DEVELOPMENT, ACCEPTABILITY, AND NUTRITIONAL EVALUATION OF HIGH-PROTEIN SOY-SUPPLEMENTED RICE NOODLES FOR THAI CHILDREN[1]

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ABSTRACT

Dehydrated rice noodles, supplemented with 20 and 30% full-fat soy flour (dry basis), were developed for use in feeding programs at Child Nutrition Centers in Thailand. In addition, 20 and 30% soy-rice noodles containing 0.2 and 0.3% dl-methionine (dry basis), respectively, were prepared. Their acceptability was tested by feeding samples to 197 Thai preschool children. Nutrient content and protein quality were determined by chemical and biological procedures. Soy-rice noodle consumption was not significantly different ($P < 0.01$) from that of regular (control) rice noodles. The 20 and 30% soy-rice noodles contained 15.0 and 18.0% protein on a moisture-free basis, respectively; the control contained 7.8% protein. Soy-supplemented (30%) rice noodles contained approximately eight times the α-tocopherol, twice the thiamin, twice the riboflavin, five times the pyridoxine, twice the vitamin B-12, twice the niacin, three times the folic acid, four times the calcium, twice the iron, twelve times the magnesium, and three times the phosphorus content that regular rice noodles contained. Protein efficiency ratios were 2.17, 2.53, 2.56, 2.68, and 3.03 for the regular, 20% soy-rice, 30% soy-rice, 20% soy-rice plus methionine, and 30% soy-rice plus methionine noodles, respectively, based on 2.50 for standard casein. Net protein utilization values for 30% soy-rice (with and without methionine) noodles were superior to those for regular noodles and not significantly different ($P < 0.05$) from those for casein. Subjective evaluations of noodles stored 5 months indicated no detrimental changes in quality. Protein costs of soy-rice noodles were substantially less than those for regular rice noodles.

Childhood protein malnutrition, a recognized major global problem, concerns many. It is resulting in increased illnesses, a high mortality rate, and impaired physical and mental growth among children in many countries (1–5). In Thailand, where protein deficiency in the diet of children 1 to 5 years old is an increasing problem in both urban and rural areas, kwashiorkor and other forms of protein-deficiency diseases have been diagnosed (6–8).

New high-protein food items readily adaptable to the Thai dietary pattern, easy to prepare, suitable for child feeding, and highly acceptable may be significant in promoting good nutrition essential for good health for those children. Fortifying traditional rice noodles (*senlek*), consumed throughout Thailand by people of all ages and economic status, by adding full-fat soy flour provides a new high-protein food in a familiar form. Dehydrated soy-rice noodles lend themselves to use at Child Nutrition Centers, where they can be incorporated easily into Thai noodle dishes. In addition, as a low-moisture food, they have long shelf-life and can be easily handled during transport.

A high-protein product was developed by supplementing rice noodles with soy flour and then evaluated.

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MATERIALS AND METHODS

Noodle Preparation

Five noodle samples were prepared in the traditional manner at a Bangkok noodle factory. By use of full-fat soy flour, 20% soy, 30% soy, 20% soy plus 0.2% dl-methionine, and 30% soy plus 0.3% dl-methionine, noodles were formulated (dry basis) as shown in Table I. Regular rice noodles served as controls. Stone-ground broken rice was used to prepare aqueous rice-flour suspensions into which soy flour, methionine, and cassava flour were incorporated. The soy flour used was Kaset full-fat soy flour, prepared semicommercially by the Institute of Food Research and Product Development (IFRPD), Bangkok, by the procedure described by Bhumiratana and Nondasuta (9). The proximate analysis of this soy flour has been reported (9) to be 3.2–4.8% moisture, 40–49% protein, 21–23% fat, 4.3–5.1% ash, and 2.2–3.0% fiber. Cassava flour was obtained locally in Bangkok and food-grade dl-methionine was supplied by IFRPD from a Japanese manufacturer. Rice-flour suspensions were commercially prepared at a Bangkok noodle factory from locally purchased broken rice (Indica variety, short grain, 10–12% moisture).

A standard noodlemaking machine (in which the suspension passes through a steam tunnel on a metal belt) was used to form gelatinized noodle (rice and soy-rice) sheets. After they were air-dried for approximately 5 hr, the semidehydrated sheets were cut into noodle strips, which were subsequently air-dried for another 5 hr. Dehydrated noodles (1-kg portions) were placed in polyethylene bags (0.002 in. thick), packed two to a cardboard carton, and sealed for shipping to Child Nutrition Centers and for using in future laboratory studies.

Storage Studies

Samples of dehydrated soy and regular rice noodles, previously bagged in polyethylene and sealed in cartons, were stored 5 months at temperatures and

TABLE I
Formulations of Soy-Rice Suspensions and Composition of Soy-Rice Noodles

Ingredient	20% Soy	30% Soy	20% Soy plus dl-Methionine	30% Soy plus dl-Methionine
A. Soy-rice suspension				
Rice-flour (42% solids) suspension (ml)	35,040	30,660	35,040	30,660
Full-fat soy flour (g)	4,000	6,000	4,000	6,000
Cassava flour (g)	184	276	184	276
dl-Methionine (g)	0	0	37	55
Water (ml)	8,440	12,660	8,440	12,660
B. Soy-rice noodle[a]				
Rice flour	79.2	69.0	79.0	68.7
Full-fat soy flour	19.8	29.5	19.8	29.5
Cassava flour	1.0	1.5	1.0	1.5
dl-Methionine	0	0	0.2	0.3

[a]% dry basis.

relative humidities nearly equal to those of outdoor conditions. Temperatures (°C) and relative humidities (%) were recorded daily on weekly climatic graphs by a recording instrument.

Moisture content in the stored samples was determined initially and at 15(±2)-day intervals. Representative 25-g samples were ground in a Waring-type blender at medium speed for 1 min; duplicate 2-g aliquots were transferred to tared weighing dishes, covered, dried in an air oven for 1 hr at 130 ± 3° C, cooled in a desiccator, and weighed. Percentage of moisture in the samples was calculated from weight loss (10).

A taste panel (untrained) comprised of 11 Thai females (approximate age range, 20–50 years) evaluated stored noodles (regular and soy-rice) with and without methionine fortification; a 9-point hedonic scale was used to measure product preferences (11). Quality factors scored included appearance, color, flavor, and texture. A score for overall acceptability was determined by averaging the quality-factor scores.

Product Costs

Consumer costs for each of the five dehydrated samples were calculated, based on these Bangkok retail prices (cents per pound, September 1, 1973): broken rice, 4.3; full-fat soy flour, 13.9; cassava flour, 7.7; and dl-methionine, 197.7. Product costs were also calculated as cost per pound of protein, with allowances for carbohydrate and fat contents.

Acceptability

One hundred and twenty-five preschool children (average age: 4.5 years) from lower-income families attending two Child Nutrition Centers in Chiang Mai Province, Thailand, participated in acceptability feeding studies. Soy-rice noodles, with and without methionine, and regular rice noodles (control) were fed in traditional Thai dishes on an alternating schedule once a week for 20 weeks; *i.e.*, each of the five noodle samples was fed four times during the test period. Noodle consumption, as an indicator of acceptability, was observed and recorded. Data were reported in four categories:

Category	*Observed noodle consumption*
1	None
2	Some
3	All
4	Extra portions requested

The amount of noodles remaining on each child's plate was observed visually and recorded as 0, 1/4, 1/2, 3/4, and 4/4 (all) of the initial serving. All fractional amounts of uneaten noodle portions were grouped together into category 2 (some) for final tabulation and data reporting. The percentage of children requesting additional servings of noodles was also recorded.

Seventy-two preschool children (average age: 3.5 years) from upper-income families attending the Kasetsart University Nursery School in Bangkok participated in the studies during a 10-week period. Each of the five noodle samples was fed twice during the test period. Noodle consumption, determined by weighing the initial amounts of noodles and any remaining after the meal, was recorded in four categories, based on the percentage of initial serving eaten:

Category	*Per cent of initial serving consumed*
1 - None	< 10
2 - Some	10–90
3 - All	> 90
4 - Extra portions requested	> 100

Nutritional Evaluation

Dehydrated soy-rice noodles (some with methionine fortification) and regular dehydrated rice noodles (control) were subjected to proximate, vitamin, mineral, and amino acid analyses by WARF Institute (Madison, Wis.). Proximate analyses for protein, moisture, ash, fiber, fat, and carbohydrate were determined according to official ADAC methods (10). Caloric values were determined using Atwater factors: protein, 4.0 kcal/g; fat, 9.0 kcal/g; and carbohydrate, 4.2 kcal/g (12). Vitamin and mineral assays were conducted as outlined in published procedures (10,13–19). The amino acid pattern in samples was determined using an amino acid analyzer (20). Methionine, cystine, and tryptophan contents were determined microbiologically (21). Chemical score was calculated from essential amino acid patterns using the FAO reference protein (12).

Nutritional value of noodles was evaluated biologically, using experimental animals, by WARF Institute. Two parameters were used to calculate protein quality: protein efficiency ratio (PER) (10) and net protein utilization (NPU) (22). In PER studies, 10 male, albino, 21-day-old, Sprague-Dawley rats per group per sample were fed *ad libitum* during a 4-week period on a 7.1% protein diet; the rations contained sucrose, oil, fiber, and adequate amounts of vitamins and minerals for optimum rat growth. Food consumption by and weight gain of the rats were recorded. NPU was determined according to the method described by Miller and Bender (22) during a 10-day feeding study using five animals per group per sample on a 7.1% protein diet. NPU and PER values were compared to casein at the same protein level in the diet.

RESULTS AND DISCUSSION

Storage Studies

Regular rice noodles and soy-rice (20–30%) noodles were stored for 5 months under atmospheric conditions; average temperature during storage was 29.6° C (successive monthly averages 30.4°, 29.9°, 29.7°, 29.2°, and 28.9° C) and average relative humidity, 79.8% (successive monthly averages 76.1, 80.1, 79.4, 80.4, and 83.1%).

Moisture contents of noodle samples, as determined initially and at 15(±2)-day intervals, are illustrated in Table II. Moisture content increased in both regular and soy-rice noodles. In stored cereal products, moisture uptake depends on relative humidity (which was high), corresponding to the amount of water vapor in the atmosphere (23). All samples reached maximum moisture content when stored for 105 days. Regular, 20% soy-rice, and 30% soy-rice noodles had maximum moisture contents of 14.0, 12.7, and 12.1%, respectively. Moisture uptake by soy-rice noodles was less than that for regular samples.

Quality changes in appearance, color, flavor, and texture in stored noodles were scored once a month by an 11-member adult taste panel. Mean scores (Table III) were derived from a score sheet based on a 9-point hedonic scale. The mean scores for regular rice noodles were higher than those for soy-rice noodles for every quality factor at all storage times, indicating the adult panel preferred the regular product. The quality factor for soy-rice noodles closest to that for regular rice noodles was texture.

Statistical evaluation (AOV) of the differences among storage times for each product and quality factor (determined for $P < 0.05$) indicated no interaction between each quality factor and storage time; *i.e.*, each quality-factor score for each product was not significantly different at any storage time. The adult taste panel, though preferring regular rice noodles to soy-rice noodles, did not detect changes in appearance, color, flavor, texture, and overall acceptability for each product during the storage period.

Product Costs

Retail prices and relative costs of protein in regular and soy-rice noodles, compared with beef and pork costs, are listed in Table IV. Protein costs adjusted for NPU indicate the actual costs for protein used during normal metabolic processes. Although adding soy flour resulted in a higher price for products,

TABLE II
Moisture Contents (%) of Dehydrated Rice Noodles Stored 5 Months

	Storage Time (Days)										
Sample	**0**	**15**	**30**	**45**	**60**	**75**	**90**	**105**	**120**	**135**	**150**
Regular (control)	10.8	12.3	12.7	13.2	13.2	13.3	13.9	14.0	13.0	13.4	12.8
20% Soy	9.5	10.4	11.4	12.2	10.9	12.7	11.9	12.7	11.8	12.1	11.8
30% Soy	8.5	9.9	9.0	10.6	11.7	11.7	11.4	12.1	11.1	11.4	11.0

TABLE III
Taste Panel Evaluation[a] of Dehydrated Rice Noodles Stored 5 Months

	Quality Factors				
Noodle Sample	**Appearance**	**Color**	**Flavor**	**Texture**	**Average**
Regular	7.9 ± 0.08	8.0 ± 0.07	7.4 ± 0.15	6.6 ± 0.14	7.5 ± 0.06
20% Soy	5.8 ± 0.14	5.8 ± 0.11	5.5 ± 0.20	5.9 ± 0.17	5.8 ± 0.14
20% Soy + met[b]	5.7 ± 0.10	5.6 ± 0.09	5.3 ± 0.07	5.8 ± 0.20	5.6 ± 0.08
30% Soy	5.1 ± 0.20	4.9 ± 0.12	4.7 ± 0.22	5.1 ± 0.22	5.0 ± 0.17
30% Soy + met[b]	5.8 ± 0.15	5.7 ± 0.16	5.0 ± 0.17	5.6 ± 0.16	5.6 ± 0.13

[a]Eleven-member adult panel. Average scores (means) and standard errors of means for 5 months reported using a 9-point hedonic scale: 1 = extremely bad, 9 = extremely good.
[b]The 20 and 30% soy-rice noodles were fortified with 0.2 and 0.3% dl-methionine, respectively.

TABLE IV
Cost of Protein in Dehydrated Rice Noodles

Product	Retail Product Cost[a] per lb cents	Protein Cost per lb of Product[b] cents	Net Cost per lb of Protein cents	Protein Adjusted Cost for NPU[c] per lb cents
Dehydrated rice noodles				
Regular	6.4	1.8	23.1	53.7
20% Soy	8.3	2.9	19.3	47.1
30% Soy	9.3	3.6	20.0	36.4
20% Soy + met[d]	8.7	3.3	22.0	46.8
30% Soy + met[d]	9.9	4.2	23.3	43.2
Casein	65.0	65.0	74.7	103.8
Beef	45.4	25.6	58.4	87.2
Pork	50.0	22.1	107.8	189.1

[a]Based on local ingredient and production costs (except for imported casein) in Bangkok (September 1, 1973).
[b]Calculated from retail product cost after allowing for carbohydrate (based on broken rice, 4.3 cents per lb) and fat (based on vegetable cooking oil, 36.0 cents per lb) contents using the least expensive Thai source of these nutrients.
[c]NPU values for dehydrated rice noodles and casein from Table VIII; for beef and pork from reference 24.
[d]The 20 and 30% soy-rice noodles were fortified with 0.2 and 0.3% dl-methionine, respectively.

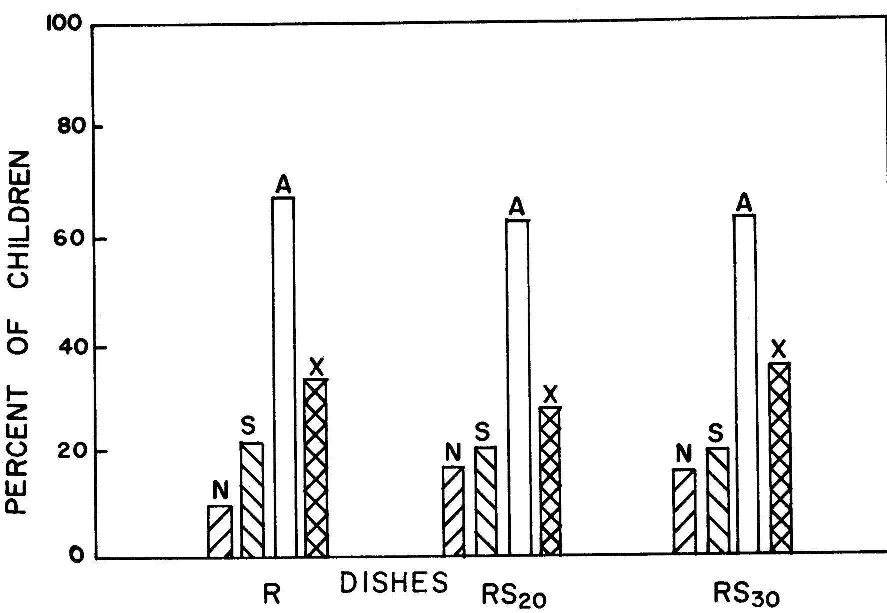

Fig. 1. Consumption of control rice (R), 20% soy-rice (RS_{20}), and 30% soy-rice (RS_{30}) noodle dishes by preschool children at the Child Nutrition Center in Ban Yang Village. N = none, ▨ ; S = some, ▧ ; A = all, □ ; X = extra portions, ☒

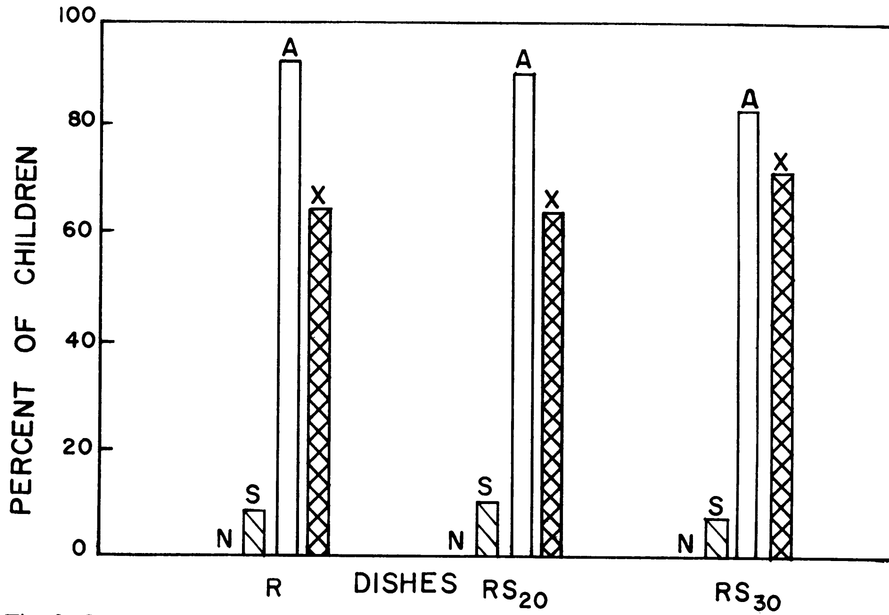

Fig. 2. Consumption of control rice (R), 20% soy-rice (RS_{20}), and 30% soy-rice (RS_{30}) noodle dishes by preschool children at the Child Nutrition Center in Ban Mai Village. Legend same as Fig. 1.

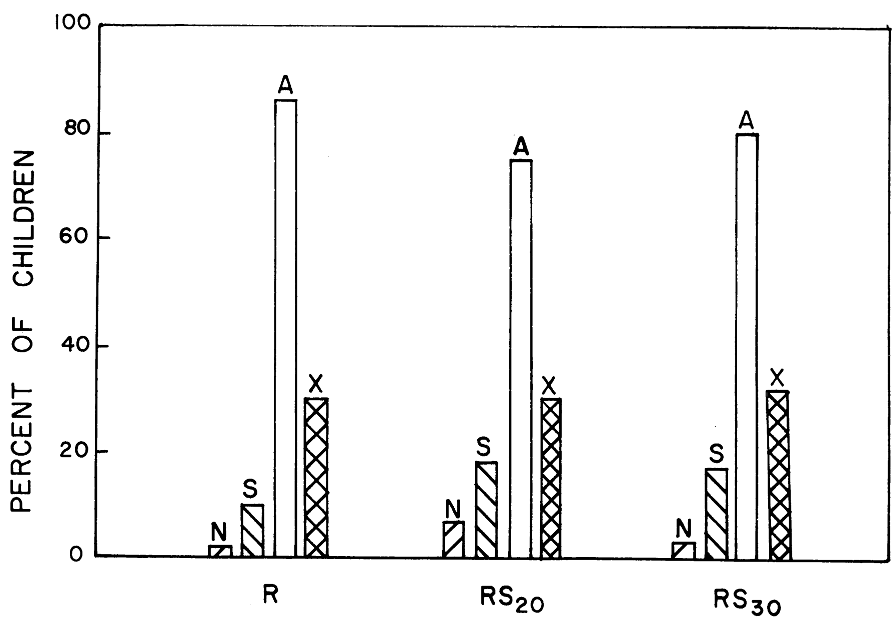

Fig. 3. Consumption of control rice (R), 20% soy-rice (RS_{20}), and 30% soy-rice (RS_{30}) noodle dishes by preschool children attending the Kasetsart University Nursery School. Legend same as Fig. 1.

protein costs of soy-rice noodles in most cases were lower than those for regular noodles. The protein cost of the 30% soy-rice noodles, adjusted for NPU, was 32% less than that for regular rice noodles. Costs for animal-protein foods are much higher, making their purchase by low-income families prohibitive.

Acceptability

The consumption of regular and soy-rice noodles by a total of 197 preschool children at two Child Nutrition Centers and a Bangkok nursery school was recorded. Figures 1-3 illustrate the eating patterns for the noodle dishes at the three testing areas. Average noodle consumption was higher at the Child Nutrition Centers than at the Kasetsart University Nursery School, attended by children from higher-income families. Possibly those at the nursery school had an adequate early-morning meal, whereas the village children from lower-income families did not. Statistical analysis of noodle consumption patterns (none, some, all, extra), however, showed that consumption of soy-rice noodles was not significantly different ($P < 0.01$) from that of regular noodles at any testing locality. There were no significant differences among the preferences for methionine-fortified or -nonfortified samples. Soy-rice noodles, therefore, were acceptable to preschool children.

Nutritional Evaluation

Proximate analyses for noodle samples appear in Table V. The protein content (dry basis) of 20% soy-rice noodles (15.0%) or 30% soy-rice noodles (18.0%) is two to two and one-third times that of regular rice noodles (7.8%). Adding full-fat soy flour to rice flour increased fat, ash, and fiber contents as well as protein content. Because of the higher fat content, the caloric value of soy-rice noodles was slightly higher than that of regular noodles.

Adding soy flour to rice flour increased the content of important vitamins and minerals (Table VI). Compared with regular noodles, 30% soy-supplemented noodles had higher amounts of α-tocopherol (eight times), thiamin (two times), riboflavin (two times), pyridoxine (five times), vitamin B-12 (two times), niacin (two times), folic acid (three times), calcium (four times), iron (two times), magnesium (twelve times), and phosphorus (three times). Soy-rice noodles, therefore, could provide important amounts of these vitamins and minerals in the diet of Thai children.

TABLE V
Proximate Analyses[a] and Caloric Values of Rice Noodles

Rice Noodles	Protein[b] %	Ash %	Fiber %	Fat %	Carbohydrates %	kcal[c]
		Nutrient				
Regular (control)	7.8	0.3	0.2	2.3	89.4	427
20% Soy	15.0	1.2	0.6	5.6	77.6	436
30% Soy	18.0	1.6	0.9	7.2	72.3	440

[a]Moisture-free basis; analyses by WARF Institute.
[b]N × 5.95 for regular noodles; N × 6.25 for soy-rice noodles.
[c]Dry basis, per 100 g sample (13).

The amino acid composition of rice noodles, regular and soy, is shown in Table VII. Increasing soy content of the noodles increased lysine content but decreased the content of both methionine and cystine (24) when expressed as mg of amino acid per g of protein. Chemical scores (which, based on the FAO amino acid

TABLE VI
Vitamin and Mineral Analyses[a] of Rice Noodles

Nutrients	Rice Noodles		
	Regular	20% Soy	30% Soy
Vitamins			
A[b]	<100	<100	<100
D[b]	0	0	trace
α-Tocopherol[c] (E)	0.37	2.06	3.04
Thiamin (B-1)	0.03	0.05	0.05
Riboflavin (B-2)	0.021	0.050	0.048
Pyridoxine (B-6)	0.021	0.063	0.116
B-12[d]	0.057	0.100	0.101
Niacin	0.243	0.296	0.564
Folic acid	0.022	0.041	0.061
Minerals[a]			
Calcium	19.2	73.6	80.0
Iron	2.33	3.46	4.68
Magnesium[c]	5.2	40.0	64.8
Phosphorus	74.0	156.0	208.0

[a]mg per 100 g sample; assays by WARF Institute.
[b]Units per 100 g sample.
[c]Assay by Department of Science, Ministry of Industry, Bangkok.
[d]μg per 100 g sample.

TABLE VII
Amino Acid Composition[a] of Rice Noodles

Amino Acid	Rice Noodles		
	Regular	20% Soy	30% Soy
Alanine	51.5	37.9	47.4
Arginine	65.9	65.3	65.3
Aspartic acid	80.0	102.2	109.8
Cystine[b]	14.5	12.0	9.2
Glutamic acid	145.8	161.0	163.5
Glycine	25.9	30.0	26.7
Histidine	7.4	10.4	12.3
Isoleucine	34.7	38.6	40.7
Leucine	66.7	68.1	70.6
Lysine	21.6	32.9	41.6
Methionine[b]	22.9	19.2	17.5
Phenylalanine	37.0	40.0	39.8
Proline	41.1	44.3	45.6
Serine	38.3	41.4	42.0
Threonine	26.8	30.4	31.3
Tryptophan[b]	10.4	9.9	9.6
Tyrosine	33.5	31.1	31.0
Valine	51.6	46.6	46.9

[a]mg per g protein; amino acid analyses by WARF Institute. All values are dry basis.
[b]Microbiological assay.

scoring pattern, indicate the most limiting amino acid in the test protein) were 40, 60, and 76% for regular, 20 and 30% soy-rice noodles, respectively. Lysine was the most limiting amino acid. Methionine-fortified samples had similar chemical scores of 60 and 76% for the 20 and 30% soy-rice noodles, respectively, indicating that adding methionine to the samples was not necessary with respect to the FAO reference protein. Casein had a chemical score of 91%, with methionine plus cystine being the limiting amino acids.

Protein quality of soy-supplemented noodles, as determined by rat growth studies, was superior to that of unsupplemented ones. Results of PER and NPU studies are given in Table VIII. These assays demonstrated that protein quality of rice noodles increased with increased soy-flour supplementation. Adding methionine evidently affected PER values. The 20 and 30% soy-rice noodles without added methionine had PER values of 2.53 and 2.56, respectively, based on 2.50 for standard casein. Those fortified with methionine had higher adjusted PER values: 2.68 and 3.03 for the 20 and 30% soy-rice noodles, respectively. Regular rice noodles had an adjusted PER of 2.17. Similarly, NPU values (47, 55, and 54, respectively, for 20% soy-rice plus methionine, 30% soy-rice, and 30% soy-rice plus methionine noodles; 42 for regular) showed improved protein quality for the 30% soy-supplemented product. Supplementation with 20% soy flour apparently did not improve the protein quality of this product, as indicated by its NPU value of 41, although the PER value was increased (Table VIII). NPU values for the 20% soy-rice noodles plus methionine and the 30% soy-rice noodles, with and without methionine, were not significantly different ($P < 0.05$) from that for standard casein, which had an NPU of 53.

Overall, considering nutritional evaluation and protein cost combined, 30% soy-rice noodles represented the best high-protein quality product. The ability of soy-rice noodles to provide high amounts of animal quality protein at a low cost can be significant in providing an excellent way to increase the amount of protein in the diet of Thai children at Child Nutrition Centers.

TABLE VIII
Protein Efficiency Ratios (PER) and Net Protein Utilization (NPU) of Rice Noodles

Diet	PER[a]	Adjusted PER[b]	NPU[c] %
Regular (control)	2.50 ± 0.04[d]	2.17	42 ± 2.7[d]
20% Soy	2.86 ± 0.06	2.53	41 ± 1.0
30% Soy	2.89 ± 0.06	2.56	55 ± 4.5
20% Soy + met[e]	3.01 ± 0.06	2.68	47 ± 4.3
30% Soy + met[e]	3.36 ± 0.08	3.03	54 ± 4.1
Casein	2.83 ± 0.06	2.50	53 ± 1.7

[a]PER = Weight gain/Protein intake. Average of 10 animals per group. Assays by WARF Institute.
[b]PER adjusted on the basis of 2.50 for casein.
[c]NPU = N Retention/N Intake × 100. Average of five animals per group. Assays by WARF Institute.
[d]Standard error of means.
[e]The 20 and 30% soy-rice noodles were fortified with 0.2 and 0.3% dl-methionine, respectively.

Soy-supplemented rice noodles, introduced as a dietary protein source in Thai child-feeding programs, use the country's cereal staple in combination with a familiar and available high-protein vegetable to produce a traditional food item. Since noodles (a main dish) are consumed in large quantities, the supplemented product represents a suitable way to increase protein intake. Soy-rice noodles have the potential for production at the village level because processing is simple and similar to that used for making ordinary rice noodles.

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Literature Cited

1. SWAMINATHAN, M. The nutrition and feeding of infants and pre-school children in the developing countries. World Rev. Nutr. Diet. 9: 85 (1968).
2. JELLIFFE, D. B. The assessment of the nutritional status of the community. United Nations World Health Organization. WHO Monograph Series No. 53. WHO: Geneva (1966).
3. STOCH, M. B., and SMYTHE, P. M. Does undernutrition during infancy inhibit growth and subsequent intellectual development? Arch. Dis. Childhood 38: 546 (1963).
4. JACKSON, R. L. Effect of malnutrition on growth of the pre-school child. In: Pre-school children malnutrition. Primary deterrent to human progress. National Academy of Science-National Research Council: Washington, D.C. (1966).
5. SCRIMSHAW, N. S. Infant malnutrition and adult learning, p. 29. Saturday Review (March 16, 1968).
6. NETRASIRI, A., and NETRASIRI, C. Kwashiorkor in Bangkok: An analytical study of 54 cases. J. Trop. Pediat. 1: 148 (1955).
7. THANANGKUL, O., WHITAKER, J. A., and FERT, E. G. Malnutrition in Northern Thailand. Amer. J. Clin. Nutr. 18: 379 (1966).
8. KHANJANASTHITI, P., and WRAY, J. D. Early protein-calorie malnutrition (PCM) in slum areas. An unpublished report. Ramathibodi Hospital, Mahidol University: Bangkok (1971).
9. BHUMIRATANA, A., and NONDASUTA, A. Report on protein food development project. Nutrition Division, Health Department, Ministry of Public Health, Bangkok (1972).
10. ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS. Official methods of analysis (11th ed.). The Association: Washington, D.C. (1970).
11. PERYAM, D. R., and PILGRIM, F. J. Hedonic scale method of measuring food preferences. Food Technol. (Symposium) 2: 9 (1957).
12. UNITED NATIONS FOOD AND AGRICULTURE ORGANIZATION. Energy and protein requirements. Joint FAO/WHO Ad Hoc Committee (March-April, 1971). FAO: Rome (1973).
13. UNITED STATES PHARMACOPOEIAL CONVENTION. The United States Pharmacopoeia (U.S.P.), 15: 889. The Convention (Mack Pub. Co.): Easton, Pa. (1955).
14. ASSOCIATION OF VITAMIN CHEMISTS. Methods of vitamin assay. The Association (Interscience Pub.): New York (1966).
15. ATKINS, L., SCHULTZ, A. S., WILLIAMS, W. L., and FREY, C. N. Yeast microbiological methods for determination of vitamins. Pyridoxine. Ind. Eng. Chem. 15: 141 (1943).
16. UNITED STATES PHARMACOPOEIAL CONVENTION. The United States Pharmacopoeia (U.S.P.), 17: 865. The Convention (Mack Pub. Co.): Easton, Pa. (1965).
17. ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS. Official methods of analysis (8th ed.). The Association: Washington, D.C. (1955).
18. PERKIN-ELMER CORP. Analytical methods for atomic absorption spectrometry. The Corporation: Norwalk, Conn.

19. FORSTER, W. A. The determination of magnesium in plant materials by means of ethylenediamine-tetra-acetic acid. Analyst 78: 179 (1953).
20. SPACKMAN, D. H., STEIN, W. H., and MOORE, S. Automatic recording apparatus for use in the chromatography of amino acids. Anal. Chem. 30: 1190 (1958).
21. HENDERSON, L. M., and SNELL, E. E. A uniform medium for determination of amino acids with microorganisms. J. Biol. Chem. 172: 15 (1948).
22. MILLER, D. S., and BENDER, A. E. The determination of the net protein utilization of proteins by a shortened method. Brit. J. Nutr. 9: 382 (1955).
23. FELT, C. E., BUECHELE, A. C., BORCHARDT, L. F., KOEHN, R. C., COLLATZ, F. A., and HILDEBRAND, F. C. Determination of shelf life of packaged cereals. Cereal Chem. 22: 261 (1945).
24. UNITED NATIONS FOOD AND AGRICULTURE ORGANIZATION. Amino-acid content of foods and biological data on proteins. FAO: Rome (1970).

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