The Study of Drying Condition for Local Dried Fermented Soy Bean (Thua Nao)

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***Abstract*—This research aims to study an optimum drying condition for the semi-dried fermented soybean and further produce a seasoning rice flake with spicy flavor. Three drying temperatures of 120, 130 and 140 ℃ were studied. The chemical and physical properties of the dried fermented sample soybean were analyzed and compared with a reference sample from a community product (Phrao district, Chiangmai province, Thailand). It was found that the chemical and physical properties of the sample dried at temperature of 130 ℃ for 35 minutes was similar to that of the community product (Phrao district, Chiangmai provinve, Thailand). The lightness (L^*) was 51.74±0.60, redness (a^*) was 5.31±0.39 and yellowness (b^*) was 20.35±1.09. The moisture content was 4.65±0.19% wet basis. The water activity (a_w) was 0.26±0.02. The overall sensory acceptance was moderate (7.27±0.59). After that the dried fermented soy bean was used to develop the seasoning rice flake (spicy flavor). The recipe from the commercial product was applied with a ratio of 35 percentage of the dried fermented soybean flake. The sensory test on the seasoning rice flake was evaluated. It was found that the overall acceptance on the spicy flavors of seasoning rice flake from the panelists was moderate with the score of 7.44±1.01.**

***Index Terms*—dried fermented soybeans, drying, seasoning rice flake**

I. Introduction

Seasoning rice flake is a mix seasoning specially made to sprinkle on top of rice to add flavor to plain rice. Japan is the origin of seasoning rice flake. There are many flavors in the market such as wasabi, seaweed, salmon and egg [1]. However, the flavors do not suit Thai taste since Thais are keen on spicier flavor.

Fermented soy bean is Thai local product popular in northern part of Thailand. The product, like other fermented soy bean product around the world, derived from an alkaline fermentation process [2]. The alkaline fermentation process is a process of high-protein food fermentation which lead to an alkaline condition. *Bacillus* spp. are major bacteria in soy bean fermentation. During the process, the bacteria produce protease enzyme which catalyze proteins in soy bean to peptides and amino acids. Fermented soy bean paste is the final product of the fermentation process. However, water activity in the fermented soy bean paste is high which lower its shelf life therefore the semi-dried fermented soybean is more common in the market. Moreover, dried fermented soy bean is used in various northern Thai recipes because of their umami flavor.

According to the characteristic of fermented soy bean, it has a potential to be developed as a seasoning rice flake that suit Thais' taste. Generally, the traditional process can produce only the semi-dried product, so the moisture content was still high. This product can not be used to produce the seasoning rice flake since high moisture content of the product can cause lump. To reduce the moisture content of the semi-dried fermented soy bean is essential. However, the process of dried fermented soy bean is a traditional process at the present, which doesn't meet up the food industry standard. It was necessary to investigate the commercial process for drying the semi-dried fermented soy bean. Therefore, this research aims to study the optimum drying condition for the semi-dried fermented soybean in order to reduce the moisture content for developing the seasoning rice flake. The seasoning rice flake will then be sensory evaluated in order to assess a possibility to make a commercial product. The raw material of semi-dried fermented soybean from the local village in the northern part of Thailand (Phrao, Chiangmai province) was used as the sample in this study (Fig. 1).

Figure 1. Semi-dried fermented soy bean from a local

II. Material and Methods

The methods of this study can be divided into two parts which were the study of drying condition for the semi-dried fermented soy bean and the development of seasoning rice flake from the dried fermented soy bean.

A. The Study of Drying Condition for the Semi-dried Fermented Soy Bean

The semi-dried fermented soy bean in this study was provided by a villager in Phrao district, Chiangmai

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province, Thailand. The initial weight and size of the sample was controlled as 20-22 grams/disk, 1-1.5 mm of thickness and 127-152 mm of diameter. The moisture content of the sample was preliminary analyzed. Then, the semi-dried fermented soy bean was dried at three temperatures (120 130 and 140 ℃) in a hot air oven and the sample was removed to measure their moisture content and weight every 5 minutes until the moisture content and weight stay constant. After that, the physical properties such as the moisture content, water activity, color and sensory of the final products were analyzed. The moisture content was measured by using the moisture analyzer (Moisture Analyze, MB54, OHAUS, Switzerland), Water activity meter (Novasina, AW Center) was used to measure water activity (aw) and the color was measured using a colorimeter (MINOLTA, CR-400). There were 4 replications for this study. After that, the moisture content in dry basis was used to plot the drying curve.

B. *The Development of the Seasoning Rice Flake from Dried Fermented Soy Bean*

The dried fermented soy bean from the best condition in the previous step was used to develop the seasoning rice flake in the spicy flavor. The recipe of the spicy flavor was adapted from the chili seasoning rice flake Thai local brand and shown in Table I.

TABLE I. THE RECIPES OF THE SEASONING RICE FLAKE FROM DRIED FERMENTED SOY BEAN: SPICY FLAVOR

Ingredients	Amount (Percentage)	
	Thai chili seasoning rice flake	Dried fermented soy bean seasoning rice flake
Dried fermented soy bean	-	35
Dried fried shallot powder	25	15
Dried garlic powder	25	25
Chili powder	25	5
Textured vegetable protein	20	10
Sugar	-	7
Salt	5	3

C. *Sensory Evaluation*

Figure 2. The seasoning rice flake sample mixed with the rice

To investigate cusumer acceptability on the seasoning rice flake, a sensory evaluation was conducted using a 9-point hedonic scale with 50 untrained panelists ranging from 18 to 65 years of age. Prior to evaluation the seasoning rice flake sample was mixed with the rice in a ratio of 1:3 w/w (Fig. 2) and served to panellist seated separatly in booths in order to allow unbiased evaluation of the sensory attributes. Samples of seasoning rice flake were evaluated in terms of product specific colour, odour, flavor, texture and overall acceptability on a 9-point hedonic scale. The acceptability attributes were valued from the lowest score 1 (dislike extremely) and the highest score 9 (like extremely).

To design an experiment in this study, a Completely Randomized Design; CRD was used. Experimental data was statistically analyzed using EXCEL (version 2016) software program. One-way analysis of variance (ANOVA) was performed with drying condition and recipe ratio as factors and $P < 0.05$ was taken as indicator of statistical differences between the means. The differences among mean values of all data were also tested using EXCEL software program using Turkey's multiple comparison test method at 95% confidence intervals.

III. RESULT AND DISCUSSION

A. *The Drying Behavior of the Semi-dried Fermented Soy Bean*

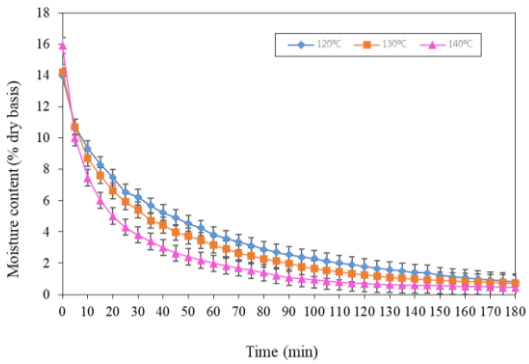

Figure 3. The drying curve of dried fermented soy bean at drying condition of 120 130 and 140 ℃.

The initial moisture content of the sample was measured prior to study the drying condition for the semi-dried fermented soy bean. The initial moisture content of the samples was between 13.95±0.98 and 15.90±0.59% dry basis (d.b.). During drying process, the fermented soy bean samples under three levels of drying condition was removed to measure the moisture content every 5 minutes in wet basis and converted to dry basis to plot the drying curve (Fig. 3). It can be seen that the moisture content of the semi-dried fermented soy bean decreased with an increasing time. A drying rate of the high drying temperature (140 ℃) was faster than that of a lower drying temperature (130 and 120 ℃). This was because the difference of temperature gradient between inner and outer the sample was large under high temperature drying condition [3]. The drying curve profile can be divided into two periods of drying which were falling and constant rate periods which was normally found in the semi-dried food or agricultural product [4]. The falling

rate drying period was found during the initial drying time between 0 and 70 minutes, after that the constant rate drying period occurred from 80 minutes until 180 minutes of the drying time. Similar results were obtained in pumpkin, corn, garlic, leek and green pepper which had the moisture content of around 10-15% d.b. [5]. According to an appropriate moisture content of the dried fermented soy bean for producing the seasoning rice flake was below 4-5%w.b. or 5-6 %d.b. (preliminary study result from the reference sample product from the community). Therefore, a suitable drying time for the semi-dried fermented soy bean drying under each drying temperature conditions were 45, 35 and 20 minutes for drying temperature of 120, 130 and 140 ℃, respectively.

B. The Physical and Chemical Properties of Dried Fermented Soy Bean under Drying Condition of 120 130 and 140 ℃

The dried fermented soy bean from the optimum time for each drying temperature in the previous study comparing with the reference sample are presented in Fig. 4.

(a) (b) (c) (d)

Figure 4. The appearance of dried fermented soy bean drying at temperature of (a) 120 (b)130 and (c) 140 ℃ and (d) reference sample.

TABLE II. THE PHYSICAL AND CHEMICAL PROPERTIES OF DRIED FERMENTED SOY BEAN POWDER

Drying condition	MC (%w.b.)	aw	Colour		
			*L**	*a**	*b**
Reference sample from the community (Roasting at 180 ℃,10 s)	4.84±0.48[a1]	0.28±0.01[a]	51.28±0.31[a]	5.90±0.02[a]	19.96±0.10[a]
120 ℃, 45 min	4.69±0.35[a]	0.28±0.01[a]	51.72±1.12[a]	5.31±0.43[b]	21.33±0.99[a]
130 ℃, 35 min	4.65±0.19[a]	0.26±0.02[a]	51.74±0.60[a]	5.31±0.39[b]	20.35±1.09[a]
140 ℃, 20 min	4.67±0.16[a]	0.27±0.01[a]	52.96±1.38[b]	5.32±0.18[b]	21.59±0.52[b]

[1]Mean ± standard deviation (n = 4). Means within a column bearing the same superscript letter were not significantly different ($p > 0.05$).

The physical and chemical propoerties of the dried fermented soy bean drying at temperature of 120, 130 and 140 ℃ were then measured. The moisture content (%wet basis), water activity (aw) and the colour of the dried fermented soy bean were compared to the reference sample from the community product (traditional manufaturing) (Table II). The moisture content of the dried fermented soy bean at drying temperature of 120, 130 and 140 ℃ were 4.69±0.35, 4.65±0.19 and 4.67±0.16%w.b., respectively, which were close to that of the reference sample from the community which was 4.48±0.48%w.b. These all moisture content values were below the critical moisture content (10%w.b.) for microbrial growth in a dried food product [6]. From the statistical analysis using Tukey's method, it was found that the moisture contents of all samples were not significantly difference at the 95% confidence level.

The water activity (aw) of the dried fermented soy bean at drying temperature of 120, 130 and 140 ℃ were 0.28±0.01, 0.26±0.02 and 0.27±0.01, respectively and they were close to that of the reference sample from the community (aw=0.28±0.01). They were all below the critical value for the dried food product (aw=0.6) [7], [8]. There was no difference among the water activity at the 95% confidence level.

TABLE III. THE SENSORY EVALUATION ON THE DRIED FERMENTED SOY BEAN

Drying condition	Colour	Flavor	Taste	Overall acceptance
Reference sample from the community (Roasting at 180 ℃,10 s)	7.00±0.53[a1]	7.20±0.77[a]	6.93±0.70[a]	7.40±0.73[a]
120 ℃, 45 min	6.67±0.72[a]	6.47±0.63[b]	6.60±0.73[a]	6.20±0.86[b]
130 ℃, 35 min	6.93±0.70[a]	6.87±0.83[a]	6.87±0.74[a]	7.27±0.59[a]
140 ℃, 20 min	6.80±0.67[a]	6.60±0.91[b]	6.80±0.67[a]	7.13±0.63[b]

[1]Mean ± standard deviation (n = 4). Means within a column bearing the same superscript letter were not significantly different ($p > 0.05$).

The colour of the sample was measured in term of *L** (lightness), *a** (redness) and *b** (yellowness) [9], [10] and shown in Table III. It was found that the lightness (*L**) of dried feremented soy bean from the community and dried at 120, 130 and 140 ℃ were 51.28±0.31, 51.72±1.12, 51.74±0.60 and 52.96±1.38, respectively. It can be seen that the lighness of the dried fermented soy bean increased with increasing of drying time and temperature since a Maillard browning reaction occured at the surface of the sample [11]-[16]. As browning reaction is the reaction between reducing sugar and amino acid which is normally found in the fermented soy bean. The lightness of the dried fermented soy bean at drying temperature of 140 ℃ was the lightest and the darkest was found in the reference sample from the community. This was because the reference sample was roasted at high temperature (180 ℃) even using shorter time. However, when comparing among the same drying method of oven drying, it was found that the sample dried at 140 ℃ was the lightest because drying time at 140 ℃ was shorter than other temperature conditions [17]-[19]. The lightness of dried fermented soy bean at 120, 130 ℃ and the reference sample from the community were not significantly difference but they were difference from the sample at 140 ℃ at the 95% confidence level. The redness (*a**) of the samples dried at 120, 130 and 140 ℃

were 5.31±43, 5.31±0.39 and 5.32±0.18, respectively. They were not significantly difference among them but they were difference from the reference sample from the community (a^*=5.90±0.02). The redness of the reference sample was higher than that of the sample dried in the hot air oven because drying time of the roasting process was shorter than that of the hot air oven drying process. The yellowness (b^*) of the sample were 19.96±0.10, 21.33±0.99, 20.35±1.09 and 21.59±0.52 for the reference sample from the community, the sample dried at 120, 130 and 140 ℃, respectively. Only sample from drying at 140 ℃ was difference from other, it was the highest yellowness value because less browning reaction took place. The lowest browning reaction was found in this condition due to the shortest time comparing with other in the same drying method and lower temperature comparing with the roasting method [17]-[19]. From the result, it can be concluded that the colour of sample dried at 120 and 140 ℃ including the sample from the community were in shade of dark yellow brown except the sample dried at 130 ℃, which was the light yellow brown colour.

C. The Sensory Evaluation

In order to select the best sample for developing the seasoning rice flake, the sensory evaluation was conducted and the result was shown in Table III. The reference sample from the community showed the highest score of all sensory attributes which were 7.00±0.53, 7.20±0.77, 6.93±0.70 and 7.40±0.73 for the colour, flavor, taste and overall acceptance, respectively. This was because the roasting method provided a good characteristic of the reference sample such as good colour and flavor due to browning reaction. The volatile compounds such as heterocyclic compounds: thiophenes, thiazoles, pyrazines, pyrroles, imidazoles and pyridines were produced from the browning reaction [20]. More volatile compounds were highly produced at high temperature [21]. The colour, flavor, taste and overall acceptance score of sample dried in the hot air oven were between 6.67±0.72 and 6.93±0.70, 6.47±0.63 and 6.87±0.83, 6.60±0.73 and 6.87±0.74 and 6.20±0.86 and 7.27±0.59, respectively. The acceptability in all samples for every sensory attributes were like moderately among the panelists. There was no significantly difference in colour and taste at 95% confidence level for all dried fermented soy bean. However, the difference was found in the flavor and overall acceptance for the sample dried at 120 and 140 ℃. The sample dried at 130 ℃ had very close values of sensory evaluation to the reference sample in every sensory attributes and they were not significantly difference at 95% confidence level from the reference sample. Therefore, drying condition of 130 ℃ for 35 minutes provided the good quality of dried fermented soy bean and the product characteristics were similar to the reference sample from the community.

D. The Development of Seasoning Rice Flake from the Dried Fermented Soy Bean

The best dried fermented soy bean from the drying condition of 130 ℃ for 35 minutes was further applied to develop the seasoning rice flake in Thai spicy flavor. A sensory evaluation was conducted on the seasoning rice flake from dried fermented soy bean to investigate the acceptability of the consumer on the developed product. The sensory evaluation showed high score for all sensory attributes, the score was between 6.96±1.26 and 7.44±1.01 (Fig. 5). The consumer acceptability was like moderately to like very much. The overall acceptance showed the highest score (7.44±1.01) followed by the colour (7.40±1.56), flavor (7.20±1.08), texture (7.08±0.96) and taste (6.96±1.26). From the result, it can be concluded that the dried fermented soy bean was possible to use to produce the seasoning rice flake in commercial product.

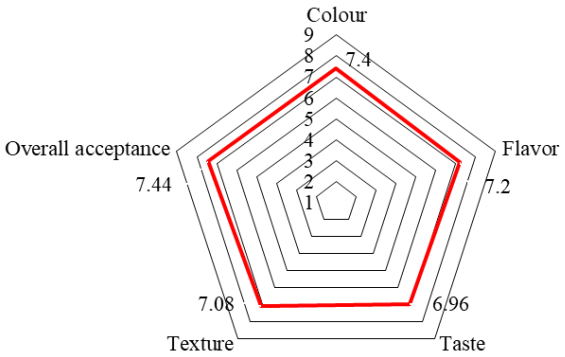

Figure 5. Spider web diagram of the sensory evaluation of the seasoning rice flake from dried fermented soy bean

IV. Conclusion

The drying condition of 130 ℃ for 35 minutes in the hot air oven was the suitable condition for drying the semi-dried fermented soy bean to reduce the moisture content to 4.65±0.19% w.b. In addition, the physical and chemical properties (moisture content, water activity and colour) and sensory evaluation value of the characteristic of sample dried at this drying condition were similar to the reference sample from the community. The consumer moderately to highly accepted in the dried fermented soy bean including to their application in producing the seasoning rice flake. The overall acceptance score for the seasoning rice flake was 7.44±1.01which is like moderately to like very much.

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