18. FEEDING OF INFANT WITH TOASTED FULL FAT SOYBEAN FOODS

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In efforts to improve the nutrition of children in regions of chronic and acute malnutrition, much attention has been focussed in recent years in exploring and experimenting with inexpensive sources of proteins heretofore not customarily used locally in the feeding of children. Various kinds of economical protein-rich plant mixtures have been developed in and for different areas in Africa, South America, South East Asia. This area of research has been reviewed by Scrimshaw and Bressani (1961). The search for high protein foods of plant origin has been spurred by the fact that in many parts of the world where symptoms of malnutrition are most obvious, the climate, farming system, and customs are such that the raising of meat and dairy cows on a large scale is not practical, thus eliminating a major source of animal protein from the local diet. Oftentimes, too, other high quality proteins, such eggs, pork, and poultry, are beyond the daily reach of the lower-income larger segment of the population in these regions.

Much progress has been made and continues to be made through an international exchange of information, with the support and through programs such as those of WHO and UNICEF. But on the whole, it seems that at the same time that nutritional programs of an international scope are being carried out, there has also been a general awareness from the part of investigators everywhere of the importance of maximizing the nutritive quality of local agricultural produces and local diets, to better aim at a greater measure of national self-sufficiency in foods and nutrition.

Furthermore, necessary though it is to join forces on a world-wide scale in effectively applying science and technology to the production of better foods for more people, it is also well to remember that, besides providing nutrients, foods have emotional, cultural, social, and historical meanings as well. The long-term success of devising nutritious diets must thus give due consideration to local traditions and age-old nutritional practices, at the same time that it makes full use of resources available locally at reasonable costs. In principle, in other words, efforts to solve the nutritional problems of any one group of individuals are best carried out without the framework of the way of life of these individuals; in practical terms, if an inadequate diet is to be effectively enriched, the food enrichment must be emotionally and physically acceptable to the people it is given to; it must be within their easy economical reach, and convenient to store and prepare; and it must be compatible with what they are used to.

Regarding the protein nutrition of children in Taiwan, the problems to be solved are not essentially different from that of many other tropical and subtropical localities in the Orient and Africa. But whereas cases of acute malnutrition such as kwashiorkor have caused concern in some African countries, these are very rare in Taiwan. Nutrient deficiencies on the island, proteins included, are

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subliminal and not acute. This means that longrange efforts and programs to remedy chronic, marginal under-nutrition would benefit the people much more than would emergency measures for acute malnutrition. Furthermore, these program must also take into consideration the socio-economic determinants of Taiwan's total development. The feeding of infants, for instance is being markedly affected by the continued industrial growth of the island which results in more women leaving the home to join the labour force in industry and other spheres of social activity. The days when infants were breasted until they were old enough to eat table foods are fast dwindling; the preference now seems to be towards a shortened period of breast-feeding or none at all. And the need then is for inexpensive popular milk substitutes and baby foods.

Plant foods traditionally favored by the Chinese include rice, soybean, and peanut. Next to rice the staple of first choice in China is soybean, which finds itself in one form or another in the daily menu of almost all Chinese, regardless of income and social stratum. As for peanut, it is not only a familiar Chinese food, but it is also a major crop of Taiwan.

Of the three staples mentioned above, the literature on studies of the possibilities of soybean in infant feeding is the most extensive. Long-term infant feeding studies with a soybean preparation were first reported by Tso in 1928 and 1929, and later in more detail by Rittinger, Dembo and Torrey in 1935. In all these studies the milky water extract of soya bean was used. Dean (1952) and Thompson (1955) prepared soya-banana mixtures for the treatment of kwashiorkor with moderate success. In 1960, Kay, Daeschner and Desmond (1960) fed infants successfully from birth to 3 months of age with a heated soya flour, Mull-Soy. More recently, Omans, Leuterer and Cyorgy (1963) reported that a toasted full-fat soyabean preparation, Sobee, supported, better growth both in rats and in infants than soybean water extract preparations like Soyalac and Saridele. Fomon in 1959, and Fomon, Owen, and Thomas in 1964, had critically evaluated the nutritive value of a soya preparation in infants and showed that both nitrogen retention and growth with the soya formula were comparable to those obtained with cow's milk or human milk. However, their feeding period of 38 to 75 days was too short to allow equivocal conclusion as discussed by Omans, Leuterer, and Gyorgy (1963).

Bearing local resources and food habits in mind, Huang, Tung, Leu, Lee and Wei (1967) compared the nutritive value of full-fat soybean-rice formula with cow's milk in infant feeding. Besides being realistic on cultural grounds, a rice-soybean formula also seemed promising from a nutritional standpoint, since the methionine of rice protein could supplement the deficiency of soybean protein in this essential amino acid. Furthermore, rice starch gelatinizes in the heated liquid formula, there by preventing the soybean flour from rapid setting. The soybean-rice food was composed of the following: full-fat soybean flour 45%, pre-cooked rice flour 15%, soybean oil 10%, sucrose 27.5% and salt mixture 2.5%. Two American brands of soya flour were used in separate preparations: ADM (made by the Archer-Daniels Midland Co.) and Wenger (made by the Wenger Co.). When dissolved in water, the soybean-rice mixtures gave baby formulas the compositions of which are indicated in Table 1. Also given in the table is the compositions of Sobee, and American commercial full-fat soya product known to support good growth in children (Omans, Leuterer, and Gyorgy, 1963), and bovine milk.

The two experimental soybean-rice formulas, as well as the two control formulas, Sobee and milk, were fed to 57 infants 1 to 6½ months of age during a controlled period of 6 months. The protein intake of the infants was at a level of 3.5 to 4.5 g per kg body weight per day. Body weight and height of each infant

Table 1. Ingredients of the soya-bean rice formulae.

Ingredients	Percentage
Full-fat soya flour	45
Pro-cooked rice flour	15
Soya oil	10
Sucrose	27. 5
Salt mixture	2. 5

Two kinds of soya flours, ADM and Wenger, were used in separate preparations.

Soya oil was 5 per cent and sucrose, 32.5 per cent during the first 6 months of the study.

Calcium phosphate dibasic, 80.7 per cent, sodium chloride, 18.8 per cent, ferrous sulfate, 0.47 per cent and potassium iodate, 3.2 per cent.

were plotted against age at half-month intervals. The growth curves of the male infants fed with the ADM formula are show in Fig. 1. Included in the subjects were a pair of identical twin boys and a pair of identical twin girls (Fig. 3) one twin in each set served as the milk-fed control. Fig. 4 shows the body weight curves of babies whose diet was changed from cow's milk to soya-rice formula or vice-versa.

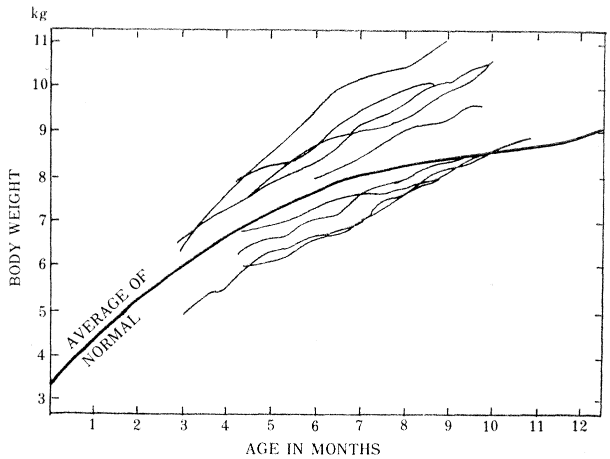


Fig. 1.

5-day nitrogen balance studies were conducted with 8 infant boys; 2 on milk, 3 on ADM, and 3 on Wenger. Results are shown in table 4.

Statistical analysis of the data indicated that infants on soybean-rice formula and Sobee gained at rates comparable to those attained by Milk-fed infants. Blood analytical data (Table 2, 3) showed no appreciable difference between test and control groups concerning hemoglobin, hematocrit, serum total protein, albumin, phosphorus, and blood urea. A slightly higher serum cholesterol level was noticed in the cow's milk group. The authors concluded that the soybean-rice formula could be used safely as milk substitute in infant feeding.

Table 2. Hemoglobin levels and hematocrit values

Group	On admission (Hb, gm/100 ml)	3 months later (Hb, gm/100 ml)	6 months later (Hb, gm/100 ml)
	M S.D.	M S.D.	M S.D.
ADM	11.5±0.98 (16)	12.2±1.20 (16)	12.5±1.02 (13)
Wenger	11.7±1.62 (16)	12.4±1.38 (16)	12.9±1.19 (14)
Sobee	11.4±1.27 (8)	12.4±0.69 (8)	12.7±0.76 (8)
Cow's milk	11.7±1.08 (11)	12.4±0.86 (11)	12.4±1.22 (11)
	(Ht, %)	(Ht, %)	(Ht, %)
	M S.D.	M S.D.	M S.D.
ADM	32±2.6 (16)	34±2.0 (16)	36±3.3 (13)
Wenger	33±4.5 (16)	36±3.9 (16)	37±3.6 (14)
Sobee	31±5.1 (8)	34±4.4 (8)	36±2.9 (8)
Cow's milk	32±4.2 (11)	34±4.4 (11)	34±3.8 (10)

Figures in parentheses are the numbers observed.

Table 3. Serum total protein and albumin levels

Group	On admission	6 months labumin	
	Total Protein (gm/100 ml)	Total Protein (gm/100 ml)	Albumin (gm/100 ml)
	M S.D.	M S.D.	M S.D.
ADM	5.87±0.58 (16)	6.30±0.37 (13)	4.23±0.29 (12)
Wenger	6.16±0.56 (16)	6.44±0.33 (14)	4.32±0.30 (11)
Soobee	6.00±0.41 (8)	6.50±0.52 (8)	4.45±0.22 (6)
Cow's milk	6.08±0.55 (11)	6.17±0.44 (10)	4.17±0.49 (8)

Figures in parentheses are the numbers observed.

It was established by Hayward and Hafner (1941) that the first limiting amino acid of soya bean protein is methionine as determined with chicks and rats. It was also shown in children that supplementation of processed soya flour diet with methionine increased its biological value (Parthasarathy et al., 1964). However, at the protein level actually taken by the infants of this study, 3.5 to 4.5 g. per kg. per day, the methionine or total sulphur-containing amino acide intake is likely to be adequate for the infant's need. Rice in the formula contributes 5 per cent of the total protein. When the protein intake is 4.0 g. per kg., either of the soya-rice formulae supplies 55 mg. per kg. of methionine which is higher than the suggested minimal requirement for infants of 45 mg. per kg. (Holt et al., 1960). Fomon et al. (1964) reported that 1.5 to 1.9 g. of soya protein per kg. body weight was enough to give normal nitrogen retention and also support normal growth in their subjects of 60 to 102 days of age. However, Graham (1964) observed signs of protein deficiency in his infants when 1.75 g. per kg. of soya protein was the sole source of dietary protein. From the view point of safety and also for the easiness of feeding, the protein content of the liquid soya-rice formulae was set at a 3.3 per cent level. When the amount of soya flour was reduced and rice flour was reduced and rice flour increased, the liquid formula was too thick to be fed easily. The authors consider, however, that this technological problem can be solved

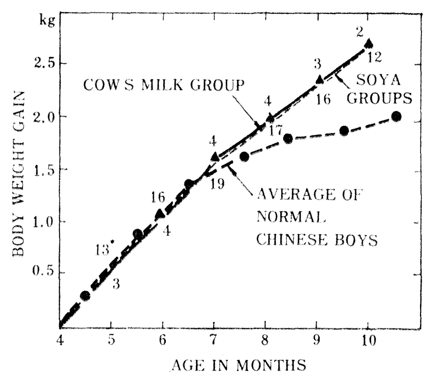
Table 4. Daily metabolic balances of nitrogen

Subject and group	Age days	Body Weight (g)	Daily balance of nitrogen				Apparent digestibility
			Intake	Output	Retention		
			(mg/kg)	(mg/kg)	(mg/kg)	(% intake)	(%)
ADM							
K.C.	221	7, 750	638	468	170	27	81
	256	8, 150	557	436	121	22	83
L.W.	273	10, 100	525	394 (12)	131	25	87
R.C.	307	8, 610	549	432 (15)	117	21	83
Wenger							
W.P.	266	9, 000	557	390	167	30	79
	300	9, 210	570	467 (23)	103	18	75
S.C.	265	9, 155	631	429 (15)	202	32	87
	292	9, 820	504	402 (12)	102	20	82
T.C.	305	7, 380	690	544 (10)	146	21	88
Milk							
S.K.	256	8, 520	559	373	186	33	84
C.Y.	305	8, 205	630	505 (13)	125	20	92
	318	8, 260	556	434 (12)	122	22	90

Nitrogen output includes dermal losses which are shown in the parentheses.
Dermal loss was not measured and was assumed to be 20 mg/kg (Joint FAO/WHO Expert Group 1965).

by adding amylase to the mixture and that the formulae might be fed safely at a level of 2.5 to 3.0 g. of protein per kg. of body weight.

Growth of the infants was affected occasionally by upper respiratory infections accompanied by fever and/or loose stools and by diarrhoea. In spite of this, the monthly body weight gains of the soya-rice babies from 7 to 10 months of age surpassed those of the average normal Chinese infants of the same ages. This fact indicates the adequacy of the test formulae in infant feeding. Comparison of the monthly body weight gains, however, has a disadvantage in that it does not show



* Figures are the numbers of subjects observed.

Fig. 2.

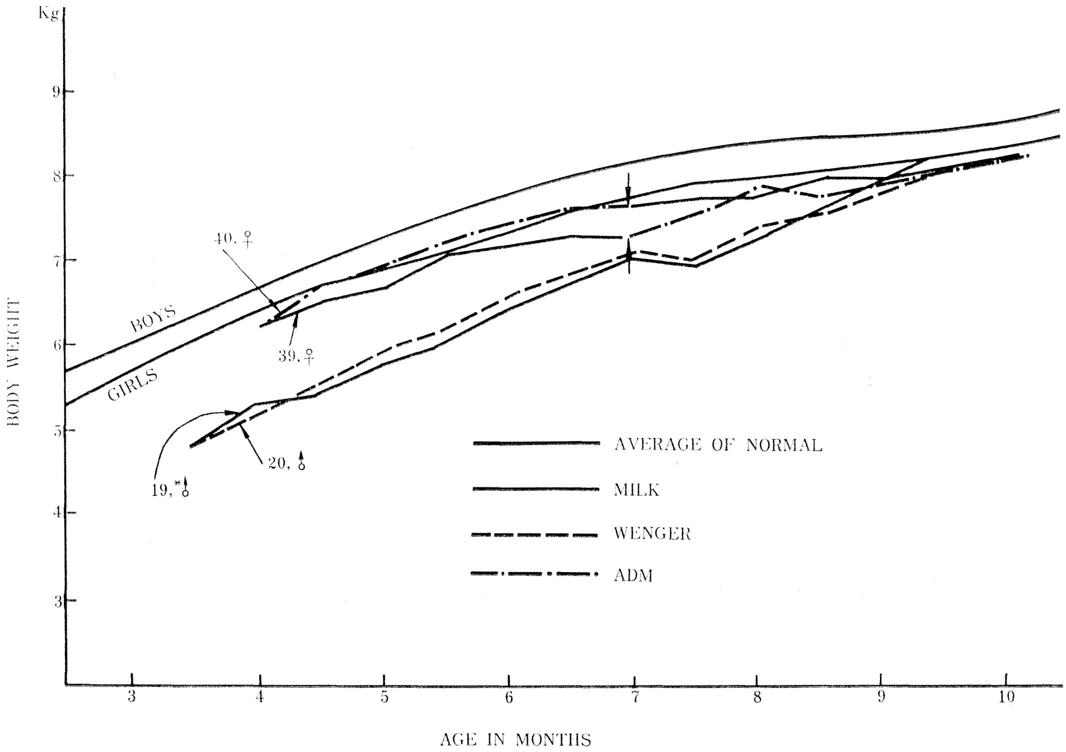


Fig. 3.

the actual body weights. This shortcoming is covered by the individual growth curves shown in Fig. 2, ADM boys showed a better growth than did the Wenger boys, although such a tendency was not seen in girls. The authors suspect that the ADM formula tastes better than the Wenger formula. This might be the reason for the better growth achieved by ADM boys, since the PER and FER of both diets were about the same for these infants. It is not clear however, whether there is really a sexual difference in acceptability of the ADM soya-rice formula.

Omans et al. (1963) showed higher serum phosphorus and cholesterol levels in cow's milk fed infants than in those fed with soya diets. However, our soya formulae were supplemented with phosphorus, and thus the serum phosphorus values of the soya infants were not lower than those of milk-fed infants.

Shepard et al. (1960) and Ripp (1961) reported the development of goiter in infants fed with Mull-Soy or Soyalac which was not supplemented with iodine. Our soya-rice preparations were fortified with iodine and no goiter was observed.

Stools were rather bulky on the soya-rice formulae compared with those of milk-fed infants. Perianal dermatitis, generally mild, was a frequent complication encountered during the early period of feeding. This is the only disadvantage found with the soya-rice diets. Incidence of diarrhoeal episodes encountered during the study was about the same in all groups.

Next, Huang and Tung (1968b) experimented with peanut in the feeding of infants and young children. For although soybean-rice was shown to be a nutritious plant mixture, the production of soybean in Taiwan is nevertheless much less than the domestic needs. On the other hand, the annual production of peanut in

Taiwan is approximately 87,550 tons, or 128,817 tons with hulls (Taiwan provincial Food Bureau, 1966), which is nearly self-sufficient. About half of this quantity is used for peanut oil production, the main edible oil of the people in Taiwan. A by-product of the oil industry is a low-fat peanut meal or cake left over after the oil had been pressed out of the peanuts. This residue is particularly high in protein. However, its protein efficiency ratio (Buss and Goodard, 1948) and biological value are rather low, because of its insufficiency in sulfur containing amino acids, especially methionine (Rutgers University, 1946–1950). If fed at a high protein level, however, its nutritive value becomes close to that of soybean protein or even casein (Breese Jones and Widness, 1946). It has been introduced into various foods in India, and shown to have good supplementary value to cereal diets (Subrahmanyan, Murphy, and Swaminathan, 1954; Doraiswamy, Parthasarathy, Tasker, Sankaran, Rajagopalan, Swaminathan, Screenivasan, and Subrahmanyan, 1962). In a peanut-soybean-rice mixture, the resulting amino acid balance would in principle have a higher biological value than either peanut or rice protein alone: Rice is limiting lysine but not deficient in sulfur containing amino acids whereas soybean contains enough lysine to at least supplement peanut, the second limiting amino acid of which is lysine.

Huang and Tung (1968a) tested the nutritive value of soybean-peanut-rice (SPR) mixtures in controlled feeding experiments lasting 2.5 to 6 months, using 18 male and 6 female infants 2 to 7 months old as subjects. The approximate ratio of soybean, peanut, and rice was 2:1:1 in mixtures. Amino acid content of the SPR mixtures was calculated to be as follows: total sulfur containing amino acid, 186 mg; lysine, 347 mg; threonine, 229 mg. per g. of total nitrogen. Lysine and threonine were thus no longer deficient in this mixture, and the total sulfur containing amino acids were only slightly below standard, if judged by the standard value of 190-220 mg. per g. total nitrogen recommended by the 1965 FAO/WHO group of experts (WHO Technical Report Series, No. 301, 1965).

The baby formula made from it was prepared as follows: Wenger rady-made

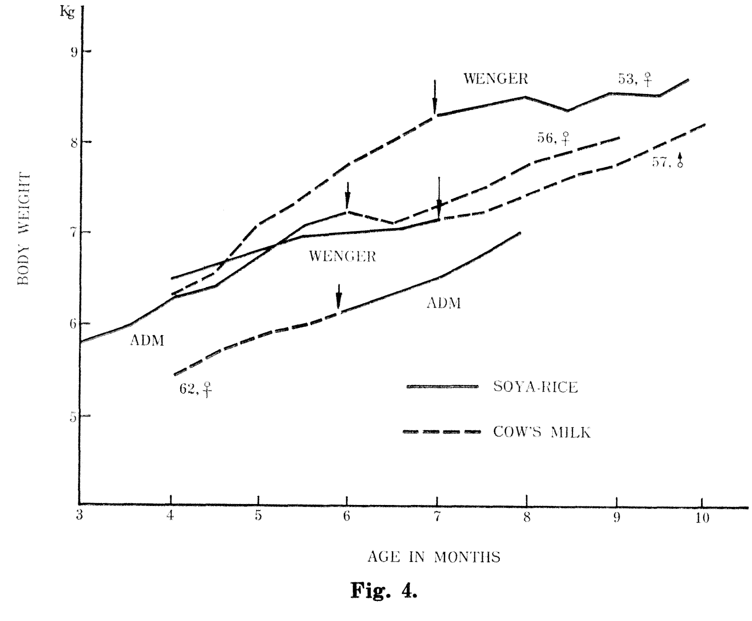


Fig. 4.

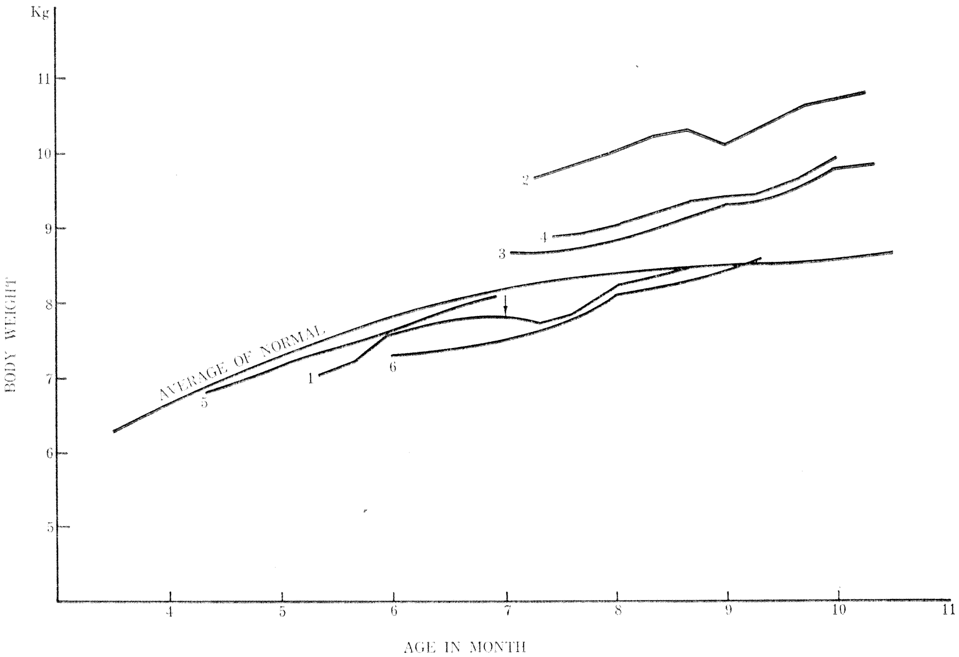


Fig. 5.

soybean-peanut-rice mixture 80%; peanut oil, 10%, sucrose, 7.5% salt mixture 2.5%, and vitamin mixture 0.1%. 200 g. of this mixture was boiled in 1000 ml. of water. The liquid formula so obtained provided 2.6 g. protein, 4.0 g. of fat and 84 Kcal per 100 g. The formula was tasty, had characteristic but mild peanut flavor, and was well accepted by the infants. The experimental babies grew well, compared to healthy breast-fed babies (Fig. 5).

Hemoglobin, total serum protein, and blood urea nitrogen levels of the subjects were all within normal ranges at the end of the feeding period. Thus, as was the case with the soybean- rice formulas, clinical as well as growth and nitrogen balance data concurred in indicating that the soybean-peanut-rice mixture constituted a plant food adequate in supporting the normal development of infants.

For many centuries Chinese have used varieties of soya bean products in their daily diets. However, the use of soya foods in infants feeding, even in the form of "soya milk", has been quite limited. Most of the pediatricians as well as the mothers have little familiarity with, or are convinced of, the value of soya preparations in the feeding of babies. It is hoped that the results of this study will be acknowledged and that the economic soya-rice formulae will be used in daily practice of infant feeding when cow's milk can not be afforded. The formulae can be used as the entire diet or as a supplementary food.

Discussion

G. W. E. Fernando, Sri Lanka: Is soya milk widely used in Taiwan for feeding infants?

Answer: Infants feeding with soya milk is quite limited in Taiwan.

S. Matsuura, Japan: How much is the protein consumption in Taiwan per capita per day?

Which per cent comes from vegetable source and animal source?

Answer:

	1953	1961	1965	1970
Protein consumption (g. per capita per day)	53.4	60.3	61.2	72.2
Vegetable protein (%)	40.9	44.5	43.6	48.9
Animal protein (%)	12.5	15.8	17.6	23.2

T. Watanabe, Japan: What about the digestibility; or nutritive value of full fat soybean, compared with soybean milk?

Did you try to use sesame seed as a supplement of methionine?

Answer: The digestibility of protein in full fat soybean is 85%. There is no difference from those of soybean milk. The pattern of essential amino acids of full fat soybean is better balanced than those of soybean milk.

J. Fukui, Japan: What does the mixture of soybean and banana mean? Does banana compensate any kind of nutrient?

Answer: I don't have any exact idea on the mixture of soybean and banana.

N. Kaizuma, Japan: I have heard your prpesentation with great interest. According to your paper, soya and peanut flour were used. Do you think which is more promissing, soya or peanut, in the standpoint of infant nutrition improvement?

Answer: Soya is more promissing from the standpoint of infant nutrition because the amino acids of its protein is better balanced.

P. P. Kurien, India: 1) What is the percentage of destruction of amino acids, particularly lysine, during toasting?

2) Was the calorie intake adequate?

3) Have you fortified the diet with vitamines?

4) What is the comparative cost between the skim-milk and soya milk diets?

5) How does the amino acid made of these diets compare with FAO reference protein protein patterns?

Answer: 1) The data is not yet available.

2) Yes. The liquid formula shows 68 Cal. per 100 cm.

3) Yes. It was fortified with vitamins.

4) 2 (skim milk): 1 (soya milk)

5) Very similar

Arwooth N. L., Thailand: 1) Could menthionine be artificially produced on the commercial scale?

2) If so, what is the precaution to prevent it from being destroyed in the cooking process?

3) Would you give the name of crops rich in menthionine commonly grown in Southeast Asia?

Answer: 1) Yes.

2) Nothing particularly.

3) Sesame.

References

1. Breese Jones, D. and Widness, K. D.: J. Nutrition, 31: 675, 1946.
2. Buss, L. M. and Goddard, V. R.: Food Res. 13: 506, 1948.
3. Dean, R. F.: Brit. Med. J., 2: 291, 1952.
4. Doraiswamy, T. R., Parthasarathy, H. N., Tasker, P. K., Sankaran, A. N., Rajagopalan, R., Swaminathan, M., Screenivasan, A. and Subrahmanyan, V.: Food Sci., 11: 186, 1962.
5. Famon, S. J.: Pediatrics, 24: 577, 1959.

6. Fomon, S. J., Owen, G. M. and Thomas, L. N.: Am. J. Diseases Children, 108: 487, 1964.
7. Huang, P. C. and Tung, T. C.: J. Form. Med. Assoc., 67: 19, 1968a.
8. Huang, P. C. and Tung, T. C.: J. Form. Med. Assoc., 67: 57, 1968b.
9. Huang, P. C., Tung, T. C., Lue, H. C., Lee, C. Y. and Wei, H. Y.: J. of Tropical Pediatrics and African Child Health, 13: 27, 1967.
10. Kay, J. L., Daeschner, C. W. and Desmond, M. M.: Am. J. Diseases Children, 100: 246, 1960.
11. Omans, W. B., Leuterer, W. and Gyorgy, P.: J. of Pediatrics, 62: 98, 1963.
12. Rittinger, F., Dembo, L. H. and Torrey, G. G.: J. Pediatrics, 6: 517, 1935.
13. Rutgers University. Bureau of Biological Research.: Comparative Determination of the Amino Acid Content and of the Nutritive value of 6 selected protein food source, (1946–1950).
14. Scrimshaw, N. S. and Bressani, R.: Fed. Proc., 20(1): 80, 1961.
15. Subrahmanyan, V., Murphy, H. B. N. and Swaminathan, M.: Brit. J. Nutr., 8: 1, 1954.
16. Thompson. M. D.: Brit. Med. J., 2: 1366, 1955.
17. Tso, E.: Chinese J. Physiology, 2: 33, 1928.
18. Tso, E.: Am. J. Physiology, 90: 542, 1929.