Development, acceptability, and proximate analyses of high-protein, rice-based snacks for Thai children.

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Urban and rural Thai children are fond of deep-fat-fried crispy chips made of rice flour. They eat them as snacks. The problem is that these snacks contain very little protein. To test whether preschool children would eat protein-enriched snack items, several kinds of deep-fat-fried crispy chips were made from a combination of rice flour and soy flour or rice flour and fish protein concentrate. The protein contents of the new snacks ranged from 17 to 24%. Their acceptability was tested with 198 first-grade children. The children found them more acceptable or just as acceptable as two commercially available snack items. Costs per unit were substantially lower than those of the commercially available control snacks. Subjective evaluations of protein-enriched snacks stored three to six months indicated no significant changes in acceptability.
**INTRODUCTION**

Protein malnutrition among children is a major global problem. High mortality and impaired physical and mental growth have been reported as consequences of protein deficiency in children (Stock and Smythe, 1963; Jackson, 1966; Scrimshaw, 1968; Swaminathan, 1968). Incidences of kwashiorkor and other protein-deficiency states have increased in Thailand recently (Thianangkul et al., 1966; Khanjanasithi and Wray, 1971). High-protein foods that fit dietary patterns of such children could be beneficial. To be readily accepted, new, high-protein foods or supplements should be similar to traditional foods, and should be produced from food sources readily available in each country considered to reduce costs. The traditional approach of conducting research to develop high-protein foods in developed nations, then attempting to transfer the results to developing countries has often failed. Research, particularly to develop food products, should be accomplished in the country of interest so supplements will be applicable to rural as well as urban economies. Results from such research are more easily transferred to other developing countries with similar cultures.

Traditional rice noodles (senlek), consumed throughout Thailand by people of all ages and economic status, have been fortified with full-fat soy flour (Siegel et al., 1975). Consumption of small amounts of high-protein snacks between meals by Thai children also can supplement a protein-deficient diet. Snacks are popular among both urban and rural Thai children and are readily available from numerous small shops and vendors (Wood, 1968; McKinnon et al., 1972). Consumption of snack foods is high in Thailand (Scrimshaw et al., 1973).

Traditional Thai snacks include rice- or cassava-based chips that are deep-fat fried, edible, and crisp. Snacks containing only rice and/or cassava are low in both protein quality and quantity. Snacks containing large amounts of protein are costly.

We developed high-protein snacks, similar to those now available, by supplementing rice flour with full-fat soy flour or soy protein concentrate. We used the country’s staple cereal (rice) in combination with a familiar and available high-protein oilseed (soy) to produce a familiar food. The new snacks were aimed at pre-school children attending rural Child Nutrition Centers and at commercial markets.

**EXPERIMENTAL**

Snack formulations

Four snack formulations called for adding high-protein ingredients to a rice base (66–68% dry basis): 32% full-fat soy flour; 26% full-fat soy flour plus 5% ground, whole sesame; 26% full-fat soy flour plus 5% fish protein concentrate (FPC); or 29% soy protein concentrate. The snack items were produced as dehydrated pieces and deep-fat fried to produce crispy chips, except for an extrusion-cooked, puffed curl that contained 29% soy protein concentrate. Acceptability of the samples was tested with 198 first-grade children at two schools. A five-point hedonic scale corresponding to facial expressions [very happy (5.0) to very sad (1.0)] was used to rate acceptability. Average scores for the snacks were from 3.6–4.8. The protein-enriched rice snacks scored significantly higher (P < 0.01) than one commercially-available (control) snack, and were comparable to a second commercially-available snack. Subjective evaluations of snacks stored 3 or 6 months indicated no significant changes in acceptability. Protein contents of the new snacks ranged from 17.2–24.6% (dry basis). Costs per unit protein were substantially lower than those of the commercially-available control snacks.

High-protein snack items, primarily deep-fat fried, were developed for Thai children. Four snack formulations were prepared by adding high-protein ingredients to a rice base (66–68% dry basis): 32% full-fat soy flour; 26% full-fat soy flour plus 5% ground, whole sesame; 26% full-fat soy flour plus 5% fish protein concentrate (FPC); or 29% soy protein concentrate. The snack items were produced as dehydrated pieces and deep-fat fried to produce crispy chips, except for an extrusion-cooked, puffed curl that contained 29% soy protein concentrate. Acceptability of the samples was tested with 198 first-grade children at two schools. A five-point hedonic scale corresponding to facial expressions [very happy (5.0) to very sad (1.0)] was used to rate acceptability. Average scores for the snacks were from 3.6–4.8. The protein-enriched rice snacks scored significantly higher (P < 0.01) than one commercially-available (control) snack, and were comparable to a second commercially-available snack. Subjective evaluations of snacks stored 3 or 6 months indicated no significant changes in acceptability. Protein contents of the new snacks ranged from 17.2–24.6% (dry basis). Costs per unit protein were substantially lower than those of the commercially-available control snacks.

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Stone-ground, broken rice was used to prepare aqueous rice flour suspensions into which the protein ingredients and seasonings were incorporated. The soy flour used was Kaset full-fat soy flour, prepared semi-commercially by the Institute of Food Research and Product Development (IFRPD), Bangkok, by the procedure described by Bhumiratana and Nondasuta (1972). The proximate analysis of the soy flour has been reported to be 32.7% moisture, 48.8% protein, 20.9% fat, 4.3% ash and 2.2% fiber (Bhumiratana and Nondasuta, 1972). Fish protein concentrate, prepared from eviscerated, whole-ground fish by solvent extraction and dehydration, was supplied as a pale, grey powder by the U.S. Agency for International Development (USAID). It contained approximately 73–75% protein. The soy-protein concentrate contained about 70% protein and was prepared at IFRPD by acid precipitation of a soy protein solution in a process similar to that described by Althul (1969). Rice-flour suspensions (54% solids) were prepared commercially at a Bangkok noodle factory from locally purchased broken rice (Indica variety, short grain). The proximate analysis of the rice was 10% moisture, 7.0% protein, 2.1% fat, 0.3% ash and 0.2% fiber. In addition, whole sesame seeds, seasonings and frying oil (a commercially-available all-purpose vegetable oil containing a mixture of peanut and cottonseed oils), were obtained locally in Bangkok.

Snack preparations

Laboratory prototypes—Snack chips. Snack prototypes were initially prepared using the formulations shown in Table 1. Ingredients were added to a 1:1 mixture of rice flour suspension (54% solids) and water. Snacks were prepared in the laboratory in a manner similar to that used for making commercial rice noodles. The suspensions were poured onto rectangular metal trays and allowed to spread evenly over the entire surface. After steam blanching for 2 min, the trays were allowed to cool for several minutes. The rice sheet was peeled from the tray and partially dried in a cabinet drier at 45°C. The sheet was subse-
quently manually cut into various sizes, small squares and rectangles and oven dried for 1 hr at 70°C. The dried snack pieces were fried in hot vegetable oil (approx 175°C) several seconds, to produce crispy snacks.

Commercial snacks—Soy-rice chips. One laboratory snack prototype (Table 1, Soy-rice) was subsequently prepared commercially (Table 1, Soy-rice chips). Ingredients were added in the same proportions (dry basis) used in the prototype except that a small amount of locally-obtained cassava flour was incorporated into the mixture. Small amounts of cassava flour improve the overall quality of dehydrated, soy-supplemented rice noodles (Siegel et al., 1975).

Soy-rice chips were prepared commercially in a manner similar to that described by Siegel et al. (1975) for rice noodles. A standard (Sengmuil) noodle-making machine was used to prepare gelatinized (soy-rice) sheets. After the sheets were air-dried for 5 hr, they were manually cut into small circles or discs with cookie cutters. The pieces were then dried as a single layer on perforated metal trays in an air oven for 1.5 hr at 70°C. The dried soy-rice chips contained approximately the same amount of soy flour and rice as the 30% soy-rice noodles developed by Siegel et al. (1975). For evaluation and acceptability studies, polyethylene bags (51 μm thick), containing 100g of dry soy-rice chips, were placed in a plastic bucket, covered, and stored at temperatures and relative humidities nearly equal to those of outdoor conditions. The soy-rice chips were deep-fat fried before being eaten.

Extruded snack—Soy-rice curls. A protein-supplemented snack (Table 1) in the form of a puffed curl was made on a Wenger 1 X-25 cooker extruder (Wenger Co., Sabwia, KS) under a pressure of 200 psi at a temperature of 125°C. Broken rice was ground into a coarse flour on a Fitz mill. The flour was used to prepare a 50-kg batch of the soy curls. The extruded product was machine cut into 2-in. pieces (curls) and dried in a continuous tunnel dryer for 1 hr at 130°C. The snacks were packed in polyethylene bags (51 μm thick) and stored in covered plastic buckets for future evaluation and acceptability testing.

Commercially-available (control) snacks

Two commercially-available snack food items, shrimp-flavored chips (11.7% moisture, 15.8% protein, 2.0% fat, 0.6% ash, and 4.9% fiber) and red-colored chips (11.6% moisture, 3.7% protein, 0.3% fat, 0.6% ash, and 3.6% fiber) were used as controls in sensory studies and for nutritional evaluations. They were dehydrated pieces which were deep-fat fried for several seconds yielding enlarged, crispy, snack chips. The shrimp-flavored chip was a relatively expensive, familiar snack that contained ground, dehydrated shrimp added to a cassava flour base. In contrast, the red-colored chip was an inexpensive snack that had food coloring added to a mixture of cassava and rice flours. Both were obtained from local markets.

Storage studies

Moisture content of each protein-supplemented snack chip (soy-rice, soy-sesame-rice, soy-fish-rice) was determined initially and at 3- and 6-month storage times. All snacks were packed in polyethylene bags (51 μm thick) and stored at temperatures and relative humidities nearly equal to those of atmospheric conditions. The children on each day of testing.

Kasetsart Demonstrated School and 82 first-grade children from lower-income families attending the Bang Bua Elementary School participated in preference scoring all snacks. A five-point hedonic scale containing five facial expressions (very happy (5.0) to very sad (1.0)), designed to correspond to a child's feeling concerning the snack item (Lachance et al., 1972), was used. Two or three snacks were scored, one at a time, by the children on each day of testing.

In addition, children at the Kasetsart Demonstrated School scored soy-rice chips, soy-sesame-rice chips, and soy-fish-rice chips after 6-months' storage. The extruded puffed curls (soy-rice curls) were scored by children at both schools after 3-months' storage.

Dietary protein value

Samples of all snacks were subjected to proximate analyses. Protein, moisture, ash, fiber and fat were determined according to official AOAC methods (AOAC, 1970). Carbohydrate was calculated by difference. Caloric values were obtained using Atwater factors: protein, 4.0 kcal/g; fat, 9.0 kcal/g; and carbohydrate, 4.2 kcal/g (UN FAO, 1973).

RESULTS & DISCUSSION

Storage studies

Moisture contents of soy-rice chips, soy-sesame-rice chips, soy-fish-rice chips, soy-rice curls and controls (shrimp-flavored and red-colored chips) stored for 3 or 6 months at atmospheric conditions are shown in Table 2. Moisture contents of all products increased during storage. In stored cereal products, moisture uptake depends on relative humidity (which was high) (Felt et al., 1945). The final moisture contents in soy-rice,
soy-sesame-rice and soy-fish-rice chips were 10.3, 10.1 and 11.1%, respectively, after 6 months’ storage.

**Proximate analyses**

Changes in composition and caloric values of soy-rice chips and control snacks after deep-fat frying are shown in Table 3. Protein content after frying represents the amount in the edible snack.

The amount of fat absorbed is important because it affects the protein calorie ratio in addition to the texture and flavor of the snacks. Soy-rice chips absorbed the least fat (six times the initial content). Shrimp-flavored chips absorbed 16 times the initial content while red-colored chips absorbed 76 times the initial fat content. High fat absorption by control snacks could be attributed to the course texture of the rice and cassava flours they contained. Soy-flour supplementation prevents excessive fat absorption in doughnuts during frying (Wolf, 1970). The protein to calorie ratio declined in all snacks after frying as the fat used in frying increased calorie content but not protein content. However, soy-rice chips had the lowest percentage decrease (16%) in protein to calorie ratio because they absorbed less fat than other snacks did.

**Product costs**

Retail product costs and costs per-unit-of-protein for the protein-supplemented snacks and control snacks are given in Table 4. Soy-rice, soy-sesame-rice, and soy-fish-rice chips had comparable costs. Soy-rice curls cost the most of the new snacks, partially because soy protein concentrate is produced in small quantities at IFRPD and is expensive. The relative cost of the soy-rice curl, based on small amounts of expensive, locally-produced concentrate, may give a somewhat misleading picture. However, at the time this work was done, that was the only local source of the concentrate available to us. As production increases in Thailand, or in countries with large-scale production of soy-protein concentrate, costs will decrease, resulting in a lower relative cost for the soy-rice curl.

The cost per pound of protein for the new snacks ranged from 31.4 cents for soy-rice chips to 79.8 cents for soy rice curls. Costs per pound of protein for the control snacks were about three and one-half to four times higher than the average for the three new snack chips (soy-rice, soy-sesame-rice, soy-fish-rice) and one and one-half times higher than for soy-rice curls.

**Acceptability**

All snack products were well accepted by children at Bang Bua School; more than 75% gave the snacks scores of 5.0. Children at the Kasetsart Demonstrated School were more discriminating as shown in Figure 1. Children from higher-income families (Kasetsart Demonstrated School) probably had more experience with snack foods.

Scores for the various snacks are given in Table 5. Dif-
Table 6—Proximate analysis and caloric values of snacks

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Proteinb (%)</th>
<th>Ash (%)</th>
<th>Fiber (%)</th>
<th>Fat (%)</th>
<th>Carbohydrate (%)</th>
<th>Kilocaloriesc (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snack</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>New snacks</td>
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<td></td>
<td></td>
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<tr>
<td>Soy-rice chips</td>
<td>18.0</td>
<td>2.4</td>
<td>4.3</td>
<td>3.1</td>
<td>72.2</td>
<td>403</td>
</tr>
<tr>
<td>Soy-sesame-rice chips</td>
<td>17.2</td>
<td>2.4</td>
<td>2.9</td>
<td>3.1</td>
<td>74.4</td>
<td>409</td>
</tr>
<tr>
<td>Soy-fish-rice chips</td>
<td>21.4</td>
<td>2.4</td>
<td>2.8</td>
<td>2.4</td>
<td>71.0</td>
<td>405</td>
</tr>
<tr>
<td>Soy-rice curls</td>
<td>24.6</td>
<td>2.3</td>
<td>0.5</td>
<td>0.2</td>
<td>72.4</td>
<td>404</td>
</tr>
<tr>
<td>Control snacks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shrimp-flavored chips</td>
<td>15.8</td>
<td>0.6</td>
<td>4.9</td>
<td>2.0</td>
<td>76.7</td>
<td>403</td>
</tr>
<tr>
<td>Red-colored chips</td>
<td>3.7</td>
<td>0.5</td>
<td>3.6</td>
<td>0.3</td>
<td>91.9</td>
<td>404</td>
</tr>
</tbody>
</table>

a Composition percentages on a dry basis  

b N X 6.26  

c Calculated per 100g sample on a dry basis

Differences among scores at Bang Bua School were not significant, but differences were significant (P < 0.01) among scores at Kasetsart Demonstrated School. Average scores for soy-sesame-rice chips (4.27) and the familiar shrimp-flavored snack (4.63) did not differ significantly (P < 0.01). Red-colored chips were scored significantly lower than any other snack tested. Soy-rice and soy-sesame-rice chips were scored significantly higher than soy-rice curls. Preference scores for soy-fish-rice chips and soy-rice curls did not differ significantly.

Changes in acceptability of protein-supplemented rice snacks stored in the dried form for three or six months were also evaluated by children from the Kasetsart Demonstrated School. Differences among snack scores for all stored samples were not significant (P < 0.01) indicating that stored snacks maintained the same eating qualities as when fresh.

Dietary protein value

Proximate analyses and caloric values for the protein-supplemented and control snacks appear in Table 6. The protein content (dry basis) was highest in extruded soy-rice curls (24.6%). Protein contents for other new snacks ranged from 17.2 to 21.4%. Control snacks contained 15.8% protein (shrimp-flavored chips) and 3.7% protein (red-colored chips). A 10-g portion of soy-sesame-rice chips, soy-rice chips, soy-fish-rice chips or soy-rice curls can provide 8, 9, 10 and 12%, respectively, of the Thai recommended daily allowances (RDA) for pre-school children four to six years old (Anonymous, 1968). Higher percentages of the Thai RDA for protein (10–14%) could be provided for younger children (1–3 yr old) by the new snacks. Further nutrient analyses are required to determine the concomitant contribution of vitamins and minerals. Percentages of calories derived from protein, calculated on a ready-to-eat basis, in soy-rice curls, soy-rice curls, shrimp-flavored chips, and red-colored chips were 15.0, 24.4, 11.4, and 2.8%, respectively (Table 3).

Previous investigation of the nutritional quality of soy-rice blends in the form of noodles showed substantial protein quality improvement. Rice noodles containing 30% full-fat soy flour, a formulation nearly identical with that of soy-rice chips and soy-rice curls and similar to that of soy-sesame-rice chips and soy-fish-rice chips, had a reported PER value of 2.58 compared with a casein control (PER 2.50) (Seigel et al., 1975). In addition, the NPU value of 55 did not differ significantly from the 53 for standard casein (Seigel et al., 1975).

CONCLUSIONS

NEWLY DEVELOPED, high-protein, rice-based snacks provide a way to add protein to the diets of Thai children. Combinations of rice with full-fat soy flour and soy protein concentrate yield products with protein of greater quantity and quality than snacks now commercially available. Using small amounts (5%) of fish protein concentrate permitted us to add animal protein without dominating the product's flavor. Incorporating ground sesame seeds into a soy-rice snack would be expected to give a product containing protein of higher biological value as the sesame seeds provided the methionine lacking in soy. Additional benefits are a nut-like flavor and crunchy texture.
The newly-developed rice snacks could provide more protein at substantially lower prices than commercially-available snacks do.

Studies with elementary school children illustrated (1) overall acceptability of the new snacks; (2) their potential values in child feeding programs; and (3) their suitability as a potential commercial item for use in urban and rural areas. The new rice snacks were acceptable to children from families of different economic statuses. Good keeping quality and ease of preparation suggest further development and use of the new snacks by all segments of the population, especially to improve the protein nutrition of children.

REFERENCES

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