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Production of Healthy Protein and Snack Foods for Small-scale Industry from Full Fat Soy Flour

Chulaluck Charunuch*, Kritsana Temtrakool, Saovaluk Runggaeng, Urai Paosungthong and Warunee Varanyanond

ABSTRACT

A village texturizer has been developed in this study to produce healthy protein and snack food products from full fat soy flour. Owing to its uncomplicated technology, lower operating and maintenance costs, this machine could be used effectively at its optimum pressure and temperature to produce food products for small–scale industry. Full fat soy flour was produced with low heat treatment and used as a raw material in the production of healthy protein and snack foods. For protein food, the production conditions were varied as: full fat soy flour:sesame residue of 100:0, 90:10; temperature of 180, 200, 220 °C; pressure of 5 and 7 bar. On the other hand, the production conditions for snack foods were varied as: full fat soy flour:tapioca flour of 20:80, 30:70; temperature of 150 , 170 °C; pressure of 3, 5 and 7 bar . The products were then evaluated in terms of appearance, water holding capacity (only protein food), texture (hardness and chewiness / crispiness) and sensorial quality. The results showed that the production of protein food should be conducted using high full fat soy flour (100%), suitable pressure (5 bar) and not too high temperature (180°C) in order to get the best product with good shape, colour and texture. In contrast, the production of snack food should be conducted using low full fat soy flour (20%), low temperatme (150°C) and high pressure (7 bar) to get the smooth circular shape and good color with high expansion. Furthermore, both finished products were evaluated in terms of the nutrition labeling, which was fitted for protein and snack foods.

Key words: full fat soy flour, protein food, snack food, village texturizer

INTRODUCTION

Soybean and soybean products have long been known as healthful additions to our diet. Recent scientific findings (Clarkson, *et al*., 1998; Omoni and Aluko, 2005) confirm this belief that the emerging health benefits of soy consumption range from lowering risk of heart disease and certain types of cancer to alleviating menopausal symptoms and enhancing bone strength. Many different beneficial components have been identified, not only the three macronutrients such as complete proteins, carbohydrate and fat, but also vitamins and minerals, including calcium, folic acid and iron. In addition, consumption of soybean foods provides health benefits because many soyfoods are not only high in fiber, but low in total fat and high in soy phytochemicals called isoflavones. Moreover, many soyfoods have lower glycemic index, which help keep blood sugar

Institute of Food Research and Product Development, Kasetsart University P.O. Box 1043 Kasetsart, Bangkok 10903, Thailand.
* Corresponding author, e-mail: ifrclc@ku.ac.th

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levels more stable, making diabetes much easier to control.

Soybean is extremely versatile and can be made into a variety of foods (NSRL, 2006). The most common soybean foods, which Asian people consumed are tofu, miso and tempeh. American, on the other hand, consume much less soy in processed forms such as soy drinks, breakfast cereals, energy bars and soy "burgers". Hence, this research attempted to utilize full fat soy flour, especially from non–GMO production in Thailand, to develop healthy protein and snack foods with the hope to benefit from many nutrients and bioactive compounds in soybean. To facilitate the production at a small scale. the machine with intermediate technology called "village texturizer" (Anonymous, 1977) was developed at the Institute of Food Research and Product Development, Kasetsart University. The major advantages of the machine are its low cost and it requires no special knowledge. It was found that the machine was capable of producing a wide variety of circular puffed products such as texturized products and snack foods, which are both highly nutritious and tasty. Another noted advantage of the machine is that it could be used in a variety of circumstances, from home to small business.

MATERIALS AND METHODS

Construction of "village texturizer"

The village texturizer, as shown in Figure 1, was constructed at the Institute of Food Research and Product Development, Kasetsart University. The machine has been modified from its predecessor into a stainless steel machine (from the original mild steel machine) to comply with the food safety requirement. In addition, it has been modified such that it could be operated automatically using a pneumatic system (compared with the original manually operated machine). This allows a convenient operation at high pressure.

Preparation of raw material (full fat soy flour)

The full fat soy flour was prepared from good quality soybean using low–heat treatment following the steps outlined in Figure 2. The flour was then analysed for its proximate compositions and PDI (Protein Dispersibility Index). The results were also compared with those of full fat soy flour from the Royal Project produced by high-heat treatment (140°C).

Production of protein food (texturized product)

For the production of protein food, full fat soy flour was first mixed with water at the ratio

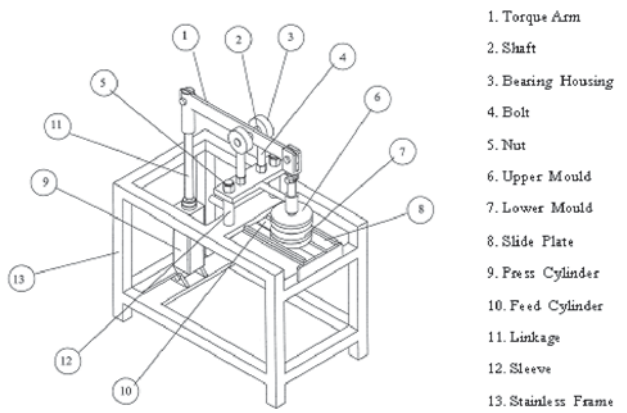

Figure 1 The modified "Village Texturizer".

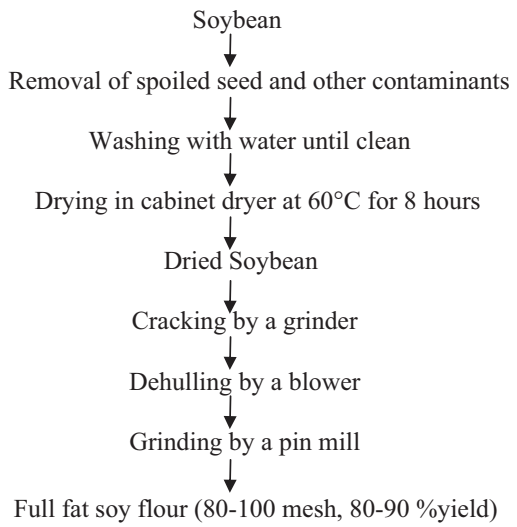

Figure 2 Processing steps of full fat soy flour by low heat treatment.

of flour: water of 5:2 and then kneaded slowly in a Kenwood Mixer to make dough. The dough was split into small balls (10 grams per each) and pressed by hand into flat shape. Each flat shape was then put in the cup (lower mould) of the village texturizer; the lid (upper mould) was centered over the cup and pressed with the setting temperature and pressure for 8 seconds. Then, the lid was released from the cup to get the puffed and texturized product, which was dried later in a cabinet dryer at 80°C for 30 minutes. The finished product could be used as meat substitute by soaking it in water and prepared as desired.

To design the experiments, the 2×2×3 factorial design was employed with three variables, namely, the ratio between full fat soy flour and residual sesame (100:0, 90:10), pressure (5, 7 bar) and temperature (180, 200, 220°C). The products were examined in terms of their appearance, water holding capacity, texture and sensorial quality. Statistical analysis (ANOVA and Duncan's multiple range test was performed to select the most appropriate product from nutrition labeling point of view.

Production of snack food

For the production of snack food, all ingredients (full fat soy flour, tapioca flour, spice and seasonings) were mixed with hot water and kneaded together to make dough with rod shape. After that the dough was steamed for 45 minutes, cooled and kept in a refrigerator overnight. Finally, the dough was sliced into small round pieces, and puffed with village texturizer under the predetermined setting temperature, pressure for 8 seconds. The puffed product had expandable structure with crispy texture suitable for eating as snack.

To design the experiments, the 2×3×2 factorial design was employed with three variables, namely, the ratio between full fat soy flour and tapioca flour (20:80, 30:70), pressure (3, 5, 7 bar) and temperature (150, 170 °C). The products were examined in terms of their appearance, texture and sensorial quality. Statistical analysis (ANOVA and Duncan's multiple range test was performed to select the most appropriate product from nutrition labeling point of view.

Measurement of physical properties

Water holding capacity (Joseph et al., 1988): Small amount of sample was first weighed and then soaked with water at room temperature for 20 minutes. Excess water was drained for 5 minutes. The sample was then reweighed. The water holding capacity was then calculated as:

Water holding capacity = (Rehydrated wt. – Original wt.) / Original wt.

Texture measurement : The TA-XT2i Texture Analyzer was fitted with the Warner Bratzler Blade Set (HDP/BSK) / the Crisp Fracture Rig (HDP / CFS) and 1/4″ Ball Probe (P/0.255) and used to measure the hardness / chewiness / crispiness of the samples.

Sensory evaluation

The sensory evaluation was conducted

with trained panelists who had experiences with food product development using a 9–point hedonic scale (1–extremely dislike to 9–extremely like) to determine the preference in terms of colour, odor, taste, texture and acceptance of protein and snack food products.

RESULTS AND DISCUSSION

Proximate analysis and protein dispersibility index (PDI) of full fat soy flour

As can be seen in table 1, the proximate analysis showed that full fat soy flour is a good source of proteins and dietary fiber, hence is suitable for the production of healthy food. Comparing with the product obtained from high–heat treatment, the PDI of full fat soy flour from low–heat treatment was higher, indicating the higher protein functionality, which is related to good fiber formation and cross–linking of protein molecules for texturized product (Harper, 1981).

Effects of operating conditions on physical properties of protein/texturized food from village texturizer

The quality of protein/texturized foods as affected by the operating conditions of the village texturizer is shown in Table 2. It was found that the ratio between full fat soy flour and residual sesame had significant effect on the water holding capacity and textural quality of protein food. Due to the better protein functionality of soybean, when other raw materials, such as residual sesame, were added into the mixture, the structure of protein food would have less fiber formation ability and was more dense, making the product had higher hardness and lower water holding capacity. For temperature, it did not have any significant effect on the water holding capacity but had a significant effect on the hardness because too much heat would burn the product, making it darker and harder. The last variable, which had more significant effect on physical properties of protein food is pressure. When using higher pressure, the product would be expanded more and have higher water holding capacity, lower hardness and chewiness, so it would be spongy after soaking in water. However, when higher pressure was applied along with higher temperature conditions, the product would be broken apart to get worse shape with black brown colour. Nevertheless, the sensory evaluation did not show any significant difference because the protein food used in prepared dish had better appearance. The optimum conditions for the production of protein food are the use of higher full fat soy flour (100 %) at 5 bar and 180 °C) in order to get the best product with good shape, colour and texture.

Table 1 Proximate analysis and protein dispersability index (PDI) of full fat soy flour.

Composition	Full fat soy flour	
	Low–heat treatment	High–heat treatment
Moisture (%)	5.50	4.80
Fat (%)	19.13	20.12
Protein (%)	41.20	38.87
Ash (%)	5.04	4.94
Carbohydrate 1/ (%)	29.13	31.27
Dietary fiber (%)	7.72	13.99
PDI	61.53	26.32

1/ not including dietary fiber

Table 2 Physical properties of protein food produced by village texturizer at different operating conditions.

Operating condition			Appearance	Water	Texture Measurement		Sensory Test				
Composition FFS[1/] : S[2/]	Pressure (bar)	Temperature (°C)		Holding Capacity	Hardness (g)	Chewiness	Color	Odor	Taste	Texture	Acceptance
100:0	5	180	good shape, best color, good texture	2.55^{a}	951.08^{A}	708.80^{A}	7.42^{a}	6.80^{a}	6.38^{AC}	5.77^{A}	6.38^{AC}
100:0	7	180	moderate shape, best color, moderate texture (spongy)	3.4^{b}	668.31^{B}	525.51^{B}	7.50^{a}	6.76^{a}	6.18^{AI}	5.92^{A}	6.18^{AGH}
90:10	5	180	good shape, good color, moderate texture (more dense)	2.0^{ac}	1074.65^{C}	895.21^{C}	6.96^{a}	6.68^{a}	5.95^{AJ}	5.69^{A}	5.80^{AMN}
90:10	7	180	moderate shape, good color, good texture	2.49^{bc}	787.69^{D}	591.12^{D}	6.35^{a}	6.38^{a}	6.41^{AD}	5.38^{A}	6.34^{AD}
100:0	5	200	good shape, moderate color, good texture	2.76^{a}	1187.99^{E}	862.97^{E}	7.04^{a}	6.84^{a}	6.34^{AG}	5.85^{A}	6.03^{AIJ}
100:0	7	200	moderate shape, moderate color, moderate texture (spongy)	3.59^{b}	633.14^{F}	510.16^{F}	7.27^{a}	6.68^{a}	6.41^{AE}	6.15^{A}	6.80^{A}
90:10	5	200	good shape, moderate color, moderate texture (more dense)	2.24^{ac}	2019.52^{G}	1450.21^{G}	6.65^{a}	6.03^{a}	5.68^{AK}	4.92^{A}	$4.99^{BCDEGIKM}$
90:10	7	200	moderate shape, moderate color, good texture	2.73^{bc}	970.11^{H}	760.53^{H}	7.12^{a}	6.60^{a}	6.26^{AH}	5.92^{A}	6.18^{AEF}
100:0	5	220	moderate shape, not good color (black brown), good texture	2.61^{a}	1118.30^{I}	875.90^{I}	7.81^{a}	6.84^{a}	6.72^{A}	5.92^{A}	6.57^{A}
100:0	7	220	not good shape, not good color (black brown), moderate texture (spongy)	3.66^{b}	655.54^{J}	524.98^{J}	7.27^{a}	6.53^{a}	6.41^{AF}	5.85^{A}	6.03^{AKL}
90:10	5	220	moderate shape, not good color (black brown), moderate texture	1.68^{ac}	2605.84^{K}	1976.43^{K}	6.42^{a}	5.72^{a}	4.53^{B}	4.08^{A}	4.14^{B}
90:10	7	220	not good shape, not good color (black brown), moderate texture	2.12^{bc}	1001.01^{L}	840.30^{L}	6.42^{a}	6.41^{a}	$5.30^{BCDEFGHIJK}$	5.23^{A}	4.84^{BFHJLN}

1/ Full fat soy flour
2/ Sesame

Table 3 Physical properties of snack food produced by village texturizer at different operating conditions.

Operating condition			Appearance	Texture Measurement		Sensory Test				
Composition FFS[1/] : TP[2/]	Pressure (bar)	Temperature (°C)		Hardness (g)	Chewiness	Color	Odor	Taste	Texture	Acceptance
20:80	3	150	good shape, good color (white brown)	643.21^{A}	5.50^{A}	7.63^{A}	6.62^{A}	5.83^{A}	5.89^{A}	6.07^{A}
20:80	5	150	good shape, good color (white brown)	628.09^{A}	4.60^{A}	6.86^{AEFGH}	5.69^{A}	6.60^{A}	6.52^{A}	5.60^{A}
20:80	7	150	good shape, good color (white brown)	442.59^{A}	3.80^{A}	7.40^{AC}	6.15^{A}	6.75^{A}	6.90^{A}	6.99^{A}
30:70	3	150	moderate shape, good color	648.02^{A}	3.90^{A}	7.33^{AD}	5.85^{A}	5.90^{A}	6.67^{A}	6.49^{A}
30:70	5	150	moderate shape, moderate color	563.44^{A}	5.00^{A}	6.86^{AIJKL}	5.77^{A}	5.52^{A}	6.29^{A}	5.60^{A}
30:70	7	150	not good shape, not good color (black brown)	485.28^{A}	3.20^{A}	5.10^{BMR}	5.23^{A}	4.83^{A}	5.60^{A}	5.22^{A}
20:80	3	170	not good shape, moderate color (brownish)	348.70^{B}	3.60^{B}	6.25^{AMNOPQ}	5.62^{A}	6.13^{A}	6.44^{A}	6.68^{A}
20:80	5	170	moderate shape, moderate color (brownish)	523.33^{B}	3.90^{B}	$5.79^{BCDEINS}$	5.77^{A}	5.67^{A}	6.36^{A}	5.80^{A}
20:80	7	170	moderate shape, moderate color (brownish)	363.19^{B}	2.60^{B}	5.25^{BFJOT}	5.85^{A}	6.21^{A}	7.06^{A}	6.26^{A}
30:70	3	170	not good shape, moderate color (brownish)	394.96^{B}	3.90^{B}	6.10^{ARSTUV}	6.15^{A}	6.21^{A}	6.98^{A}	6.30^{A}
30:70	5	170	not good shape, moderate color (brownish)	340.46^{B}	3.10^{B}	5.25^{BGKPV}	6.23^{A}	5.90^{A}	6.98^{A}	5.72^{A}
30:70	7	170	not good shape, not good color (black brown)	462.23^{B}	3.30^{B}	5.25^{BHLQV}	6.00^{A}	5.52^{A}	6.21^{A}	5.60^{A}

1/ Full fat soy flour
2/ Tapioca flour

The effect of operating conditions on physical properties of snack food from village texturizer

From Table 3, although it is seen that temperature had a significant effect on textural properties (hardness and crispiness) of the product, the sensory evaluation did not show the significant effect of temperature on the odor, taste, texture and acceptance of the product. For the appearance, higher temperature (170°C) and higher full fat soy flour (30%) tended to produce the product with poor shape and worse color due to lower starch component and high heat treatment. Therefore, the optimum conditions for the production of snack food should be the use of low full fat soy flour (20%) and low temperature (150°C) in order to get the smooth circular shape and good color product. On the other hand, the pressure of 7 bar should be used as it gave the product with more expansion, hence higher level of crispness, which is desirable for snack food (Ding *et.al.*,2006).

Nutrition labeling of healthy protein and snack foods

According to the high protein (42%), high dietary fiber (21%) and no cholesterol contents of protein food as shown in Table 4, this product can be used as a meat substitute to prepare various healthy dishes. Similarly, the nutrition facts of snack food have shown that this food contains suitable calories, low fat, high protein, high dietary fiber, low sodium and no cholesterol, which corresponds to the recommended dietary guidelines for snack foods.

CONCLUSION

To promote and add value to Thai agricultural soybean, full fat soy flour from low–heat treatment was utilized to produce protein and snack foods through the use of an intermediate technology machine called "Village Texturizer". The machine can be constructed in Thailand with low cost and can be used to develop healthy protein and snack foods at both the home scale level and small business. Both products enhance good consuming behavior and provide alternative choices of health food for Thai consumers.

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Table 4 Nutrition labeling of healthy protein and snack foods.

Protein food			Snack food		
Nutrition facts			Nutrition facts		
Serving size : 1 package (100 g)			Serving size : 1 package (30 g)		
Serving per package : 1			Serving per package : 1		
Amount per serving			**Amount per serving**		
Calories 440 kcal			**Calories** 120 kcal		
		% Daily Value*			% Daily Value*
Total fat	17 g	26 %	**Total fat**	1 g	2 %
Cholesterol	0 mg	0 %	**Cholesterol**	0 g	0 %
Protein	42 g		**Protein**	3 g	
Total Carbohydrate	31 g	10 %	**Total Carbohydrate**	23 g	8 %
Dietary fiber	21 g	84 %	Dietary fiber	1 g	4 %
Sugar	4 g		Sugar	2 g	
Sodium	5 mg	0 %	**Sodium**	260 mg	11 %
* Percent Daily Values are based on a 2000 calorie diet.			* Percent Daily Values are based on a 2000 calorie diet.		

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