy individual has a specific level of protein needed it may vary under different conditions. Variability in levels needed from one individual to another is great. FAO/WHO (1957) have recommended a sufficient intake to cover the needs of nearly all the population and which therefore can be regarded as a practical allowance. The FAO "safe practical allowances" (FAO/WHO, 1957) are based on the FAO average minimum requirements for the reference proteins (eggs and milk). This value was then corrected according to the protein score and an increment of 50 percent of the minimum requirement was added for all age group other than infants in order to cover the needs of the individual variations.

The U.S. Recommended Dietary Allowances (RDA) were developed by the Food and Nutrition Board of the National Research Council, National Academy of Science. The RDA are intended to meet the needs of essentially all individuals in the population and, except for energy, admittedly are generous and probably in excess of the needs of the majority of the population. Table 3 shows a comparison of various dietary standards recommended for protein intakes.

Adults

A well-nourished adult, after growth has ceased, is in nitrogen balance. Adults are in balance on the average although there is considerable fluctuation of both intake and excretion.

Previous studies have indicated that a protein with a biological value of 100 is capable of replacing the necessary losses on an equivalent nitrogen basis. The most promising method is to calculate the minimal protein

Table 3. A comparison of various dietary standards recommended for protein

Group	RDA[a]		Canadian 1963[b]		FAO[c]		
	age	protein gm	age	protein gm	age	Country A[d,e]	Country C[d,f]
Adult men	22	65	25	50		46	59
Adult women	22	55	25	40		38	49
pregnant		65		50		50	65
lactation		75		50-60		2.6 x kg	3.6 x kg
Infant	0-1/6	2.2 x log					
	1/6-1/2	2.0 x kg					
	1/2-1	1.8 kg					
Children	1-3	25	1-2	25-30	1-3	26	32
	3-6	30	2-6	30	4-6	27	35
	6-8	35	7-9	40	7-9	35	45
	8-10	40	10-12	50	10-12	54	69
Boys	10-12	45	13-15	75	13-15	64	94
	12-14	50	16-17	55	16-19	59	76
	14-22	60	17-19	60			
Girls	10-14	50	13-15	75	13-15	59	71
	14-22	55	16-19	50	16-19	41	52

[a] Taken from Recommended Dietary Allowances, 1968, pp. 15-20.

[b] Taken from Pike and Brown, 1967, p. 460.

[c] Taken from Hegsted, 1964b, p. 155.

[d] "Safe practical allowances" include an arbitrary increment of 50% over the average minimum requirement, except in infancy, where an increment of 25 to 30% is suggested.

[e] These calculations are for a country with an assumed protein score of 81, presumably comparable to the United States.

[f] These calculations are for a country with an assumed protein score of 62.

requirements from the minimal urinary nitrogen excretion corrected for losses in the feces and skin. Fecal losses are of the order of 10 percent of the intake (Hegsted, 1968). However, there are several errors in balance methods: First, the intake may be overestimated, then the excretion will tend to be underestimated. A two percent error is done with a diet high in protein. Second, in balance studies losses through hair, nail, skin, etc., are rarely measured. These losses may be small but may be significant. Third, information is seldom available on body composition which may influence the results and make interpretation difficult (Hegsted, 1964a).

Sherman concluded from many of his own studies that 0.5 gm mixed protein per kilogram body weight is enough for maintenance (Irwin and Hegsted, 1971a). Protein deficiency in adult is rarely seen when caloric intakes are adequate or nearly adequate.

The RDA for an adult is 0.9 gm per kilogram of body weight. That is, 65 gm of protein for 70 kg male and 55 gm for 58 kg female. Milk, beef, veal, lamb, poultry, fish, egg, cheese, cottage cheese, dry beans, dry peas, lentils, and peanut butter are good sources of proteins. Two or more cups of milk and two or more servings of meats or meat substitutes in a well balanced diet will provide adequate protein for the daily need.

In developing countries, the use of low cost, high quality protein from vegetable mixtures and new protein concentrates should be encouraged. These new mixtures will meet the protein needs and will be discussed under the availability and acceptance of new foods.

Infants and Children

Nutrition is very important during the early years of the child's life. Growth is rapid, especially during the first year. Foundation for adult health is based on a good nutritive status in early childhood. Improved nutrition has increased the average life expectancy in many developed countries.

There is practically no experimental evidence on minimum protein needs of children. Estimates can be made similar to those for adults. In addition to maintenance requirement, the protein required for growth may be estimated from rates of growth. The final result should be corrected by losses in the feces and skin.

A liberal allowance of protein is desirable throughout childhood in order to provide for increase in muscle mass, for the formation of matrix of skeletal tissue, and for protection against disease. The protein requirements of infants are high during the first few months of life.

In The FAO Committee report in 1957 presented an estimate of the minimal requirement for protein at different ages (Figure 3). A comparison of their data in Figure 3 with that of Hegsted (1957) in Figure 4 shows that the FAO value at birth is somewhat lower than that of Hegsted. The curve falls slowly with age, until adolescence when the protein needs considerably are increased. The data presented by both groups of workers are minimum requirements. It is important to note that only protein of high biological value is being considered.

Holt et al. (1960) stated that breast feeding does not produce maximum nitrogen retention in the young infant. The infant is born with a low total nitrogen content of two percent compared to three percent in the adult. However, these authors have discussed the fact that rapid maturation caused by feeding high levels of dietary protein may not be an advantage.

Hegsted in 1957 presented a theoretical estimate of the daily protein requirements for children which included: (1) only growth required the greater part of the intake in the first few years; (2) even the growth spurt during adolescence appears small relative to the larger body size of that age; and (3) the requirement shortly after birth appears to be equal to or slightly above the intake provided by human milk.

The RDA suggested for the infant from zero to two months of age, the allowance of 2.2 gm protein per kg of body weight; at two to six months, 2.0 gm; and at six to twelve months, 1.8 gm. By one to three years of age, the requirement is expressed in total grams of protein needed and is 25 gm; three to six years, 30 gm; six to eight years, 35 gm, eight to ten years, 40 gm.

The only protein food needed during early infancy is milk as it contains all the essential amino acids necessary for growth. Sufficient amounts of human milk will meet the protein requirement of the infant. A much higher intake of protein is found in cow's milk than in human milk. However, cow's milk is diluted in the formulas used for infants to reduce its high protein content. Most children in the United States are using good quality protein with

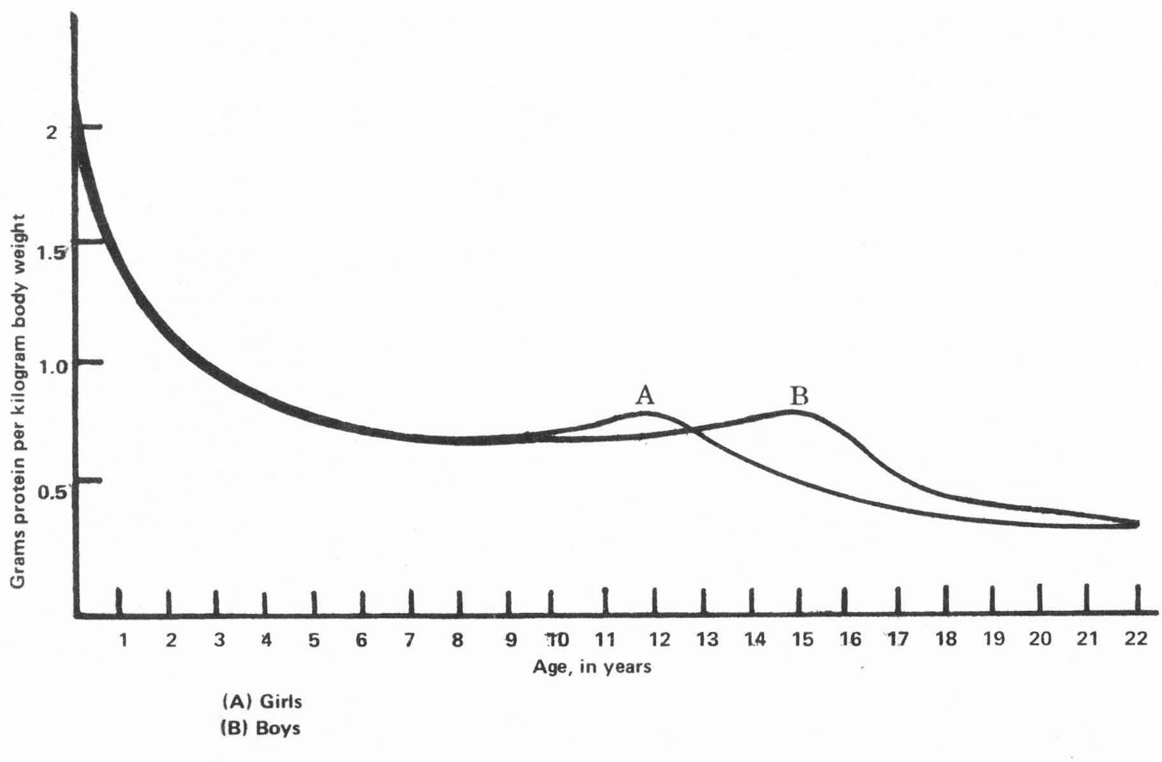

Figure 3. The average minimum requirements of reference protein at different ages according to the FAO Committee on Protein Requirements (Hegsted, 1964a, p. 143).

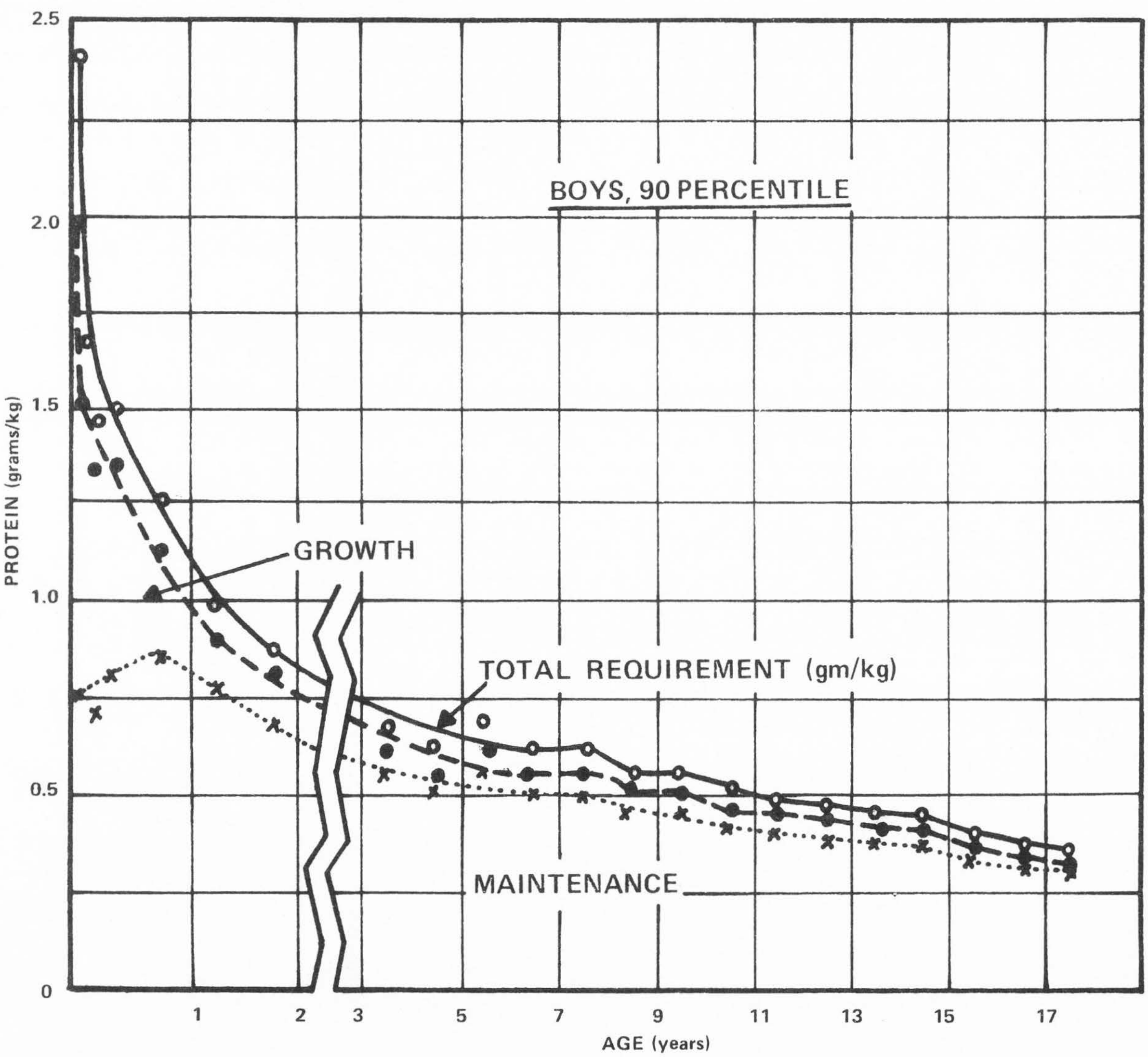

Figure 4. Theoretical estimates of the daily protein requirements for children (Hegsted, 1957, p. 225).

a high NPU value if the recommendation of including 50 to 66 percent of animal protein is in the diet. Other dietary sources of complete protein such as meat, egg yolk and cottage cheese should be introduced to the infants as soon as possible.

An adequate protein for children in the United States is provided by two to four cups of milk although three to four is desirable and two or more servings of meats or meat substitutes. In some developing countries adequate protein is provided by mixtures of cereals, other plant proteins and if possible a limited amount of animal protein.

Adolescents

It is well known that adolescents have a high incidence of protein-calorie deficiency and of tuberculosis, especially in girls. The ignorance of nutritional information, the figure and skin problems of physical fitness, the frequenct nibbling of the empty calorie foods, the emotional stress, the use of food money for other purposes, dating hours, and many other factors may be the causes of protein inadequacies for adolescents (Huenemann, et al., 1968).

Adolescent's nutritional requirements are considered greater than those of children because of the strenuous nature of their work and activities and because of their growth. Nutritional needs vary between sex, at different periods of adolescence and under varying conditions of activity, constitutional type, and climate.

Recommended daily allowances of protein for boys in the age group of 10-12 is 45 gm, 12-14 is 50 gm, 14-22 is 60 gm, and for girls in the age group of 10-14 is 50 gm, and 14-22 is 55 gm. Four or more cups of milk, and two or more servings of meats or meat substitutes are adequate to meet the protein needs for teenagers. Many studies have indicated that girls of this age do not use four cups of milk. They should include at least two or three cups of milk in their daily diet.

Pregnant and Lactating Women

The state of nutrition of the pregnant woman has an important influence on the course of the pregnancy and on the health of the infant. Inadequate diet of mothers during pregnancy is closely associated with a high incidence of pregnancy wastage, prematurity, and neonatal mortality. During pregnancy, additional protein is required for the formation of new maternal tissues and fetal growth and maintenance. Protein deficiency may be the result of lack of adequate food supply, use of predominantely a one food eating pattern which is not nutritionally adequate, and food taboos. In the developing countries, there is not only a deficiency of the total protein but also in the quality of the dietary protein.

Minimal protein requirements are obviously increased during pregnancy and lactation. It may be estimated from the nitrogen content of the fetus and accessory tissues and of the milk produced for the minimal requirements during pregnancy and lactation.

If the average infant weighs 3.5 kg at birth and contains a 2 percent nitrogen, an additional 450 to 500 gm of protein would be required, primarily during the last half or trimester of pregnancy. This would require an additional 4 to 6 gm of protein per day above the estimated maintenance. A similar calculation for breast milk based upon the production of a liter a day containing 1.2 percent protein gives an increased requirement of 12 gm per day (FAO/WHO, 1965b).

Data are available which indicate that high protein intakes during pregnancy increase the likelihood of a favorable outcome. The apparently normal birth weight of many infants and the milk production of lactating women in developing areas have made the question pertinent for the nutritionists to reconsider what is the best recommendation of protein for these pregnant and lactating women. See Table 4 for the 1965 recommendations for some developing countries: India, Southern Africa, and Central America; and several of the developing countries.

For pregnant women to meet the US RDA recommendations, there is a total need of 65 gm of protein. The use of four or more cups of milk for pregnancy, six or more for lactation and two or more servings of meats or meat substitutes will be sufficient for this demand.

Human milk contains 1.29 gm of protein per 100 ml. The upper limit of the daily milk protein output is 15 gm. Since 1 gm of milk protein was produced from 2 gm of food protein, addition of 30 gm food protein daily

Table 4. Recommended allowances for dietary protein during pregnancy and lactation[a]

Country	Weight lb or kg	Calories	Protein gm
1. USA,[b] 1968, F&N Board			
Non-pregnant	120 lbs	2100	55
Pregnant, 4-9 mo		2300	65
Lactating		3100	75
2. Canada[c] 1963			
Non-pregnant	124 lb	2400	40
Pregnant, 7-9 mo		2900	50
Lactating		2900-3400	50-60
3. Great Britain, 1950			
Non-pregnant		2250	66
Pregnant, 1-5 mo		2500	63
6-9 mo		2750	102
		3000	111
4. Norway, 1957			
Non-pregnant	60 kg	2500	60
Pregnant, 7-9 mo		2900	85
Lactating		3500	100
5. India			
Non-pregnant	45 kg	2300	45
Pregnant, 5-9 mo		2300	100
Lactating		2700	110

Country	Weight lb or kg	Calories	Protein
6. Holland, 1961			
Non-pregnant		2400	60
Pregnant, 7-9 mo		2700	80
Lactating		3100	100
7. South Africa, 1956			
Non-pregnant	130 lb	2300	55
Pregnant, 7-9 mo		2600	80
Lactating			80
8. Japan, 1961			
Non-pregnant		2100	60
Pregnant, 1-5 mo		2400	75
6-9 mo		2700	90
Lactating		3000	95
9. Central America 1955, INCAP			
Non-pregnant	50 kg	2000	50
Pregnant, 7-9 mo		2500	75
Lactating		3000	90

[a] FAO/WHO, 1965b, p. 50. [b] Food and Nutrition Board, 1968, p. 19. [c] Pike and Brown, 1967, p. 460.

is needed for this purpose (FAO/WHO, 1965b). According to the 1968 RDA, addition of 20 gm of protein is needed or a total of 75 gm for lactation.

Dietary recommendation for protein for pregnancy and lactation from different countries has been compared by the FAO/WHO Expert Committee (1965b) in Table 4. They have also summarized and reported the dietary intakes of protein of pregnant women in various countries in the world (Table 5). It also gives the economic level of the group studied.

Senior Citizens

Lack of teeth or poor fitting dentures, poor food habits, physical defects, low income, living conditions and other psychological factors influence the intake and utilization of protein which lead to protein malnutrition in the majority of senior citizens (Alexander and Stare, 1968).

Systematic changes in aging man with respect to protein digestion and absorption have been sought in numerous studies of gastric, pancreatic and intestinal functions. There are two advocates, one has claimed that it is necessary to provide higher protein for the elder person to cover the requirement. However, other studies have shown that groups of the aged when fed diets containing protein of high biological value have average requirements similar to those of groups of young people. This agrees with the National Research Council RDA, that is, 55 gm of protein is required for a person age 55 or more. Good sources of cheap protein are ground meat, cold cuts,

Table 5. Summary of reported diets of pregnant women[a]

Country	Tri-mester	Year	Subjects	Calories	Protein gm
Scotland	III	1958	Wives of skilled workers	2512	78
			Wives of unskilled workers		72
Holland	middle	1953	Rural districts	2770	81
(Amsterdam)	III		Urban dwellers	2620	76
Australia (Adelaide)	III	1963	Clinic attenders	2342	82
U. S. A. (Tennessee)	III		Middle or lower income group	2020	70
New England)	III		Various income group	1915	67
Israel (Nagov)	III	1970	Women of poor education	2064	71
Egypt (Alexandria)	III	1960	Poor women	2046	72
India (Calcutta)	33-36	1962	Low socio-economic status	2010	72
South India (Hyderabad)	II	1962	Poor-class women	1520	40
(Coonoor)		1958	Poor-class women	1815	44
New Guinea					
(Chimbu)			In poor condition	1490	19
(Ajamaroe)		1958	In poor circumstance	1450	31
(Waropen)			In poor circumstance	1170	15

[a] FAO/WHO, 1965b, pp. 49-51.

dry or evaporated milk, low fat cheese such as cottage, poultry, and canned fish.

Special consideration of the specific needs of the individual senior citizen is necessary for the best nutritional program for this age group. Among the factors that must be considered are the following:

1. Inability to chew all foods.
2. Specific foods known to cause discomfort should be omitted. Eating too rapidly, too much food at one time, and anxiety contribute to poor digestion.
3. Frustration, loneliness, boredom, and fear of the future may decrease intake or increase the indulging in excessive food.
4. Ignorance of quantitative needs is as great as for those for younger people.
5. Appetite declines owing to the decrease of gastric juice secretion and the sense of taste.

Factors Influence Protein Requirements

Many factors influence adult protein requirements. Some of these are caloric intake, protein quality, total nitrogen intake, body size, stress, climatic variation, performance of work, and individual variability in utilization or metabolic use. In addition, the dietary requirements of certain amino acids are affected by the sparing effect of other nutrients (Swendseid, Williams and Dunn, 1956). The following are the factors affecting protein utilization: amino acid balance. Equally important as the presence of all essential amino acids for protein synthesis is the balance of amino acids available to the cell which is influenced by caloric value, immobility, injury, and emotional stability. As the caloric value of the diet drops below a certain critical point, the retention of nitrogen drops, indicating that part of the protein was used for energy. If caloric level is adequate, the level of protein utilization depends on the protein needs. The ability to synthesize protein responds negatively to a lack of activity. A healthy individual in bed at rest looses nitrogen at a rate of 12 to 18 gm per day. Injury increases nitrogen excretion. Abnormal emotional stress such as fear, anxiety, or anger increase the secretion of adrenaline, which in turn causes a series of changes that result in loss of nitrogen.

ESSENTIAL AMINO ACID REQUIREMENTS

The importance of some amino acids of protein to make them adequate for growth and maintaining muscle tissue in rats was noted as early as 1915 by Obsorne and Mendel. Depending upon their ability to maintain life and promote growth, proteins were classified as complete and incomplete. Later on, Rose found out that this is also true for human beings (Robinson, 1967). That is, a protein deficient in some amino acids would retard growth and allow deficiencies in humans. Thus, amino acids were classified as essential and non-essential amino acids.

Reference Pattern of Amino Acids

The pattern of amino acids needed for growth differs from the one needed for maintenance. The optimum pattern varies with the physiological state of the individual. In general, the pattern for optimum growth will be also good for maintenance and repletion of depletion tissues. This is the reason that egg and human milk proteins which have the highest nutritive value for growth were discussed by FAO/WHO (1957) as the ideal proteins to obtain a reference pattern of essential amino acids. The FAO established a pattern of essential amino acid requirements based on the minimum amino acid requirements determined experimentally with young adults fed purified amino acid diets as compared to the values of the egg protein which was used as a standard.

Hegsted (1964a) discussed different patterns of essential amino acid mixtures used for standards in human studies (Table 6).

Table 6. Patterns of amino acid requirements

Amino acid	Infants	Adult female	Adult male	Average	FAO pattern	Amino acid Committee (adults)	Egg protein
Histidine	1.5	--	--	1.5	--	--	--
Isoleucine	5.7	2.9	2.8	3.8	3.0	2.8	4.0
Leucine	6.8	3.9	4.4	5.0	3.4	4.2	5.3
Lysine	4.7	3.2	3.2	3.7	3.0	3.2	3.7
Methionine	2.0	2.2	4.4, 0.8	2.4	1.6	1.3	1.8
Total sulfur amino acids	--	3.5	4.4, 4.0	4.0	3.0	3.8	3.2
Phenylalanine	4.1	1.4	4.4, 1.2	2.8	2.8	1.3	3.5
Total aromatic amino acids	--	7.1	4.4, 5.6	5.7	6.0	6.2	6.1
Threonine	4.0	1.9	2.0	2.0	2.0	2.0	3.0
Tryptophan	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Valine	4.8	4.1	3.2	4.0	3.0	3.6	4.4

Taken from Hegsted, 1964a, p. 150.

Mitchell and Block (1946) suggested that the biological value of a protein (Y) may be estimated approximately from the maximum percentage deficit in the most limiting amino acid (X) by the equation, $Y = 100 - 0.634X$. A calculation of nutritive value from a consideration of amino acid patterns is often called the protein score. The most limiting amino acid may not entirely determine the nutritive value but all deficits may contribute.

Rosenberg and Eckert (1961) claimed that multiple amino acids should be supplemented in the proper ratio to each other and in balance with the next limiting amino acid or nutrient in the diet.

Needs of Essential Amino Acids

It is well known that all the higher animals, other than ruminants, require a dietary source of isoleucine, leucine, lysine, methionine, phenylalnine, threonine, tryptophan and valine. They are not synthesized in the rat, the human or other higher animals. However, the quantitative requirements are not the same for all species.

Another amino acid, histidine, is necessary for growth of infants in all species, including the human infant.

The primary data for man have been reported by Rose (1957) for adult men, by Leverton (1959) and Swendseid et al. (1959) for adult women, and for infants by Holt et al. (1960). In adult subjects the criteria of adequacy have been uniformly measured by nitrogen balance. When an essential amino acid is eliminated from the diet, a negative nitrogen balance ensues promptly.

The criteria used by Rose and Leverton differ somewhat. The minimal requirement as defined by Rose (1957) is "the smallest amount capable of including a distinctly positive nitrogen balance." Leverton et al (1956) used "the amount which will keep a subject to nitrogen equilibrium, where the difference between intake and excretion is within $\pm$ 5 percent." From the above definitions, Rose would get higher values than Leverton.

In infants, the criterion of adequacy was the amount required for normal nitrogen retention and normal weight gain. Data do not permit satisfactory statistical evaluation.

Adequate data on the amino acid needs of children from 1 to 10 years of age or of adolescents are not available. Information on the period of pregnancy and lactation is not sufficient to establish recommendations. In addition, the need of elderly have not been fully studied (Irwin and Hegsted, 1971b).

Rose (1957) concluded that the caloric requirement to maintain nitrogen equilibrium of the subjects needs to be increased when they received an amino acid diet. However, Metta, Firth and Johnson (1960) when using diets in which nitrogen is supplied as amino acids did not find that the caloric needs of animals was increased.

Hegsted (1964b) has shown in Table 7 the average estimates of minimal requirements of indispensable amino acids for infants, children, and adult men and women. The data on the patterns of amino acid requirements are more easily compared if they are converted to amino acid ratios, which is usually done by comparing the requirements of the other amino acids to that of

Table 7. Estimates of minimal requirements of indispensable amino acids

Amino acid	Infants (mg/kg)	Adult female (mg/day)	Adult male (mg/day)	Children (mg/day)
Histidine	34	--	--	----
Isoleucine	126	450	700	1000
Leucine	150	620	1100	1500
Lysine	103	500	800	1600
Methionine	45[a]	350	1100[b], 200	800[c]
Total SAA	--	550	1100, 1010	----
Phenylalanine	90[c]	220	1100, 300[c]	800
Total aromatic AA	--	1120	1100, 1400	----
Threonine	87	305	500	1000
Tryptophan	22	157	250	250
Valine	105	650	800	900

[a]In presence of adequate cystine.
[b]No cystine supplied.
[c]In presence of adequate tyrosine

Taken from Hegsted, 1964b, p. 155.

tryptophan, the one required in smallest amount. Although, there are marked similarities in the patterns mentioned above, there are serious discrepancies in comparing one set of data with another. Swendseid et al. (1961) pointed out that the tryptophan level in the FAO pattern is high for young men. They question the use of this pattern as a universal standard. Any reference pattern should be called provisional and be the subject for further research.

Obviously, it is very important that the quality of a protein depends both on the patterns of the essential amino acid it contains and on the amounts supplied per unit of protein or nitrogen. Mitchell and Edman (1962) questioned about the reliable requirements given in Table 6 which they believe are seriously underestimated, since in the nitrogen balance studies, the losses through the skin, hair, etc., are not taken into consideration.

Whether amino acid content should be used for the only factor for determining the minimal nitrogen requirement was questioned by Hegsted (1964a). He supplemented an egg protein diet with methionine but did not substantially improve the biological value. It is possible that the essential amino acid needs are partially determined by the total nitrogen intake, and the values accepted have been measured only at relatively high total nitrogen intakes. Many factors influence the practical requirements of amino acids such as quantity of protein, the amount of protein and/or amino acids, the proportion of essential and non-essential amino acids, variance in individual needs, and other interrelated factors. Hence, it is necessary in establishing safe allowances or dietary recommendations that the amounts are high enough to provide adequately for the needs of the majority of people.

Factors Affecting the Availability of Dietary Amino Acids

Not all of the amino acids present in the diet are available to the body. The availability can be reduced by two important factors. First, by incomplete digestion and absorption. The amount of one individual amino acid may influence the rate of absorption of another amino acid. The amino acids of most animal proteins are more efficiently absorbed than that of vegetables but the exact reason is not clear. It is probably that the high fiber content of vegetables is an important reason. In addition, the presence of inhibitors which inactivate certain digestive enzymes are found in vegetables. An example is the inhibitor found in raw soy beans which is inactivated by heat. Second, by damage to proteins and amino acids from excessive heat treatment or other processing which inactivates or destroys certain essential amino acid such as lysine.

Amino Acid Toxicities and Imbalances

The concept of amino acid balance has special significance among nutritional balances for three reasons: all the amino acids needed are obtained together from the proteins of food stuffs; all amino acids are used concomitantly for the synthesis of proteins; and there is practically no storage of amino acids in the body (Harper, 1964).

Amino acid imbalance

Harper (1959) defined amino acid imbalance as a change in the proportions of amino acids in a diet which results in a depression in food intake or growth rate that can be completely prevented by a supplement of the indispensable amino acid present in least amount in the diet in relation to the amount required for optional performance. There are two types of amino acid imbalances. One results from addition of a protein or amino acid mixture lacking one indispensable amino acid to a diet containing low or moderate amount of protein (Harper and Kumta, 1959). It is quite predictable to make this type of imbalance. The other results from addition of a small amount of amino acid or acids to a low-protein diet. Although such an addition does not markedly change the amino acid balance, it may cause a substantial depression in growth rate. Usually, it is the second limiting amino acid for growth which causes the imbalance (Rosenberg, Culik, and Eckert, 1959).

Imbalances primarily occurs when the chemical score of the diet is less than 50. Usually the imbalances are produced by small supplements of amino acids. When the protein level is not sufficient for maximum growth, food intake can be depressed owing to an imbalance, even though the chemical score of the diet exceeds 50. The relationship between chemical score and amino acid imbalance is influenced by the ratio of indispensable to dispensable amino acids in the diet. The lower the ratio, the better a protein of low chemical score can be tolerated (Munaver and Harper, 1959).

When an imbalance is created by adding a mixture of amino acids lacking one amino acid to a diet, the total amino acid content of the diet is increased and more of the next limiting amino acid is required to prevent a depression in growth rate. The absolute amount of amino acid needed to recover from this depression may also be increased (Kumta and Harper, 1960). Dean (1958) explained that the amino acid imbalance caused a depression of food intake which decreased growth rate. Bressani (1962) illustrated the effect of amino acid imbalance on nitrogen balance. He used 15 percent gelatin and 8 percent casein as a source of protein in a diet for young growing dogs and found that omitting one amino acid at a time decreased the nitrogen balance below that obtained on the basal diet. When both amino acids were omitted, the decrease was not as great as when only one amino acid was fed. The ratio of those two limiting amino acid had an even greater influence on nitrogen retention. Either high or low ratio decreased the retention. His study makes the biological value of amino acid imbalance more meaningful and brings the important relationship between balance and nutritive value.

Amino acid toxicities

Excessive amounts of amino acids may not be metabolized rapidly enough to prevent accumulation of the amino acid or metabolic products of it. Toxic effects of excess tyrosine and methionine are well known examples (Stekol and Szaran, 1962). Toxic effect of a given quantity of an individual amino acid is less when the diet is adequate than when it is inadequate. Also, growth depression is greater when the diet is low in protein (Sauberlick, 1961).

Many studies have indicated that amino acid toxicities may be reduced in severity by improving the limiting amino acid; however, a growth depression is not prevented. In imbalances, improving a diet with a supplement of the most limiting amino acid completely prevents the growth depression and usually stimulates growth.

Amino acid antagonism

An amino acid antagonism effect is produced when structurally similar amino acids compete for a site upon the same enzyme. The best known examples are the interference by the excess of leucine with the utilization of isoleucine and valine (Cohlan and Stone, 1961) and the interference by an excess of lysine with the utilization of arginine (Harper, 1964).

The growth depression due to such an antagonism is completely or largely prevented by a small supplement of a structurally similar amino acid or acids not originally limiting in the diet. The same mechanisms can be suggested to explain amino acid antagonism as were proposed to explain amino acid toxicity and imbalance.

Rosenberg, Rohdenburg, and Eckert (1960) emphasized that it is possible to depress food intake and growth rate by certain alterations in the amino acid balance of a diet so that not only is a point reached at which no further response is obtained upon adding another increment of an amino acid but a point of over-balance or imbalance may be reached and the response becomes negative. These are the most important factors influencing adverse effects of amino acids.

PROTEIN DEFICIENCIES AND DISEASES INFLUENCED BY DIETARY PROTEIN

Protein Deficiencies

Malnutrition is prevalent in many countries around the world. Food supplies are inadequate or are unattainable for many segments of the populations in the developing countries because of outdated methods of farming which make crop yield low, the financial inability to buy food that is on the market, overpopulation and the high prevalence of infections. In many areas calorie and protein needs cannot be met. What protein food is available often goes to the wage earner of the family thus the infants and preschool children often show the highest percentage of protein deficiency. Other important factors that have contributed to this widespread deficiency include: poor digestion and absorption owing to chronic diarrhea; excessive metabolism of protein which often happens during fever, following surgery, wound healing of any type, and following burns; excessive lose of protein in nephrosis, hemorrhage, burns, and exudates; failure to synthesize protein in liver injury.

Protein deficiencies are more likely to be seen among pregnant women from: low-economic groups who are ignorant of the essentials of a good diet; the elderly who have too low an income to secure food, insufficient understanding of the importance of diet, lack of incentive to eat, or poor health; and the chronically ill who have poor appetites but increased protein requirements.

Hunger edema

The association of hunger and edema is characterized by low plasma protein. About 80 percent of the osmotic pressure of the plasma protein is due to albumin, and albumin is mainly affected by a protein deficiency. The maintenance of the normal inter-extra vascular fluid volume depends upon the plasma protein concentration (Hegsted, 1964a). Body fluids increase as tissue fat and proteins are lost. Salt intake, intravascular pressure, renal function, vascular permeability, tissue tension, posture and the hormone effects are factors which may cause edema. From 1. 5 to 3 even 4 gm of protein per kilogram of body weight are prescribed, according to the conditions. It is recommended that two thirds of protein should come from complete protein foods. All the essential amino acids must be provided simultaneously to secure maximum synthesis in the body. Thus, each meal should contain complete protein foods to compensate for the incomplete protein foods. Sufficient calories should be included for maximum protein utilization. For effective feeding, small meals with between meal feeding would be more acceptable. A high-protein beverage is very helpful in obtaining high protein intake (Robinson, 1967). The consistency of the diet can be modified depending upon the patients conditions.

Protein-Calorie Malnutrition

It is well-known that if carbohydrate and fat are inadequate to provide needed calories, protein will be used for this purpose and the net protein value proportionally reduced. Therefore, in protein-calorie malnutrition, it is important to consider the protein quantity and quality, the proportion of calories, and the physical properties of the food which affects the protein utilization (Roe, 1970).

Protein-calorie malnutrition

The protein-calorie malnutrition is widespread among the infants and young children of the world between the ages of 3 months to 3 years, especially in developing countries. A number of different factors contribute to its causation which include lack of necessary foods, faulty infant and young children feeding practices, lack of hygiene, and the common infectious diseases of childhood. The problems in any specific area should be studied in relation to food supplies, dietary and weaning patterns, sanitation, infection, and the whole socio-economic background to find a way to solve the problem.

Protein-calorie malnutrition is often classified as two major variants. Figure 5 shows the different types of protein malnutrition in children. Kwashiorkor is a protein deficiency with adequate or nearly adequate caloric intake. It is characterized by arrested growth, pitting edema, muscle wasting, dermatosis, hair changes, enlarged liver, diarrhea, mental apathy, misery, low serum albumin, and psychic changes. It occurs most frequently in

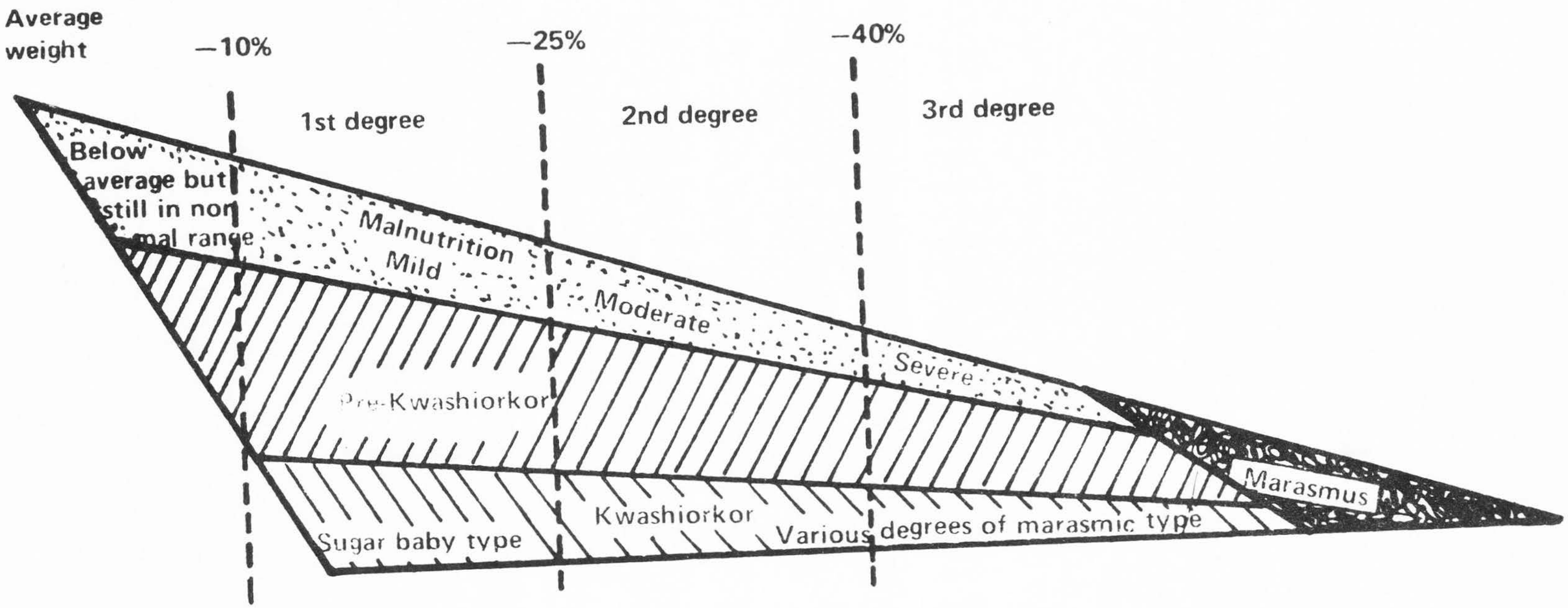

Figure 5. Classification of the different types of protein malnutrition in children (Fernando, Béhar, and Arroyave, 1964, p. 531).

children aged one to three years, during or after weaning. It is commonly precipitated by infection which increases the rate of breakdown of tissue protein and decreases intake of protein. Tropical Africa, Ceylon, Indonesia, Jamaica, India, and some other developing countries have received the most attention on this disease (Lives in Peril, 1970).

The other major variant is marasmus, which is caused by deficiencies of protein and caloric intakes and is characterized by serious wasting, nearly complete loss of body fat, and greatly retarded development. The children lose their lipid reserve and their own tissue, especially muscle, which furnishes both protein and additional calories. In developing countries, marasmus is the most prominent clinical feature which often occurs in infants and children below the age of 15 months (Aykroyd, 1970).

The most rapid period of brain growth takes place during the first month of extra-uterine life and this is largely a process of protein synthesis. Furthermore, marasmus in infants at an early age reduced the skull circumference and thus is likely to influence brain growth (Mönckeberg, 1969).

Treatment

The victims of protein-calorie malnutrition needs proper food and care for a long period of time to promote the satisfactory development of their physical and mental ability. High calorie followed by high protein intake is recommended. About three to five gram of protein per kilogram of body weight are given to the patient. The high biological value of animal proteins are preferable. The great difficulty of producing an abundance of animal protein foods in developing countries is recognized. Reconstituted non-fat dried milk and vegetable protein mixtures (incaparina, fish concentrates) have been shown to be effective. Other dietary and medical care should be instituted (Robinson, 1967).

Prevention

In appropriate circumstances protein-calorie malnutrition can be largely eliminated in a generation. It is very important to provide an adequate diet, especially protein of high biological value within a reasonable cost and to educate the mother with respect to infant feeding. Healthy human milk will provide adequate protein for breast feeding until six months. Other easily digestive high protein foods should be added to meet the requirements after six months. In prosperous countries, artificial feeding using cow's milk or formula is convenient and sanitary. However, this is impossible for poor and developing countries owing to the shortage of cow's milk and poor sanitation.

In the long run, the participation of programs in agriculture, food processing, education, economics, medicine, and public health are required to produce a stabilized situation. The permanent solution of malnutrition in infants would contribute much toward the solution of the complex problems facing the developing countries in the world today.

Protein and Injury

Physical injury results in damage to and loss of body protein both locally at the site of the injury and as part of the reaction to injury. First, injury may cause loss of protein by separating tissue from the rest of the body or by destroying it; second, for defense and repair of the damaged tissue, the injury is followed locally by an inflammatory reaction in which the participants are fundamentally structures made of protein; and third, the most prominent feature of general response to injury is an increased output of nitrogen (Cuthbertson, 1964).

In the course of the first 10 days following a severe injury in the catabolic phase the loss of protein is proportional to the previous level of protein intake and varies with the severity of the illness and the magnitude of the injury. This may continue for several weeks and amounts in total to some 1.5 kg or nearly 12 percent of the total body content of protein. Table 8 shows the protein loss during the first 10 days following severe injury. Immobilization of large parts of the body affects not only the nitrogen turnover, but also the calcium and phosphorous turnover. The first few days after surgery or injury, protein catabolism is greater than anabolism. Therefore, high protein intake will be catabolized which results in raising the urea nitrogen in the blood to a dangerous level, especially when fluid intake is inadequate or renal function is impaired.

Nutritional considerations after surgery or injury

A satisfactory state of protein nutrition ensures rapid wound healing by providing the correct assortment and quantity of essential amino acids, increase the resistance to infection, exert a protective action upon the liver

Table 8. Assessment of protein loss during first 10 days following severe injury or operation to a 70-kg man[a]

Source of loss	Simple fracture of femur or both bones of legs	Muscle wound equivalent to 4 hands in volume	35% burn involving in considerable part full thickness of skin	Gastrectomy
Loss of tissue (gm)	--	500-750	5-60	5-60
Hemorrhage or exudate (gm)	Unknown (as internal may be as much as 200 gm)	150-400	150-400	20-180
Catabolic phase (gm)	580 (may rise to 860)	650	600	525-650
Approximate estimate of disuse atrophy (gm)	100	100	150	100
Total protein lost (gm)	680 (may rise to 960 or even 1360)	1650-1900	1400-1650	650-990

[a]Taken from Cuthbertson, 1964, p. 401.

against the toxic effects of anesthesia, and reduce the possibility of edema at the site of the wound. The level of protein to be used depends upon the previous state of nurrition and the nature of the injury.

It is recommended that a high protein intake be provided when the anabolism phase begins. A daily intake of 100 to 150 gm or more of protein will usually be sufficient on an adequate caloric intake of 2500 to 3500 calories (Robinson, 1967). The consistency of the diet can be modified as the patient's condition improves. Other considerations should be taken under various conditions: fluid and electrolytes balance and vitamin supplements are two factors that need to be considered when planning the daily diet and menus (Zintel, 1970).

Protein Deficiency and Infective Disease

It is believed that optimum nutrition is required for maximum resistance to disease. The interaction between protein malnutrition and infective disease is dynamic and is usually characterized by synergism. The synergistic effects lie both in the many different ways in which protein deficiency can interfer with mechanisms of resistance to infection and the extent to which infective disease reduces nitrogen retention and often results in negative nitrogen balance. First, antibody formation (Pretorius and Devilliers, 1962); second, phagocytic response, that is children with the severe protein deficiency of Kwashiorkor often show little or no leucocytic response even to serious infections (Scrimshaw and Behar, 1961); and third, altered tissue integrity. It is well-known that the skin and mucous membranes which prevent the invasion of infectious agents are seriously affected by protein deficiency.

Febrile Disease

Fever is an elevation of temperature above normal and results from an imbalance between the heat production in the body and the heat eliminated from the body.

Some of the important changes in fever which may affect nutrition are: (Robinson, 1967) Metabolic rate increases seven percent with every degree (Fehrenheit) rise in body temperature; increased protein metabolism places a heavy burden upon the kidney; reduced liver glycogen storage; increased respiration and the excretion of body waste accelerate the loss of body water, sodium chloride and potassium; decreased motility; and reduced absorption of nutrients.

General dietary considerations

The diet during illness depends on the nature and the severity of the existing pathologic conditions and the length of convalenscence. It is usually sufficient to provide 100 to 150 gm of protein. The easily digested protein foods with high biological values such as milk and eggs are most desirable. High protein beverages will help to meet the high protein intake. The caloric requirements which is increased 50 percent or more, depends on the body temperature, the degree of destruction of tissue, and the amount of restlessness. Carbohydrates and emulsified easily digested fats are used to meet the energy requirement. Occasionally, too much fat will cause nausea. Vitamins, salt, and fluid should be taken into consideration. Bland, readily digested foods should be used to afford maximum rest to the body, to facilitate ready digestion and rapid absorption. The consistency of diet is dependent upon the patient's conditions. Small frequent feeding may be more desirable (Robinson, 1967).

Liver Disease

Besides many other vital functions, the liver plays an important role in protein metabolism. The liver maintains appreciable protein reserves which are readily released for the maintenance of the serum protein level. Body proteins which are synthesized from the amino acids is controlled by the liver in that excess amino acids not needed for tissue synthesis are deaminized and thus made available for energy. The resulting ammonia is converted to urea and the remainder of the amino acid yields glucose or fatty acids for energy (Robinson, 1967).

Hepatitis

Hepatitis is an inflammation of the liver in which necrosis or rapid destruction of the liver cells occur.

The objectives of the dietary treatment are to avoid further injury and strain to the liver, and to aid in the regeneration of liver tissue. A liberal diet and adequate rest are absolutely required to avoid liver damage. Sufficient protein is necessary for the maintenance and repair of the liver tissue itself and to furnish lipotropic factors for the utilization of fat (Davidson, 1970). An intake of 1 and one-half to 2 gm of protein per kilogram of body weight will be satisfactory with 3000 to 4000 calories daily are required to allow maximum utilization of protein.

Poor appetite and anorexia are characteristics of this disease. Persuasion, encouragement, good cookery and attractive food service will be helpful to get the patient to eat. Small meals with interval feedings and a bed-time snack are more effective. The consistency of the diet is dependent upon patient's conditions. It is perferable to take regular diet as soon as possible to allow wider choice of foods.

Hepatic coma

Hepatic coma is a neurologic disorder which results in ammonia intoxication.

The fundamental principle in the dietary treatment of hepatic coma is to restrict protein metabolism to a minimum, thereby reducing the amount of ammonia produced. Catabolism of tissue proteins must be avoided. Usually, 1500 to 2000 calories daily are sufficient to keep body tissue breakdown to a minimum. Carbohydrates and fats provide almost all of the energy. At first 20 gm of protein daily is prescribed by most physicians. However, protein-free diets are recommended by some physicians. An additional 10 to 20 gm is added when improvement occurs. Progression is continued until the protein intake reaches 1 gm per kilogram of body weight (Robinson, 1967). The protein-free diet consists of commercial sugar-free emulsions, or glucose in beverage or fruit juice which may be used through oral or tube feeding.

The details of a regimen of 20 gm, 40 gm, and 60 gm protein diets are described in Table 9 which also gives example of a 40 gm protein, 2100 calorie diet (Dietary Department, 1969).

This diet is designed for the individual who must restrict his daily intake of protein. In order to maintain the diet at a moderate sodium and potassium level, some foods are restricted.

It provides approximately 40 gm or 8 percent protein, 110 gm or 46 percent fat, 240 gm or 46 percent carbohydrate, 2,100 calories, 100 mEq of sodium, 55 mEq of potassium. The following foods must be included in each day's menu pattern: 1/2 cup (4 ounces) milk, 3 ounces meat or substitute, 4 servings starch, 2 servings vegetable, 5 servings fruit or fruit juice, 6 servings fat, 4 or more servings sugar and sweets, and soups made from allowed food, as desired and beverage, as tea, coffee, gingerale or cola, as desired.

Suggested menu pattern is given which may be changed but it is important to include a protein food (milk, meat, or egg) at each meal.

Breakfast	Lunch	Dinner
1/2 cup fruit or juice	1 egg	2 ounces of meat or
1/2 cup cereal or	1 cup fruit salad with	2 ounces cheese
1 slice toast	1 tbsp. mayonnaise	1/2 cup potato
1/2 cup milk	1 slice bread or	1/2 cup vegetable
2 tsp. cream or	5 saltines	1/2 cup vegetable salad
1 tsp. butter	1 tbsp. butter	with tbsp. French

Table 9. Food exchange lists for low protein diet[a]

Item	Food Allowed	Food not Allowed
<u>Beverages</u>	<u>Milk</u>	
Average per 4 ounces	chocolate low fat (2% or 1%)	*fortified skim low fat (1%-2%)
<u>Milk</u>	whole buttermilk	or buttermilk
PROTEIN - 4 gm	skim	"non-fat dry
Na-60 mg (2.6 mEq)	evaporated or condensed,	milk solids added
K-168 mg (4.3 mEq)	reconstituted (1/4 cup	
<u>Coffee, tea</u>	evaporated or condensed	
PROTEIN - 0	and 1/4 cup water)	
Na-1 mg (.05 mEq)		
K-36 mg (.9 mEq)	<u>Other</u>	
<u>Gingerale or cola</u>	coffee	
PROTEIN - 0	tea	
Na-10 mg (.5 mEq)	gingerale or cola, unless on	
K-45 mg (1.1 mEq)	fluid restriction	
<u>Meat or substitute</u>	Example: 1 egg lunch + 2 oz	MORE THAN THE AMOUNT
Average per 1 ounce	meat dinner = 3 servings.	SPECIFIED
PROTEIN - 7 gm.	Each of the following may be	meat broths
<u>Meat</u>	considered ONE ounce serving:	gravies
Na-23 mg (1 mEq)		meat extracts
K-135 mg (3.4 mEq)	1 ounce meat, fish fowl, cheese (3" x 2" x 1/4")	
<u>Cheese</u>		
Na-185 mg (8 mEq)	1/4 cup cottage cheese or canned fish	
K-31 mg (.8 mEq)	1 egg (at least <u>one</u> per day)	
<u>Egg</u>		
Na-61 mg (2.6 mEq)		
K-65 mg (1.6 mEq)		

Table 9. (Continued)

Item	Food Allowed	Food Not Allowed
Starches Average per serving PROTEIN - 2 gm. NA-175 mg (7.6 mEq) K-150 mg (3.8 mEq)	Each of the following may be considered ONE serving: 1 slice bread 1/2 cup cereal, macaroni, potato, rice, spaghetti 1/3 cup corn 5 saltines, 2 graham or 10 small round crackers 1 plain cookie 1/3 cup flavored gelatin or sherbet 2" wedge of fruit pie 1/2 cup fruit cobbler	MORE THAN THE AMOUNT SPECIFIED pie or cake; custard or cream filled cake, cookies, ice cream; with fruit, nuts or chocolate Any not listed on allowed list
Fruits and Juices Average per 1/2 cup PROTEIN - 0.5 gm NA-2 mg (.08 mEq) K-140 mg (3.5 mEq)	Any kind of fruit or juice may Be used. For Vitamin C use citrus fruits melons or strawberries often.	MORE THAN THE AMOUNT SPECIFIED
Vegetables Average per 1/2 cup PROTEIN - 2 gm Na- canned, 236 mg (10 mEq) Frozen and fresh, 21 mg (.1 mEq) K-140 mg (3.5 mEq)	Any kind of vegetable may be used except those listed under "food not allowed."	MORE THAN THE AMOUNT SPECIFIED Vegetables high in protein such as collards, fresh peas, dried peas, and beans pickles olives sauerkraut

Table 9. (Continued)

Item	Food Allowed	Food not Allowed
Fats Average per serving PROTEIN - .1 gm Na-100 mg (4 mEq) K-4 mg (.1 mEq)	Each of the following may be considered ONE serving: 1 tbsp. butter or margarine 1 tbsp. mayonnaise, salad dressing, fats and oil *6 tbsp. light light (50%-coffee) cream *2 tbsp. or 1 ounce cream cheese or sour cream *Do not exceed this amount per day	MORE THAN THE AMOUNT SPECIFIED
Sugars and sweets PROTEIN - 0 K-negligible	1 tbsp. or 10 small or 2 large pieces equal one serving: candy-coated mints, jam, marsh-mellow gumdrops, jelly, plain caramels, hard candy, jelly beans, sugar	ANY NOT LISTED candy with fruit, nuts, chocolate or coconut
Seasonings and Spices	May be used as desired use salt moderately	

[a]Taken from Dietary Department, 1969, D154-2.

Breakfast	Lunch	Dinner
1/2 tbsp. sugar	1/2 tbsp. jelly	dressing
1/2 tbsp. jelly	1/3 cup sherbet	1 tbsp. butter
beverage	1/2 tbsp. sugar	1/2 cup fruit
	2 tbsp. cream	2 tbsp. cream
	beverage	1/2 tbsp. sugar
		beverage

Between meals included: one starch serving, 2 graham crackers; one fat serving, 2 tbsp cream cheese; one fruit serving, 1/2 cup orange juice; two sugar servings, 4 marshmallows.

Renal Disease

Acute glomerulonephritis

Acute glomerulonephritis is also known as hemorrhagic nephritis. It is characterized by oliguria, hematuria, some albuminuria, slight generalized edema, varying degrees of hypertension, and some azotemia. Nausea and vomiting are especially annoying symptoms (Robinson, 1967).

Diet does not play an important role during the acute phase; however, nausea and vomiting make it impossible to provide adequate intake. During the period, effort should be made to provide sufficient fluid to maintain water balance and to provide adequate non-protein calories to avoid excessive tissue catabolism. Glucose can be given intravenously or fruit juice through tube feeding for fluid and calories. As the patient improves, a more progressive diet can be given. Adequate carbohydrate and fat reduce the nitrogen metabolism to a minimum hence reduce the work of the kidney. During the acute phase, protein intake is restricted to 0.2 gm per kilogram of body weight and can be increased for those who have recovered to 0.5 gm per kilogram of body weight for adult and 0.75 gm for children. If there is marked albuminuria, the protein intake should be increased by the amount of protein lost in the urine.

The 20 gm protein diet can be used only a few days. The 40 gm and 60 gm protein diets will maintain nigrogen equilibrium in the adult and may be used for longer periods of time providing that the patient is not previously malnourished. The caloric intake is adquate for energy needs. Complete proteins are included at each meal and there are no protein losses in the urine. Sodium and fluid adjustment should be considered.

Sugar, hard candy, syrup, jelly, and marshmallows contribute effectively to the carbohydrate intake without increasing protein intake. Cream and butter add energy and palatability to the food. But excessive use may cause nausea. Between-meal feedings are desirable to provide a continued source of calories thus minimizing tissue catabolism. Vitamins, iron and calcium supplements may be given accordingly.

Chronic glomerulonephritis

Chronic glomerulonephritis is characterized by proteinuria, hematuria, hypertension, frequent urination and nocturia, and massive edema. Eventually renal failure will occur.

The objectives of nutritional management include: to maintain a state of good nutrition to afford better resistance to infection, to avoid unnecessary harm to the kidney, and to provide attractive, easily digested meals adjusted to the individual patient's requirement (Sachiko, Garlston and Taylor, 1969).

There are two controversy dietary regimen used for this disease. One recommends moderate to severe protein restriction in chronic nehpritis, the other believes that there is no benefit from limiting protein under normal levels of intake. During the latent period, normal level plus the amount of protein in the urine are sufficient. When nitrogen retention becomes marked, further restriction to 40 or 50 gm daily is recommended. The patient who is malnourished, edematous and who looses much protein in the urine may require a higher protein intake of as much as 80 to 100 gm daily. Sufficient amounts of carbohydrate and fat should be provided to ensure adequate energy intake. Sodium, potassiumn and fluid adjustment should be considered. Small frequent feedings are desirable.

Abnormalities in Amino Acid Metabolism

Phenylketonuria

Phenylketonuria is seen particularly in Northern European populations and is extremely rare among the Japanese, Negro, and Jewish populations. Phenylketonuria is a hereditary metabolic disease characterized by mental deficiency which usually becomes apparent in infancy, neurological abnormalities and the presence of phenylpyruvic acid in the urine. The condition is caused by a deficiency of phenylalnine hydroxylase in the liver, which results in an excessive accumulation of phenylalnine in the blood and spinal fluid and is excreted in excess in the urine.

The nature and cause of the brain damage in this disease are not well understood. However, it is clear that either phenylalanine or one of its metabolities, when present in excess, seriously interfers with brain function, eventually producing irreversible change (Mckean, Schanberg, and Giarman, 1962).

A diet low in phenylalanine will regularly control the biochemical abnormalities (Fisch, Solberg, and Borud, 1971). If it is done in early infancy normal mentality can be expected. There are several commercial preparations available, such as Ketonil and Lofenelac which are suitable substitutes for milk formula. Lofenelac is a combination of low-phenylalnine casein hydrolyzates, fat, carbohydrate, and the minerals and vitamins comparable to the usual milk formulas. Lofenelac contains 0.06 to 0.1 percent of phenylalaine and provides 20 calories in each ounce.

Phenylanine is essential for growth, a certain amount should be included in the diet. Smith and Waisman (1971) recommended an initial intake of 60 mg per kilogram of body weight. The protein needs of the infant are essentially met by the use of Lofenelac with natural foods low in phenylanine such as fruits, fruit juices, vegetables other than legumes, and cereals. A range of 3-10 mg per 100 ml is a safe range for optimum growth and development (Smith and Waisman, 1971). The intake will be adjusted according to serum phenylalanine. It must be checked at short intervals.

How long this therapy should be continued is still unknown. Usually the myelination is virtually completed after three to four years old. The normal diet might be used after the central nervous system has been fully developed. It is very important to educate the patient's parents about principles of this diet to help them in managing the diet.

Maple syrup urine disease (branched chain keto aciduria)

Maple syrup urine disease is an inborn error caused by a block in the oxidative decarboxylation of the keto acids of the branched chain amino acids-leucine, isoleucine, and valine. This results in the accumulation of the corresponding alpha-keto acids which gives urine the characteristic maple syrup odor. Symptoms start soon after birth: an absence of Moro reflex and the development of irregular, jerky respirations. These are followed by signs of spasticity and ketanic spasms of the spine. The infants rapidly decline and die within a few weeks or months (Holt and Snyderman, 1970).

A diet low in leucine, losleucine and valine will correct the biochemical abnormalities and has resulted in striking clinical benefits. The diet should be started as early as possible to prevent the damage of the nervous system.

Natural foods are all well supplied with branched-chain amino acids, therefore, it is necessary to provide a synthetic diet in which protein is entirely furnished by a mixture of pure amino acids. A small amount of milk can be used for a minimum amount of branched chain amino acids which are needed for growth. The intake is adjusted at intervals to maintain normal plasma levels (Hsia and O'Flyne, 1970).

Milk Intolerance

Milk is known as the best source of protein. However, there are many studies which indicate that drinking milk causes abdominal cramp or diarrhea. This often happens to Orientals and Africans (Huang and Bayless, 1968, Bolin and Davis, 1969). They concluded that an inherited lactase deficiency caused this type of milk intolerance. Soybean milk can be used in this case. However, many cases of milk allergy in USA and Europe are not caused by lactase deficiency. The exact causes are unknown. The protein in the casein or some fraction of the casein molecule as well as other proteins in milk appear to be responsible for these allergy cases.

CONCEPTS OF INTERRELATIONSHIPS

Protein-Calorie Interrelationship

Protein metabolism is not only interrelated with but also dependent upon the dietary sources of energy. Protein can not be utilized for growth or maintenance nor preventing the breakdown of tissue protein when the diet does not provide sufficient amounts of other energy courses, such as carbohydrates and fats. The effects on protein utilization are shown in Figures 6, 7, 8.

Calloway and Spector (1954) stated that energy level is the deciding factor in nitrogen balance on a fixed adequate protein intake and there is an individual limiting energy level beyond which increasing calories without protein or protein without calories is ineffective. Thus, therapeutic diets designed for the correction of malnutrition must be based on this principle.

It is well-known that dietary carbohydrate and fat have protein-sparing effects. Carbohydrate and fat metabolites may provide some necessary links for the phosphorylation of amino acids or for other energy-consuming steps involved in the synthesis of body protein (Nakano and Ashida, 1970). Carbohydrates seem to be more effective than fat. The nitrogen-sparing action of sugar is more effective when it is consumed simultaneously with the protein (Roe, 1970). In fact, there are many different findings and interpretations. The practical implications remain unclear.

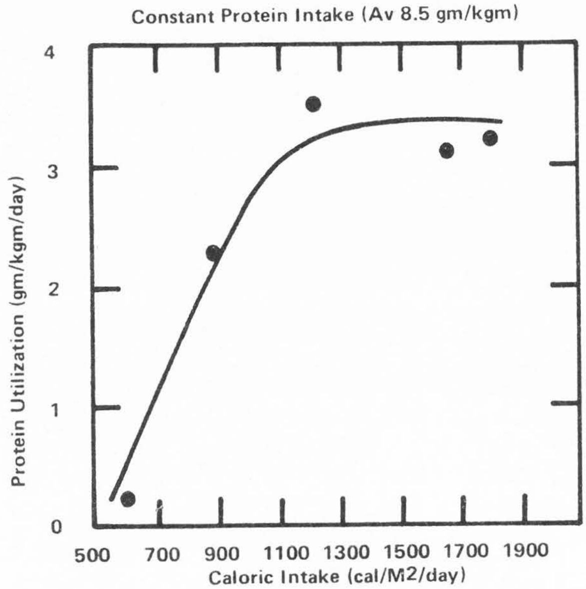

Figure 6. The influence of level of caloric intake on protein utilization (Pike and Brown, 1967, p. 433).

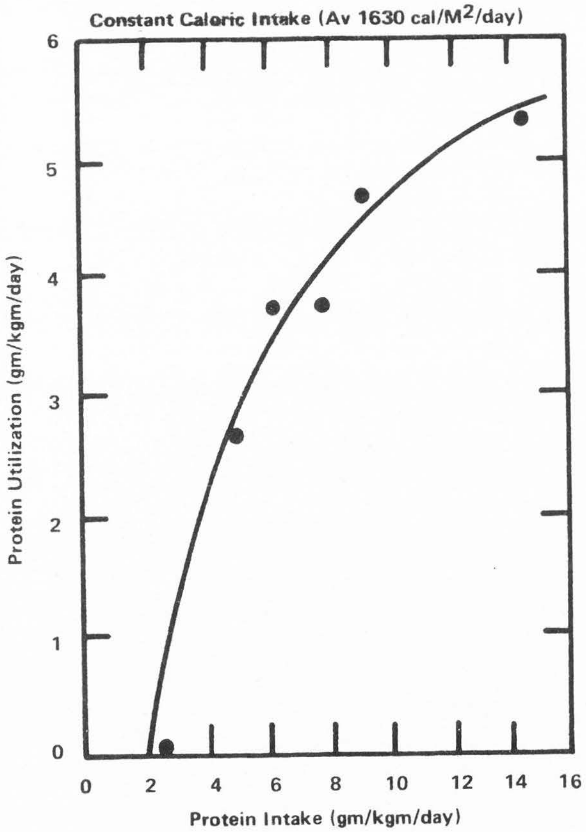

Figure 7. The influence of level of protein utilization (Pike and Brown, 1967, p. 433).

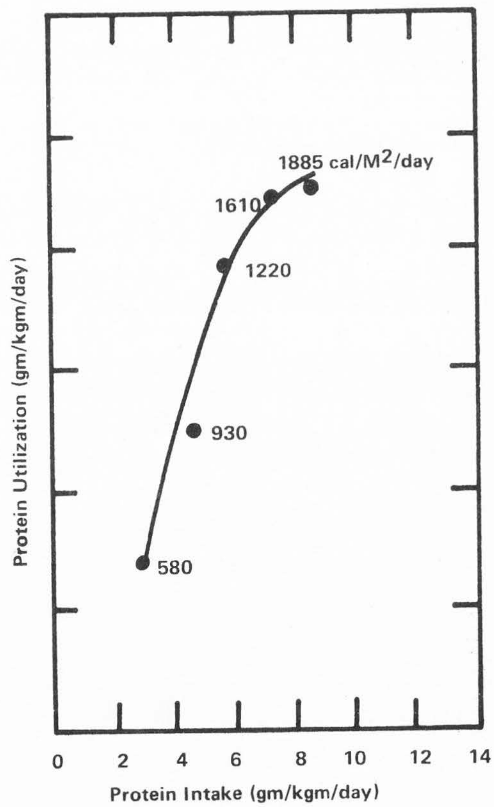

Figure 8. Influence of simultaneous variation of protein and caloric intake levels on protein utilization (Pike and Brown, 1967, p. 433).

Amino Acid Interrelationship

The nutritional value of a dietary protein depends on the extent to which the kinds and quantities of all the amino acids required for tissue synthesis are reached. That means the ratio of dispensable to indispensable amino acids should be met to fulfill the tissue requirements. If the non-essential amino acid can not be synthesized in the body through absence or deficiency of an enzyme system, then the amino acid should be supplied in adequate amount in the diet. Proteins which do not fulfill tissue requirements are utilized ineffectively because they do not provide the correct balance of amino acid for tissue synthesis. The adverse effects of amino acid imbalances, toxicities, and antagonisms which have been discussed previously explain clearly the interrelationship among amino acids.

Amino Acid-Vitamin-Trace Mineral Interrelationship

Excessive amounts of amino acid may be particularly detrimental in animal fed diets deficient in certain vitamins. Many trace minerals as well as many vitamins are necessary to be enzymes and corzymes or as a part of the enzyme structure to activate the catalytic reaction that takes place in protein and/or amino acid metabolism. Recent discoveries have included that at least ten or more minerals, most of the B vitamins and vitamin A are needed by the enzymes that play an important role in protein catabolism and/or anabolism (Roe, 1970). For example, Debey, Snell and Baumann

(1952) found out that the addition of small amounts of methionine markedly retard growth of pyridoxine-deficient rats.

Why was pellagra endemic in corn eating populations and not in groups consuming less nicotinic acid but no corn? How could milk which was low in nicotinic acid cure or prevent a nicotinic acid deficiency disease? Figure 9 presents a summary of the concepts in the conversion of tryptophan to nicotinic acid which fully explains the above questions. Tryptophan is usually called a niacin precusor, 60 mg of tryptophan are equivalent to 1 mg of niacin. Tryptophan constitutes approximately 1 percent of the protein content of a diet in which complete protein foods predominate.

Pyridoxine is essential for the conversion of tryptophan to nicotinic acid. The absence of pyridoxal phosphate blocks this reaction and leads to the accumulation of an intermediate product kynurenine (Wiss and Weber, 1964).

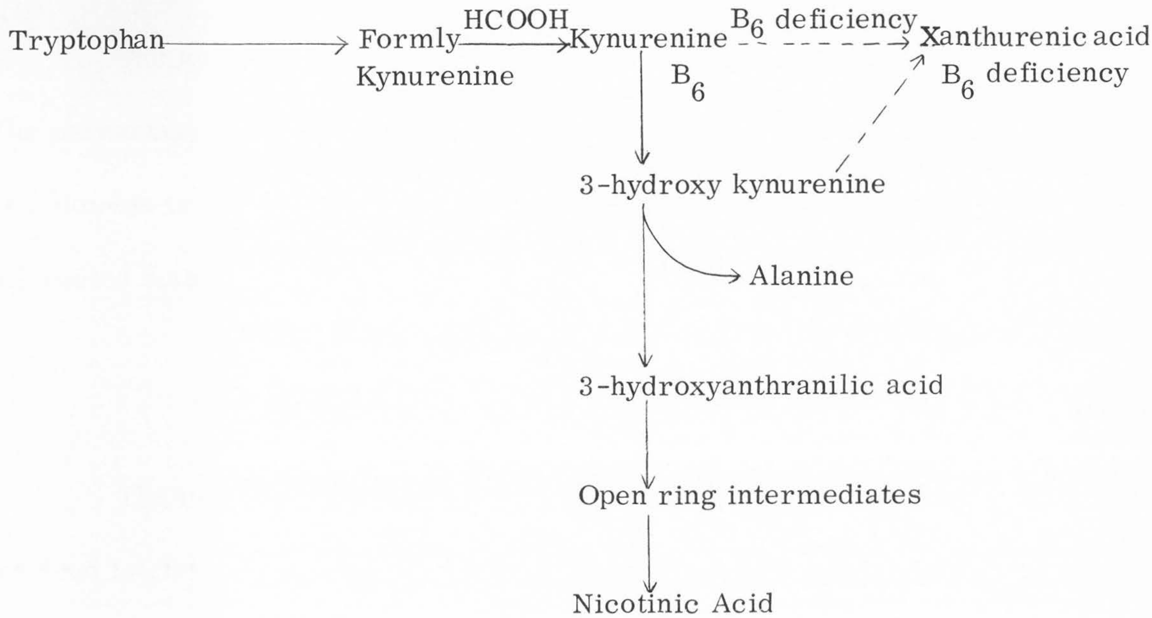

Figure 9. Conversion of tryptophan to nicotinic acid (Pike and Brown, 1964, p. 58)

PROTEIN DEFICIENCY IN THE DEVELOPING COUNTRIES

The lower the income, the larger proportion of it is spent for foods. The percentage of expenditure of the income on food in the urban population of Colombia is 52; Iran 48; Ceylon 68; Japan 42; Greece 41; Sweden 32; and the United States 25 (Chassemi and Massouch, 1971).

Ghana

The individual average income is small. However, the percentage spent for food is rising in recent years. In 1959, it was 63 percent.

The greatest problem appears to be the lack of protective foods in their diets. In the north a typical meal will consist of porridge; in the south tubers are eaten with a spicy sauce that supplies the fats, minerals, and vitamins.

There is no detailed study about the nutritional intake of the individual Ghanain. The general level of nutrition is low. Malnutrition is widespread throughout the country. Infant mortality is high. In the coastal and the southern forest region where cassava is a basic food, calories are usually adequate but the prevalent protein shortage is reflected in large number of cases of kwashiorkor. In the north, marasmus is frequently observed. Pregnant and lactating women and children are particularly vulnerable (May, 1965).

Nigeria

The nutritional equilibrium in Nigeria is more threatened than in other tropical African countries, because of its very prosperity. Throughout the country, people are underweight, especially children. Nutritional levels vary with the people and with the season. Porridge is the basic food made with cereal in the north with some manioc (cassaca) added, or with manioc products in the south with some grains and cereals added. It fills the stomach of the Nigerians, but is predominately starch and low in good quality protein. The addition of meat, fish, and dried fish would increase the quality of the protein, but they are very expensive and are considered to be luxury foods.

The deficiency in protein and caloric intake are common. The mortality rate for children under five years of age reaches almost 50 percent. The child is breast-fed for a long period and is weaned abruptly when the next child needs the breast. The older one is then shifted to a diet of manioc, thus creating the conditions of kwashiorkor, pre-kwashiorkor, and marasmus in childhood which are often observed in this country (May, 1965).

Republic of the Congo

The land tenure, poor quality of the soil, lack of fertilizers, lack of purchasing power, and scarcity of technicians in all fields combined with considerable tribal rivalries and unrest jeopardize the production and distribution of food (May, 1965).

There is a shortage of quality proteins and an abundance of starchy foods: manioc, corn, plantain and rice. When manioc is the sole basic food, malnutrition results, because its proteins are of poor quality.

In the Congo, disease caused by nutritional deficiencies are second only to communicable diseases. Besides many other nutritional diseases, kwashiorkor causes were 20 percent of total nutritional deficiencies in this country (May, 1965). This is ascribed to a deficiency of protein in the food, due to the low biological value in maternal milk and to an insufficient availability of foods containing high quality protein.

Algeria

In 1959, the total number of calories consumed per capita per day in Algeria was estimated to be 2,236, or which 77.4 percent was derived from carbohydrate, 10.10 percent from fats, and only 11.6 percent from protein (May, 1967). Cereal, especially barley and wheat form the major part of all diets.

Weaning habits are nutritionally harmful everywhere. Children of all groups are breast-fed until they are one or two years of age; then, when goat's or camel's milk is not available, they are suddenly shifted to diets of starchy foods and soon fall victims to kwashiorkor, which is common in Algeria. Infant mortality is high and puberty occurs late among girls, because of deficient diets.

Morocco

In spite of a general sufficiency of food, uneven distribution caused inadequacy of diets. Yet, the adequacy of supply is marginal and is seriously threatened by the high rate of population growth.

Moroccan diets are of the classic antique Mediterranean type based on cereals and oil. Barley and wheat are preferred. The consumption of fish and fresh milk is very low. The levels of caloric intake and protein vary widely (May, 1967).

Signs of nutritional deficiencies are widespread in Morocco. The following population groups are the most commonly affected: the preschool children, especially during the very early years following weaning, the school children from five to twelve, and the women. Signs of malnutrition rarely occur in the adult. The signs most commonly observed are generally associated with a shortage of energy-producing foods, vitamin D, calcium, and protein. Kwashiorkor is common, it occurs between the twelfth and eighteenth month after birth, reaching a peak among two-year-old children.

Most children are underweight and show evidence of retarded development. Women, always poorly fed, especially when pregnant and lactating, show evidence of anemia.

Pakistan

The diets of Pakistan have a common character, they are low in calories and inadequate in protective nutrients. The Pakistani diets are among the poorest in the world, according to the survey of FAO/WHO in 1958, the total caloric intake was 3,000 calories, the total protein intake was 47.3 gm of which, only 8.3 percent was derived from animal proteins (May, 1961).

The food resources are inadequate at all times. Rice and wheat are the basic foods of Pakistan. There are no adequate statistics on which to base a description of nutritional disease in Pakistan. However, malnutrition, especially protein malnutrition in children remains a major problem.

Egypt

The diet of the Egyptian varies in different population groups. The major portion of the calories in all population groups is supplied by cereal, which may constitute as much as 75 percent of total calories consumed. It provides a major portion of the proteins of the diet, but animal proteins from all sources only account for about 16 percent of total proteins consumed. Animal foods in the diet are primarily skimmed milk, cheese and clarified butter, with fish available on a reginal basis and all meats in very limited amounts.

The amount of food available would provide an adequate caloric intake with somewhat low levels of protein consumption, especially of animal proteins, and a low intake of protective foods. The inequalities in the distribution of available foods, the lack of modern storage and canning methods and deficiencies in the transportation systems tend to limit the food consumption.

The average diet of the majority of the Egyptian population is not a nutritionally balanced one. About 75 to 80 percent of the inhabitants do not receive an adequate diet. Although the caloric intake and total protein consumption is at or above recommended levels, most of proteins consumed are of vegetable origin and the total consumption of animal products is at an extremely low level (May, 1961).

Manifestations of low level of nutrition include kwashiorkor, the high infant mortality rate, the high mortality among preschool children, and the retarded growth rates of infants and young children. This is due to in part to proverty and in part to ignorance of nutritional knowledge.

Ceylon

There are no normal times for Ceylon, which is dependent upon the world market to feed 50 percent of the people at home. The people consume about 2,000 calories daily, 57 percent of which comes from cereals (May, 1961). Very few proteins of animal origin are found in the average Ceylonese diet, not only because of the poverty but also of religious beliefs and customs.

The poverty due to a variety of causes is the basis for the inadequate intake of proteins and calories. It affects primarily women and children.

About 50 percent of pregnant women do not eat enough food especially protein food. Half of the infants do not get enough food to eat, mainly due to unsatisfactory breast feeding and to the inability of mothers to purchase enough infant foods. At least 20 percent of the preschool children and school children need more food to eat. Kwashiorkor was observed among children of this age.

India

Even in normal times food resources are inadequate for the teeming population of India. The common characteristics of all India diets are their extremely high cereal content, and their marked deficiency in protective foodstuffs. The caloric intake was about 2,000 calories. Proteins of animal origin contributed 8.1 percent of the total calories (May, 1961). Rice, wheat and millet are the most popular cereals. Little meat, egg, and milk are eaten because of their great cash value and religious beliefs.

The problem of deficiency diseases in India is enormously complicated. Full or partial cases of kwashiorkor have been observed in various parts of the country. The patients come mostly from the poor classes of people living on diets that are both quantitatively and qualitatively inadequate.

THE AVAILABILITY AND ACCEPTANCE OF NEW FOODS

The Protein Gap

Three major steps are needed to deal with the world food situation: population control, increased food production, and improved and increased protein quality and quantity in the diet (Stare, 1971). Once the food is produced, sanitary methods of handling and storage at a price commensurate with the economic level of the people in an area must be introduced. Sanitary methods must also be employed in the preparation and service of the food.

The introduction of high-yielding varieties of maize, wheat, and rice have shown the success of modern plant breeding in some developing countries, such as Brazil, India, Philippines, Irag, Kenya, Pakistan, and Turkey (Lives in Peril, 1970). Cereals contain a small amount of high quality proteins and which are the major source of energy in the developing countries (Figures 10 and 11). Besides, very few developing countries can afford to divert grain production from human to animal consumption. Therefore, genetic improvement of the cereal grains are used. The introduction of the gene Opaque-2 into maize, a cereal deficient in lysine and tryptophan, increases the content of both amino acids, the lysine by as much as 70 percent in whole maize. Another gene, Floury-2, increased lysine, tryptophan, and methionine levels in maize (Lives in Peril, 1970).

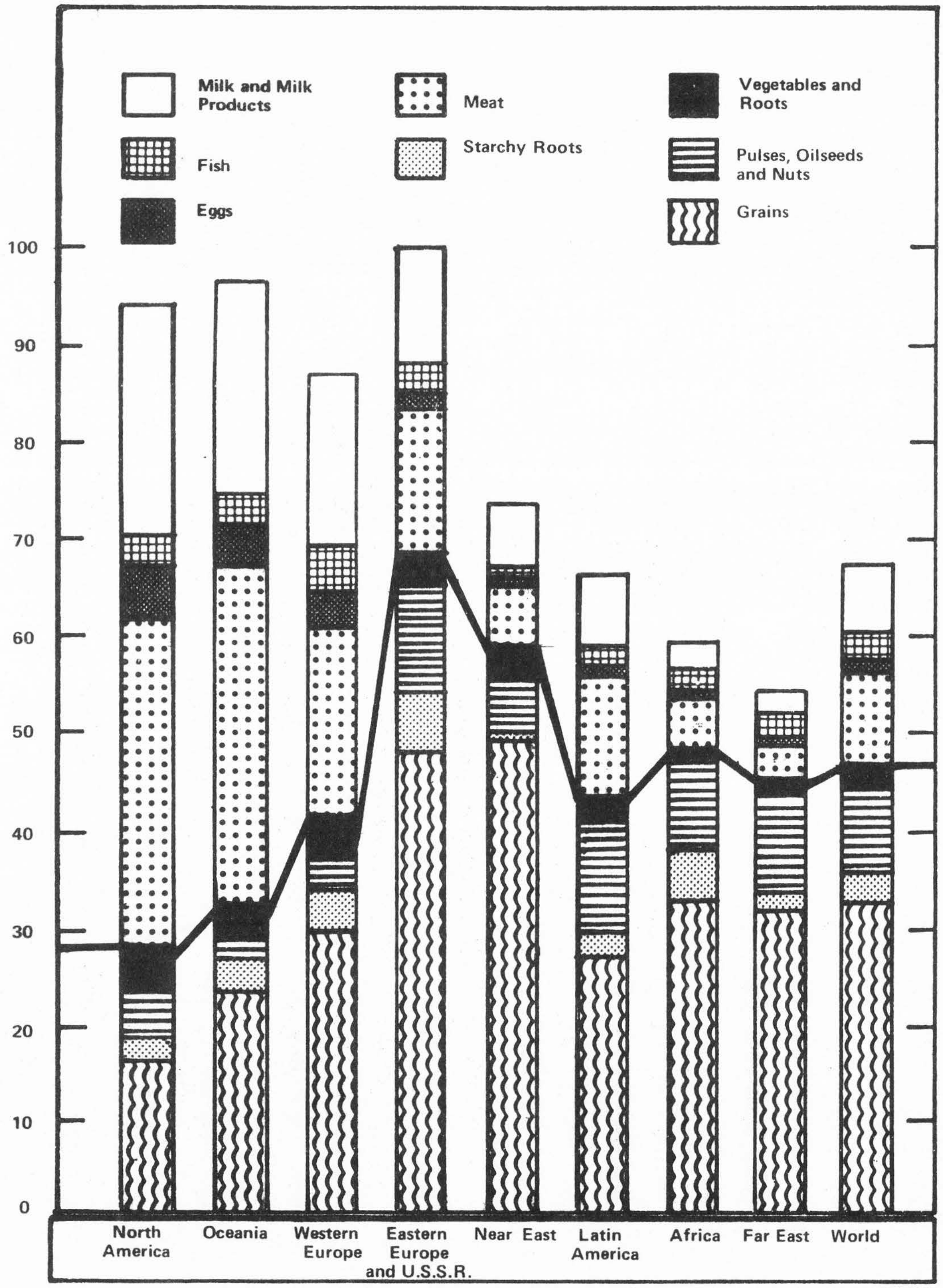

Figure 10. Protein supplies from major food groups (Lives in Peril, 1970, p. 44).

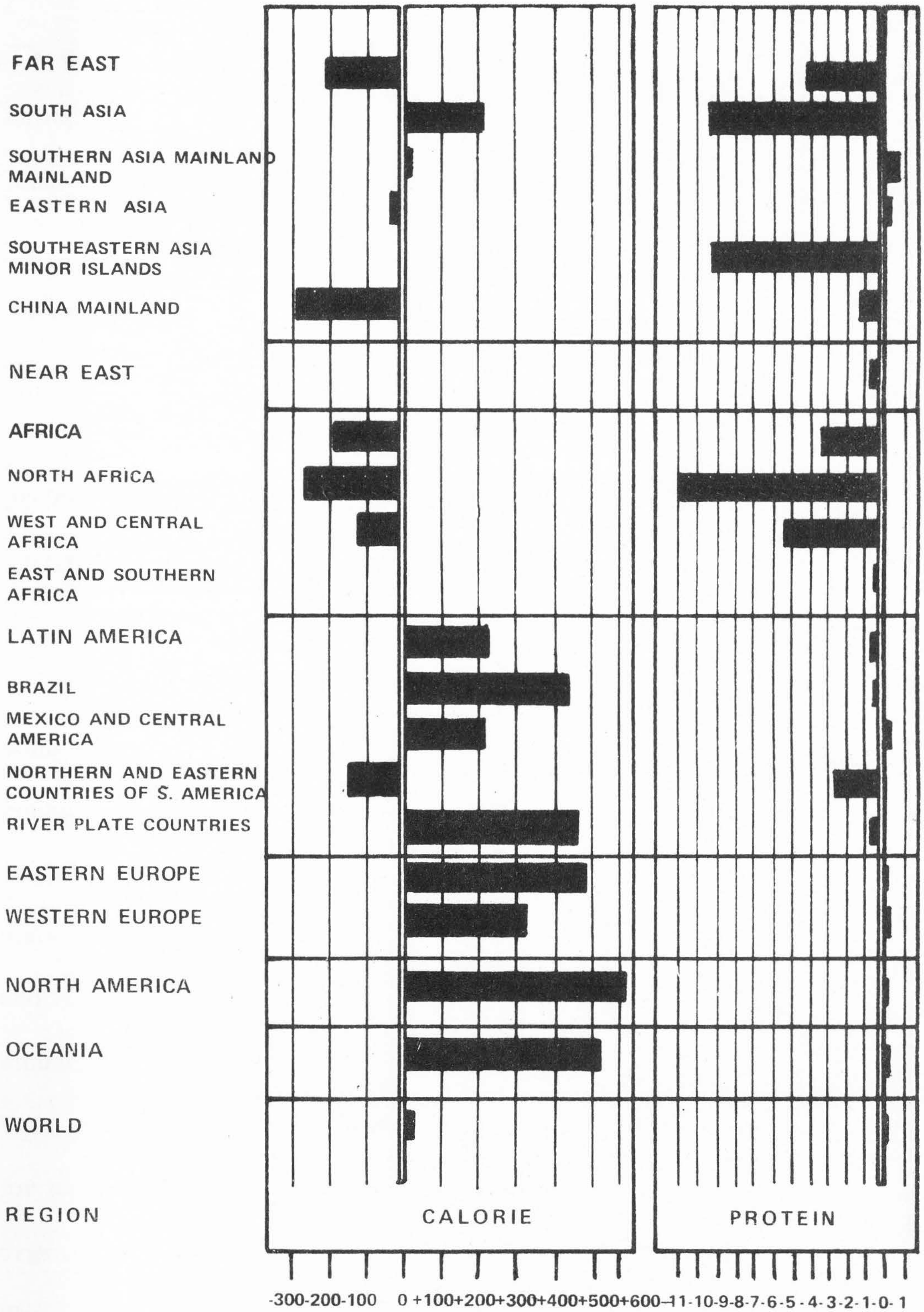

Figure 11. Regional differences between food supplies and needs (in terms of calories and of locally available proteins, assuming protein requirements at 20% above average needs) (Lives in Peril, 1970, p. 42).

Pulses such as beans, peas, and lentils contain 20 to 40 percent protein on a dry weight basis which is three to four times as much protein as do cereals. The use of oilseeds from groundnut, soybean and cottonseed have shown a high nutritional value in many studies and to be perfectly safe for human consumption (Schweizer and Ries, 1969).

To increase yields of milk, egg, cattle and poultry will involve breeding programs, eradication of diseases and pests, and the provision of feed to tide animals over periods of seasonal shortage.

The fish, shellfish, and crustaceans are important sources of animal proteins for those areas near the sea.

Protein Supplements

The long-term solution to malnutrition in most countries will have to come from the local production of appropriate food mixtures, together with the commercial processing necessary to combine them into a high quality protein food for children. A variety of protein rich food mixtures are now available, among them Incaparina in Latin America, Ariac in Nigeria, Fortifex in Brazil, and Superamine in Algeria (Table 10). A soybean drink which adds significant amounts of protein to the diet is being sold in cola bottle by one cola company in Hong Kong (Nick, 1969). Another cola company has developed a soya drink for India. Concentrates of protein from fish, leave, algae, yeast, and micro-organisms have been developed to use as protein supplements (Clark, 1970). The first two products are being used in some countries and are satisfactory but

Table 10. Examples of protein food mixtures[a]

Product	Country	Composition	Protein content (percentage)
Incaparina	Guatemala	maize, cottonseed flour, vitamin A, calcium carbonate	27.5
	Colombia	same--plus defatted soybean flour	27.5
	Mexico	Same--plus defatted soybean flour but without cottonseed flour	27.5
Fortifex	Brazil	maize, defatted soybean flour vitamins, dimethionine, calcium carbonate	30.0
Pronutro	South Africa	maize, skim milk powder, groundnut soybean, fish protein concentrate, yeast, wheat germ, vitamins, niacin, sugar, iodized salt	22.0
Protone	United Kingdom Congo	maize, skim milk powder, yeast vitamins, minerals	22.4
Ariac	Nigeria	groundnut flour, skim milk powder, salts and vitamins	42.0
Lac-Tone	India	groundnut flour, skim milk powder, wheat and barley flour, vitamins, calcium	26.0
Aliment de sevrage	Senegal	millet flour, groundnut flour, skim milk powder, sugar, vitamins, calcium	20.0
CSM	United States	maize (precooked), defatted soybean flour, skim milk powder, sugar, vitamins, calcium	20.0
Supro	East Africa	maize or barley flour, torula yeast, skim milk powder, salt condiments	24.0
Laubima	Middle East North Africa India Pakistan	parboiled wheat, thicken peas, vitamins, minerals, skim milk powder	17

[a]Taken from Lives in Peril, 1970, p. 35.

are expensive. The others have not been acceptable for human consumption (Woodham, 1969).

The Acceptance of New Foods

There are a few obstacles encountered in the acceptance of new foods: unfamiliarity, beliefs and cultural as well as food habits, cost, taste preference, and physiological reactions (Niehoff, 1969). New foods must be properly introduced to be accepted and used as a desirable food. Perception by the individual of the advantage to be gained from making the change is the key to adoption of changes.

Nutrition Education for Changing Food Habits

There is no instinct to guide man in the proper selection of foods which meet the nutritional needs of the body. Each new generation must be taught what foods to select and why and how food affects health. Mothers and housewives are the major targets. It is essential to include: family meal planning to provide nutritionally satisfying meals at least cost; how to buy to get the most nutritive value for the money spent; how to prepare food to preserve nutritive value while appealing to family tastes and considering cooking facilities; safe and sanitary methods of storing, handling and serving food; and the availability of local food programs and how to make the best use of them. Through the improvement of her knowledge, the nutritional status of the whole family will improve.

There are many ways to carry out the education program such as individual contact-home visits; group contact-general meeting, demonstration, group discussion; mass contact-exhibition, tour, campaign, and advertisement-leaflet, picture and chart, movie, radio, television, newspaper, and magazine.

A dynamic nutrition education program that begins in early childhood and continues through the elementary and secondary schools can help young children to acquire positive attitudes toward food selection and prepare them for adult and parental responsibility (Lamb, 1969). The school has an important role in promoting and maintaining the nutritional well-being of the child so that he may learn and function at optimum levels. Its responsibility for this program chiefly involves: health service, classroom teaching, school feeding, parent and community involvement.

Motivation is the key for better learning. A better figure, an improved complexion, and glossy hair are the most attractive motivations of teenage girls for better food selection. For boys, it will be strong physical fitness and muscle mass. A healthy baby is the best gift for the pregnant and lactating women for learning more about the adequate balanced diet.

SUMMARY

In most countries in Africa and in South and East Asia the foods which are produced do not provide adequate diets or in some areas enough food for the population. In most areas, it is not severe shortages of food supplies, it is the inequality of food distribution and the defective quality of the diet. One of the most severe deficiencies is in protein because of the poor quality and imbalanced diets due to lack of nutritional knowledge and ignorance of the special need of large groups of people such as pregnant and lactating women, and children. The solution to this problem is to help these developing countries in techniques to produce more food, make better use of their present food, provide acceptable high protein foods at a reasonable cost, and educate the people with ways to use the principles and modern knowledge of nutritional requirements to obtain better health.

Many methods which are widely used in evaluating the nutritive value of protein are discussed, such as: protein efficiency ratio, nitrogen balance, carcass analysis, nitrogen balance index, depletion and repletion, chemical score, net dietary protein value, net dietary protein calories percent, and other biological methods.

Minimal protein and essential amino acids needs are discussed under various age groups. The suggested protein intake and different provisional amino acid patterns needs are given.

In the United States adequate protein needs for adults should include two or more cups of milk and two or more servings of meats or meat substitutes; for children, two to four cups of milk and two servings of meats or meat substitutes; for adolescents, four or more cups of milk and two or more servings of meats or meat substitutes; for pregnant and lactating women, four to six cups of milk and two or more servings of meat or meat substitutes in a well balanced diet.

In developing countries, meats, egg, milk and dairy products may be unavailable or expensive. Mixtures of vegetable or cereal proteins should be used. Fish, poultry, sheep, goats or other meats are good quality animal protein sources and should be used if available. Oilseed proteins, fish protein concentrates and many other new forms of protein-rich foods should be properly introduced to the developing countries to be accepted and used as desirable foods.

The symptoms and dietary treatments of protein deficiencies and diseases influenced by dietary protein were discussed. Kwashiorkor and/or marasmus are prevalent in certain developing countries owing to their typical cereal diet pattern, poverty and ignorance.

Education of mothers is most important. From the improvement of their knowledge, they learn how to make the best use of their food dollar, how to plan and prepare delicious nutritionally adequate and balanced meals for the family, how to feed children adequately under sanitary conditions. In developing countries, sanitation for storage, preparation and service may be first concepts that are taught as they are very important. The protein needs of many patients with diseases are discussed.

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