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Development of Nutritious Soy Fortified Snack by Extrusion Cooking

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ABSTRACT

A nutritious soy fortified snack with good texture and good protein quality was achieved from formula 8 containing 18% of soy flour (9% DFS + 9% FFS) replaced in a blends of corn grit and broken rice, 2% soybean oil and fortified with a mixture of vitamins, minerals and amino acids. Mixed ingredients were adjusted to 16.5 ± 0.5% moisture content and fed at 365 g/ min to extrusion process at 165–167°C melt temperature employing Berstorff laboratory twin screw extruder operated at 300 rpm. The obtained snack had expansion ratio (ER), bulk density (BD) and compression force (CF) of 3.9, 58 g/L and 60.17 N, respectively and was subsequently sensory evaluated (9-point hedonic scale) for preference and acceptance together with control samples and popular market snacks. Snack sample from formula 8 had gained the highest score in color, flavor, texture and overall acceptability ($P \leq 0.05$). Protein content in the developed snack sample is 9.9% which was 46.67–70.69% higher than in the market snacks. Furthermore, there was also a greater quantity of lysine and methionine plus cystine and all those essential amino acids were accounted for at least 80% of the FAO/WHO (1973) recommendation. It also exhibited as a good source of vitamin B_6, B_2, calcium and sodium, and also rich in B_{12} and iodine. In addition, ratio of calories gained from carbohydrate, protein, fat from the snack was almost equal to Thai-RDI. Thus, the developed soy fortified snack could be regarded as a palatable and nutritious snack.

Key words : nutritious snacks, soy fortified snack, direct expanded snack, corn grit-broken rice based snack, twin-screw extruder.

INTRODUCTION

In Thailand, snack foods from extrusion process had increasingly gained popularity, (Sinthavalai, 1984; Kosayothin, 1996). However, nutritional quality in the market snack products were found unfitting. In such products, cereal carbohydrate, frying oil and flavor coating oil are the main sources of calories. Reasonably low protein content (2.44 to 11.06%) in market snacks was reported by several workers (Boonyasirikool *et al*., 1986; Plernchai *et al*., 1999). Thus, high consumption of such snacks could lead to malnutrition in children and obesity, which leads to several diseases in adult. Malnutrition and over nutrition was found to account for 15–20% in Thai population (Tontisirin, 1996). Consumption of snack as a meal could be applicable if it could provide protein of 2.5–3.0 g per 100Kcal or else at least 10–12% of total calories is obtained from

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protein. Or if the calories gained from consuming the snack was from carbohydrate, fat and protein are in the range of 55–65%, 20–30% and 10–15%, respectively.

Generally, main ingredient of extruded snacks is cereal, which has low protein content, and limited in lysine, the essential amino acid needed for growth but high in methionine and cystine. In contrast, soy protein is high in lysine but low in methionine and cystine. Hence, an optimal incorporation of full fat soy flour (FFS, 43.6% protein, 18% fat) or defatted soy flour (DFS, 47.2% protein, 1.0% fat) in snacks could increase protein quality (Boonyasirikool *et al*., 1986, Harper, 1981). Several food products had been developed to add up protein content by a combination of cereal and soybean flour (Nuguchi *et al*., 1981; Cheman, *et al*., 1992; Adesina *et al*., 1998). The objective of this research was to develop a nutritious extruded snack by the use of soybean flour and some micronutrients fortification to improve nutritional and textural quality employing extrusion process.

MATERIALS AND METHODS

Corn grit (30–50 mesh), full fat soy flour (FFS, 80–100 mesh), defatted soy flour (DFS, 100–140 mesh), Chainat 1 broken rice (30–50 mesh), mixture of vitamins, minerals and methionine consisted of food grade 46.98% $CaCO_3$, 40.85% refined salt, 6.14% ascorbic acid (Hoffman La Roche, Switzerland), 5.10% L – methionine. (BP/USP, Ajinomoto, Japan) and 0.93% of vitamin B_1, B_2, B_6, B_{12}, A, D, E, (Hoffman La Roche, Switzerland), KI (G. Amphrey, India), L – Lysine (BP/USP, Ajinomoto, Japan), Saroline roasted chicken flavor no. 802184 were supplied by Thai Maize Products Ltd., the Royal Project, Archer Daniels Midland Company, Decature, Illinois, U.S.A, Saeng Ruang Flour Mills, Asia Drug Chemicals Ltd., Part, and Bush Boak Allen (Thailand) Ltd. respectively. Soybean cooking oil (Grape brand) was purchased locally.

Improvement of nutritional value by soy flour inclusion

Although an improvement in textural quality in corn grit-broken rice extruded snack studied by Boonyasirikool and Charunuch (2000) was accomplished, it required an improvement in nutritional quality. Therefore, in this study, it was used as a control formula coded as formula 1 in Table 1. Defatted soy flour was applied by substitution at 6, 12, 18, 24% in the blends of corn grit-broken rice which were coded formula 2, 3, 4,5, respectively. Soybean oil was reduced from 2 to 1%. The amount of $CaCO_3$, sugar and the mixture of methionine, minerals and vitamins were unchanged except for 0.25% of lysine was additionally fortified.

Ingredients preparation

Raw materials were weighed and mixed thoroughly in Telegram bearmixer for 5 min. prior to store tightly in polypropylene (PP) bag.

Extrusion process

Mixed ingredients were fed to the extruder by a volumetric feeder at 365 g/min (K-Tron Soder AG 5702, type 20, Switzerland). Water was pumped at 19.0 g/min to the ingredients to achieve 16.5 ± 0.5% moisture content. Extrusion process was performed by a laboratory co-rotating twin-screw extruder (Hermann Berstorff Laboratory Co-rotating Twin Screw Extruder ZE25 x 33D) which comprises of 7 parts of barrel ended with a 25 mm thick die plate with a ring shape opening (external diameter of 10.5 mm internal diameter of 9.5 mm). The screw was operated at 300 rpm. L/D = 870:25 Temperature of barrel 1-7 and 9 was 30, 35, 45, 95, 135, 155, 130 and125°C, respectively. Melt temperature was 165-167°C. The extruded samples

were electric oven dried at 80°C for 10 min. then were coated with roasted chicken seasoning powder at the proportion of snack : soybean oil : seasoning powder was 700 : 135: 165 in a hot air injected octagonal kettle for 10 min. The coated snack samples were kept in the air- tight polypropylene (PP) bags prior to subjected to chemical analysis (A.O.A.C,1990), protein content (g) per 100 Kcal, expansion ratio, bulk density, compression force and sensory evaluation.

Physical properties examination

Expansion ratio (ER) =

$$\frac{\text{thickness of a ring shaped extruded sample (mm)}}{\text{width of the ring shape die outlet (mm)}}$$

Thickness of a ring shaped extruded sample were averaged from 10 pieces of sample and 3 measurements were performed on each piece.

Width of ring shape die outlet was 10.5 mm (external diameter) - 9.5 mm (internal diameter)

Bulk density (BD) =

$$\frac{\text{(wt. of snacks + wt. of container) – (wt. of container) (g)}}{\text{volume (L)}}$$

Texture analysis

Textural quality of the snack samples was examined for compression force (CF) by applying a TA-XT2 i Texture Analyzer. P_{50} compression probe (50 mm. dia. cylinder aluminum) was applied to measure compression force required for samples breakage which indicates hardness. Testing condition was 5.0 mm/s pre-test speed, 5.0 mm/s test speed, 10.0 mm/s post test speed. Each measurement was conducted on 50% strain of individual piece and 20 pieces were measured for averaging.

Sensory evaluation

After seasoning coating the snack with roasted chicken flavor, the snack samples were subjected to sensory evaluation conducted by a 20-member of experienced taste panel screened from researchers and researcher's assistants of the Institute of Food Research and Product Development, Kasetsart University. A 9-point hedonic scale (1 - extremely dislike to 9 - extremely like) was used to determine the preference in color, flavor, texture (crispiness) and overall acceptance. The SPSS software was then applied for statistical analysis of ANOVA and DMRT test of difference between samples at 95% level of confidence. Snack containing the highest protein content or close to standard (Autret, 1969) and gained the highest overall preference scores or at least 7 were subsequently selected for further textural improvement.

Textural improvement by adjusting the content of soybean oil and $CaCO_3$ and the use of FFS

Since texture and expansion of the product was influenced by $CaCO_3$ and oil (Guy, 1994; Boonyasirikool and Charunuch, 1997, 1999, 2000)). Therefore, optimizing the amount of calcium carbonate and soybean oil or substitute full fat soy flour (FFS) for DFS was studied in formula 4, 6, 7 and 8 (Table 3). Extrusion process, physical examination and sensory evaluation were carried out resembling the earlier procedure.

Sensory evaluation, proximate and nutrition analysis of the developed nutritious soy fortified, control and market snacks

The succeeded samples from the above sensory evaluation were subsequently compared to control samples (0% soy flour) and two popular market samples (T.W.T and T.T. coded) which were most similar in the manufacturing process and flavor coating. Sensory evaluation was performed by the same panel members.

The developed soy fortified snack was finally analyzed for proximate and essential amino

acid content at the laboratory of Section of Nutrition, Department of Health, Ministry of Public Health. The analysis of nutritional value for one serving was accomplished at the Institute of Nutrition, Mahidol University at Salaya, Nakhon Pathom.

RESULTS AND DISCUSSION

Improvement of nutritional value by soy flour inclusion

Table 1 displays the formulation and chemical composition with 0, 6, 12, 18, 24% DFS substitution in corn grit-broken rice blends. Formula 1 was the formula of corn grit-broken rice based snack created by Boonyasirikool and Charunuch (2000) and was regarded as control. It was detected that as the content of DFS was increasing from 0 to 6, 12, 18, 24% protein content was detected to increase at 42.39, 82.75, 110.14, 145.84% increment, respectively from control formula (0% DFS).

Table 2 summarized protein (g)/100 Kcal, physical and sensory quality. Despite the highest protein content of 12.12% or 2.8 g/100 Kcal, offered by formula 5 (24% DFS), several preference were evaluated the lowest and particularly, preference in color, as an appearance initially perceived was significantly ($P \leq 0.05$) lower than formula 4, 3, and 2. The lower score could probably due to the inclusion of soybean which had been noticed to cause darkening (Hettiarachchy and Kalapathy, 1997). It was statistically concluded that although the scores in formula 4 was lower, but was not significantly ($P \leq 0.05$) different from formula 2 (6%) and 3 (12%). On the other hand, the acceptance score of formula 4 (7.20) was significantly ($P \leq 0.05$) lower than formula 2 (7.55) in which 6% DFS was substituted. Formula 4 (18% DFS) which had offered the second highest (10.36%) protein content and displayed ER, BD and CF of 3.95, 60g/L and 62.85 N, respectively had gained a moderately high scores in color, flavor, texture preference and acceptance of 7.30, 7.15, 7.35 and 7.20, respectively.

Even though the protein value of 2.39 g/ 100 Kcal of snack samples formula 4 is slightly below the value of 2.5-3.0 g/ 100 Kcal that is recommended for good foods (Autret, 1969), it is considerable higher than the market snacks (Table 5). It was additionally recognized in Table 1 that protein content in snack samples from formula 4 (18% DFS) was 110.14, 47.58, and 14.98% higher than control samples, 6% and 12% DFS fortified snack, respectively. In comparison with market snacks previously examined, protein content in formula 4(10.36%) was 53-79% higher (Boonyasirikool *et al*., 1986; Plernchai *et al.*, 1999). Therefore, formula 4 (18% DFS) was chosen for further development.

Textural improvement by adjusting soybean oil and $CaCO_3$ quantity and the use of FFS

The textural attributed of soft crispy, puffy and light are closely related to the expansion ratio, bulk density and compression force was widely accepted in snacks. A range of 3.06–4.03 was reported for the expansion ratio (Mohamed, 1990; Boonyasirikool *et al*., 1996; Boonyasirikool and Charunuch, 2000). Wide range of 50–160 g/L bulk density was also reported (Moore, 1994; Boonyasirikool *et al.*, 1996; Boonyasirikool and Charunuch, 2000).

Table 3 shows physical properties of snack samples formula 4, 6, and 7 with the varied ratio of $CaCO_3$: soybean oil incorporated in DFS. Half of DFS was replaced by FFS in formula 8 and soybean oil was omitted. It could be observed that the snack samples displayed slightly different in physical properties but were totally in ranges previously reported. However, higher preferences except for color were evaluated in formula 7 and 8 (7.43, 7.25, 7.55, 7.50 and 7.55, 7.20, 7.50, 7.55, respectively) than formula 4 and 6 ($P \leq 0.05$). Optimal quantities of $CaCO_3$ and soybean oil are presumably affected

preference. It was reported that good texture and eating quality of extruded cereal snacks could be offered by 2% of soybean oil and 1% $CaCO_3$ (Boonyasirikool and Charunuch, 2000) and the overall oil content was reported not to exceed 3% (Boonyasirikool and Charunuch, 1997). The use of fat containing ingredient, FFS at 6.0 - 7.5% was reported to replace 1% of soybean oil (Boonyasirikool *et al*., 1996, Boonyasirikool and Charunuch, 1999). Therefore, snack samples from formula 7 and 8 were selected to compare with some market snacks by sensory evaluation.

Sensory evaluation, proximate and nutrition analysis of the developed soy fortified snack, control and market snacks

Table 1 Formulation and chemical composition of DFS fortified corn grit-broken rice based snack.

Formulation (%)					Chemical composition (%)					
Formula	Corn grit and broken rice blends	Defatted soy flour (DFS)	$CaCO_3$	Soybean Oil	Moisture	Protein	Fat	Ash	Fiber	Carbohydrate by difference
1	93	0	1	2	4.96	4.93	16.98	4.10	4.44	64.59
2	88	6	1	1	4.18	7.02 (42.39%)*	16.80	4.02	5.43	62.55
3	82	12	1	1	3.99	9.01 (82.75%)*	16.98	4.53	3.64	61.85
4	76	18	1	1	4.31	10.36 (110.14%)*	16.88	4.75	3.47	60.23
5	70	24	1	1	3.79	12.12 (145.84%)*	16.80	5.04	4.15	58.10

( ) * Percent of protein increment

Table 2 Protein-calorie ratio, physical properties and sensory qualities of corn grit-broken rice based snack fortified with DFS.

Formula	Protein (g)	Physical properties			Sensory quality			
	/100 Kcal	Expansion ratio	Bulk density (g/L)	Maximum compression force (N)	Color	Flavor	Texture	Acceptance
1	1.14	4.30	52	51.60	-	-	-	-
2	1.63	4.10	56	59.40	7.58^{a}	7.18^{a}	7.63^{a}	7.55^{a}
3	2.06	4.00	57	62.63	7.40^{a}	7.03^{ab}	7.58^{a}	7.30^{ab}
4	2.39	3.95	60	62.85	7.30^{a}	7.15^{ab}	7.35^{ab}	7.20^{bc}
5	2.80	3.90	57	53.69	6.88^{b}	6.83^{b}	7.10^{b}	6.93^{c}

In a column, means with the same letter are not significantly different at $P \leq 0.05$

Table 4 shows the preference scores of snack samples formula 7 and 8, market snacks coded as TWT. and TT. and formula 1 (control). It was obvious that snack samples from formula 8 gained the highest preference score in color, flavor, texture and acceptance but were not statistically different from samples formula 7 ($P \leq 0.05$). In contrast, preference score in formula 8 (soy fortified) were statistically different from formula 1, TWT. and TT. (non-soy fortified) at $P \leq 0.05$. The result could be explained by the findings of Noguchi *et al.* (1981) that increasing protein content in the extruded snack to 10% by adding isolated soy protein to rice flour led to a smooth surface and a crispy texture. Furthermore, Guy (1994) stated that addition of protein to 5–15% would decrease expansion, hence, resulted in the denser and crispier texture. The study of corn-based breakfast cereal produced from twin-screw extruder had discovered that replacement of 16% of DFS had offered a better texture and acceptance than samples from 0%, 12% and 20% DFS under the limit of 3% total fat content (Boonyasirikool and Charunuch in 1997).

It could be detected that snack samples from formula 8 which 9% DFS was replaced by FFS for being a source of soybean oil had gained a greater preferences than snack formula 7 which were formulated 18% DFS and 2% soybean oil. It could

Table 3 Comparision of physical qualities and sensory evaluation for the best texture of flavored nutritious soy fortified snack.

Formula	Ratio of DFS, FFS: $CaCO_3$: soybean oil	Blends of corn grit and broken rice	Physical qualities			Sensory evaluation			
			ER	BD g/L	CF (N)	Color	Flavor	Texture	Acceptance
4	18,0:1:1	76	3.95	60	62.85	7.35^{a}	6.98^{ab}	7.08^{c}	7.08^{b}
6	18,0:2:2	74	3.85	60	75.36	7.53^{a}	6.82^{b}	7.28^{bc}	7.10^{b}
7	18,0:1:2	75	4.00	56	63.43	7.43^{a}	7.25^{a}	7.55^{a}	7.50^{a}
8	9,9:1:0	77	3.90	58	60.17	7.55^{a}	7.20^{a}	7.50^{ab}	7.55^{a}

In a column, means with the same letter are not significantly different at $P \leq 0.05$

Table 4 Sensory evaluation of soy fortified snacks (formula 7, 8), control and 2 market snacks (T.W.T, T.T).

Formula / Code	Color	Flavor	Texture	Acceptance
8	7.73^{a}	7.80^{a}	7.83^{a}	7.90^{a}
7	7.50^{ab}	7.43^{ab}	7.50^{ab}	7.48^{ab}
T.W.T.	6.48^{d}	7.03^{bc}	7.20^{b}	7.03^{bc}
T.T.	7.03^{c}	6.58^{c}	6.38^{c}	6.48^{d}
1 (control)	7.23^{bc}	6.88^{bc}	6.53^{c}	6.65^{cd}

In a column, means with the same letter are not significantly different at $P \leq 0.05$

be explained that the use of oil containing ingredients (FFS) other than added oil would results in better distribution in the mixture, thus offered a finer structure of better uniformity (Boonyasirikool and Charunuch, 1999). Therefore, snack samples from formula 8 were selected as a prototype of nutritious soy fortified snack for nutritional value analysis.

Calories and protein content of nutritious soy fortified snack in comparison to market snacks

Protein content in the soy fortified formula 8 samples (9.9% or 2.15g /100 Kcal, Table 5) was slightly lower than the soy fortified formula 4 samples (10.36%, Table1) due to the lower protein content in FFS (43.6%) than in DFS (47.2%). Nevertheless, protein in soy fortified formula 8 was 46.67% and 70.69% higher than market snacks investigated by Plernchai *et al*. (1999) and Boonyasirikool *et al*. (1986), respectively. Table 5 shows that calories gained from the soy fortified snack (formula 8) was from protein, fat and carbohydrate at 8.60%, 35.97% and 55.43%, respectively. It could be noticed that the value of 8.60% is relatively high and closed to 10% which is recommended by Thai RDI and was higher than 5.66% and 4.85% detected in the two market snacks. In contrast, calories from fat in the soy fortified snack was 35.97% which was higher than 30% recommended by Thai RDI, but was much lower than 41.18% and 41.42% detected in two market snacks. In any case, it was stated by Tontisirin (1996) that frequently consume food in which more than 30% of calorie is generated from fat would definitely cause obesity and resulted in health problems. Nevertheless, with higher protein and crude fiber content and lower in fat than market snacks, the developed soy fortified snack could be regarded as a palatable and nutritious snack. Lowering of fat content could simply be achieved by decreasing the amount of coating oil.

Comparison of essential amino acid in the soy fortified snack; raw materials, breakfast cereal and FAO/WHO standard (1973)

Table 5 Comparision of caloric value, percent contributed by protein, fat, carbohydrate and protein per 100 Kcal of nutritious soy fortified snack to market snacks and recommended value.

Snack(100 g)	Protein (g)	Fat (g)	CHO (g)	Crude fiber (g)	Energy (Kcal)	Protein ← % total energy →	Fat	CHO	Protein (g)/100 Kcal
Market snack[1/]	6.75 (46.67%) ↑	21.85	63.46	1.20	477.5	5.66	41.18	53.16	1.41 (52.25%) ↑
Market snack[2/]	5.80 (70.69%) ↑	22.00	64.20	0.44	478.0	4.85	41.42	53.73	1.21 (77.68%) ↑
Nutritious soy fortified snack (formula 8)	9.90	18.40	63.80	4.00	460.4	8.60	35.97	55.43	2.15
THAI RDI	50	65	300	25	2,000	10	30	60	2.5 – 3.0

( ) ↑ The higher percentage of protein in nutritious soy fortified snack in compared to market snack

Source : 1/ Plernchai *et al.* (1999)

2/ Boonyasirikool *et al*. (1986)

Despite the lower amount of protein in broken rice, it was discovered that most of the essential amino acids other than lysine and methionine were higher than FAO/WHO recommendation (Table 6). In contrast to FFS, lysine was found slightly greater amount with the lesser amount of the rest of essential amino acids. Despite of the high protein content of FFS, 0.25% lysine was fortified in addition to the previous fortified 1% of a mixture of vitamins, minerals and methionine to improved protein quality. It was confirmed by chemical scores of 111 and 128 for lysine and methionine+cystine of the soy fortified snack samples displays in Table 6 and was higher than in broken rice (67, 82 respectively) and in FFS (70, 37 respectively). Furthermore, it was apparent that the content of all the essential amino acids in the nutritious soy fortified snack samples was higher than FAO/WHO recommendation and was almost the same as soy fortified breakfast cereal developed by Boonyasirikool and Charunuch (1999).

Comparison of nutritional value in soy fortified snack and Thai RDI

Analysis for a nutritional value of one serving (30 g) of the soy fortified snack was performed and the nutrition label is presenting in Table 7. Total calorie gained from one serving was 140 Kcal and in order to get 2000 Kcal that is required daily for one adult as stated in Thai RDI, 14.29 servings or 428.57 g of the snack must be consumed and would provide a nutrients in relation to the Thai RDI in percentage of 86% of carbohydrate, protein, vitamin A and B_1 ; 129% of fat ; 214% of vitamin B_2 and calcium; 140% of vitamin B_6, 428% of B_{12}, 357% of iodine and 157% of sodium. On the other hand, dietary fiber (57%), iron (57%) and potassium (29%) were existed in low quantity.

Table 6 Comparision of essential amino acid contents in nutritious soy fortified snack, raw materials, broken rice–based breakfast cereal and FAO/WHO standard (1973) in mg/g of protein.

Essential amino acid	Broken rice[1/]	FFS[1/]	Broken rice based breakfast cereal[2/] (6% FFS+10% DFS)	Nutritious soy fortified snack (formula 8) (9% FFS+9% DFS)	FAO/WHO[1/] 1973
Isoleucine	43	28	37(93)	33(82)	40
Leucine	80	37	61(87)	74(105)	70
Lysine	37 (67) [3/]	39 (70)	63(114)[3/]	61(111)[3/]	55
Methionine + cystine	29 (82)	13 (37)[3/]	36(103)[3/]	45(128)[3/]	35
Phenylalanine+ tyrosine	68	42	61(102)	65(108)	60
Threonine	39	28	33(83)	33(82)	40
Tryptophan	11	8	12(120)	10(100)	10
Valine	51	30	40(80)	38(76)	50

Source : 1/ Amino acid content of Thai foods. Nutrition Division, Health Dept; Ministry of Public Health. Jan 1990. ISBN 974-7955-60-1 39 p.

2/ Boonyasirikool and Charunuch (1999).

3/ Limiting amino acid

( ) Chemical score is the percentage of essential amino acid content in samples compared to the recommended content.

Table 7 Nutrition labeling of nutritious soy fortified snack (formula 8).

Serving size: 1 package (30 g)	
Serving per package: 1	
Amount per serving	
calories 140	Calories from Fat 50
	% Daily Value[1/]
Total fat 6 g	9%
Saturated fat 0.5 g	2%
Cholesterol 0 mg	0%
Protein 3 g	6%
Total carbohydrate 19 g	6%
Dietary fiber less than 1 g	4%
Sodium 270 mg	11%
Sugars 6 g	
Vitamin A	6%
Vitamin B_1	6%
Vitamin B_2	15%
Vitamin B_6	10%
Vitamin B_{12}	30%
Calcium	15%
Iron	4%
Iodine	25%
Potassium	2%

[1/] Percent Daily Values are based on a 2,000 kcal diet. Your daily values may be higher or lower depending on your calorie needs.

	Calories	2,000	2,500
Total fat	Less than	65 g	80 g
Saturated fat	Less than	20 g	25 g
Cholesterol	Less than	300 mg	300 mg
Sodium	Less than	2,400 mg	2,400 mg
Protein		50 g	62.5 g
Total carbohydrate		300 g	375 g
Dietary fiber		25 g	30 g

Calories per gram
Fat = 9 Carbohydrate = 4 Protein = 4

It could be noticed that the developed soy fortified snack were as nutritious as could be a good source of protein and several kinds of vitamin and minerals. It was possible to subjected to a nutritional claim for vitamin B_2, B_6, calcium, sodium as "good source", and B_{12} and iodine could claim as "rich in" according to the nutritional claim regulation of Thai Food Legislation. The further research could aim to decreasing the amount of coating oil and fortifying of dietary fiber to gain nutritional improvement.

CONCLUSION

It was feasible to develop an acceptable and nutritious soy fortified snack that was improved in quality and quantity of protein, vitamins and minerals. Physical and sensory quality of snack products depend largely on type and quantity of soybean flour, $CaCO_3$ and vegetable oil. The developed soy fortified snack was produced from 77% of corn grit and broken rice blends (50:50), 18% of soybean flour (9% DFS + 9% FFS), 1% $CaCO_3$, 3% refined sugar, 1% mixture of vitamins, minerals and methionine and 0.25% additional fortification of lysine. ER, BD and CF of the obtained snack was 3.90, 58 g/L, 60.17N, respectively. Protein content in the developed snack was 9.9% or 2.15 g for 100 Kcal. The content of fat, carbohydrate, dietary fiber were 18.4 0%, 63.80%, 4.0%, respectively and total energy gained from the snack was from protein, fat and carbohydrate at 8.60, 35.97, and 55.43%, respectively which was almost comparable to 10% 30% and 60% that was stated by Thai RDI. In addition, it was a good source of B_2, B_6, calcium and sodium and also rich in B_{12} and iodine. The snack gained a moderately high score in texture preference and acceptance (9-point hedonic scale). The scores were different and higher than two popular market snacks and control snack (0% soybean) at $P \leq 0.05$. Further improvement of textural quality is recommended to lower the ER to slightly below 3.50. The decreased ER would simultaneously reduce the absorption of coating oil which subsequently, reduce the oil content of the snack.

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