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Original Research Article

Development of fish cracker from surimi supplemeted with pumpkin

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ABSTRACT

The objective of this study was to develop a new fish cracker recipe in order to improve product qualities by substituting the fish meat with surimi (*Nemiterus hexodon*) and replacing cassava starch with pumpkin for having higher nutritional values. Fish cracker from surimi consisted of the following ingredients: surimi (58.0%), cassava starch (38.0%), salt (2.0%), sugar (1.5%), MSG (0.5%). For the replacement formula, cassava starch and pumpkin were incorporated in difference ratios (93:7, 89:11, 85:15, 81:19 and 77:23 %w/w). The sensory evaluation tests showed that the most acceptable formulations of the cracker were obtained using 85%cassava starch and 15%pumpkin combinations. Hardness, crispness and swelling ratio increased with increasing of pumpkin. Scanning electron microscope (SEM) revealed that the internal structure of cracker were significantly affected by the amount of pumpkin. Increase of the addition of pumpkin up to 15% result the formation of smaller air cells and thicker pore walls. The chemical compositions of the cracker including, moisture, protein, fat, ash and carbohydrate content were 2.00%, 11.82%, 35.34%, 3.00% and 47.84% respectively. The scores obtained in the consumer test (5 point hedonic scale) were: color (4.35), odor (4.23), taste (4.56), crispness (4.65) and overall preference (4.60). This research showed that the product can be extended to commercial production.

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INTRODUCTION

Fish cracker is a very popular food product which is widely consumed in the Southeast Asian countries. The snacks are suitable for all genders and ages. Currently, there were various scientific research to have improved fish cracker product such as types of fish and quality (Zzaman et al., 2017; Kaewmanee et al., 2015) and to improve the tasted of cracker (Mir et al., 2017). Also, nutritional enhancement to create new fish cracker for consumer's need (Chai-Mongkol, 2012). The product highlight of these snacks are rich in protein (>10%). However, it usually has dark objectionable colors due to the fish content and it has a fishy smell that may have an effect on consumer purchase intention. The guideline for potential development of fish cracker should focus on improving the color and flavor of the product, couple with texture characteristics of the product.

The development of fish cracker product by using surimi substitutes for fish meat is a potential enhancement of the product, since surimi is a finely grounded fish fillets that removes blood fat and fishy odors. Surimi is also produced at the industry level, enabling the manufacturer of the cracker to choose the type of fish that will be used as raw material. In general, producing cracker using surimi is easier than producing cracker using fish meat. The preparation of fish meat to be used as a mixture of cracker must be carried out through a process of cutting cleaning and grinding fish, which is a step the requires personnel management and sanitation in the factory. If this process is produced, it will make the management of the factory sanitary easier. In addition, the nutritional value added to the fish cracker product by adding a nutritious carnations, especially β-carotene (29% of the recommended daily intake), is an antioxidant in meat. Pumpkin is low in calories and rich in vitamin A needed by our bodies for good eyesight and healthy skin. Pumpkin's yellow color adds to the nutritional value and makes the color of the product more desirable.

Therefore, this study was conducted to investigate the effects of different ratios of cassava starch to pumpkin on the physicochemical properties of the surimi cracker and consumer testing to study the feasibility of commercial production.

MATERIALS AND METHODS

1. Study on the formulation of fish cracker production from surimi

The basic formula of fish cracker was obtained by using the observation area of fish cracker production at Ban Dao, Thambon Leam Pho, Amphoe Yaring, Pattani Province. Further, the production of fish cracker was carried out by replacing fish meat with surimi from ORNATE THREADFIN BREAM (*Nemipterus hexodon*). This develop formulation consisted of 58%surimi, 38%cassava starch, 2%salt, 1.5%sugar and 0.5%MSG. The making process are illustrated in Figure 1.

The acceptance criteria of the fish cracker from surimi is based on the sensory score assessment of 40 untrained panelist (9-point Hedonic Scale). The score must not less than 80% in term of appearance color odor taste and overall preference.

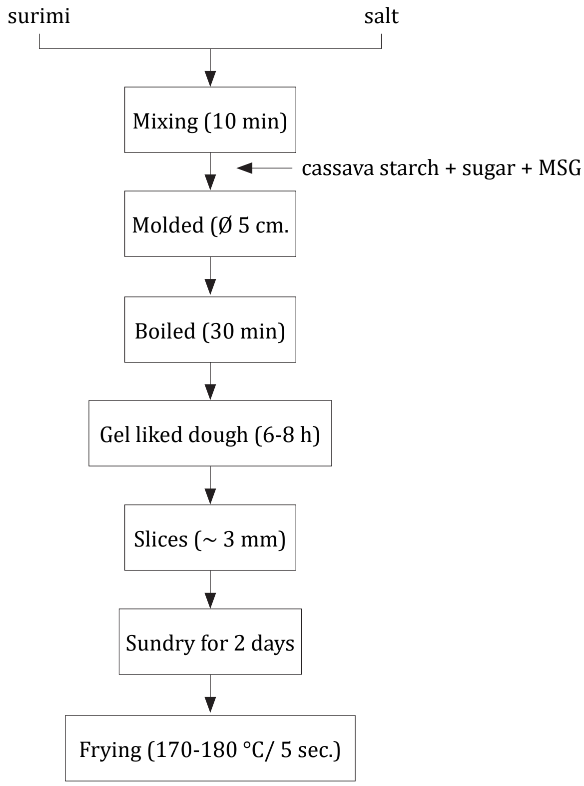

Figure 1. The process of making fish cracker from surimi

2. Study on the replacement of cassava starch with pumpkin in fish cracker production from surimi

The experiment was carried out in accordance with the formula and process of the study from step 1. Pumpkin (*Cucurbita maxima*) were harvested from a field at a local farm in Yala district of Thailand. It is a leafy green vegetable with moderately hard knobby skin, edible yellow/orange flesh and whitish-yellow seed. The pumpkin were selected for their uniformity of shape, weight, and color. Pieces weighing approximately 125 g each were then wash and boiled. The pumpkin pieces were placed into polyethylene bags for storage at 4 °C until use.

The substitutions of pumpkin pulp in cassava starch using ratio of cassava starch and pumpkin in 5 levels; 93:7, 89:11, 85:15, 81:19 and 77:23 (w/w), respectively. The physical, chemical characteristics and sensory evaluation of fish cracker from surimi supplemented with pumpkin were evaluated as follow;

2.1 Physical characteristics

2.1.1 Determination of color

The color of cracker was measured at a planar sample surface lightness (L*), redness/greenness (a*) and yellowness/ blueness (b*) were measured using Hunter Lab (Color aqualab S3600090, Hunter Associates Labolatory, VA, USA)

2.1.2 Determination of hardness and crispness

Hardness and crispness were measured by a penetration test using a texture analyzer (TA-XT2 stable Micro System, England). The cracker samples ware place on a fabricated hollow cylindrical base (25 mm inner diameter, 1.5 mm thickness, stainless steel). Force was applied using a 5 mm spherical compression probe (P/0.25s) at constant speed of 3 mm/s until the sample cracked. Hardness and crispness was reported.

2.1.3 Determination of microstructure

The cracker samples were cut and mounted on aluminum tube using double adhesive tape. The samples were sputter-coated with old-palladium to render thermoelectrically conductive by using (Edward S150A sputter coating device) and then scanned using Quanta 400 scanning electron microscope (FEI, Czechina). The micrographs were taken at magnification of 50X for the surface and cross section parts of the cracker.

2.1.4 Swelling ratio

Swelling ratio was measured using seed displacement method (Anukulwattana, 2014). Sesame seeds are poured into the cup of mug and squeeze the cup to smooth. After that, measure the volume of sesame seed using cylinder. The amount of sesame seeds was obtained (V_1). Three pieces of unfried fish cracker were placed in the original cup and added the sesame seeds into the cup again, after manual squeeze of sesame seeds, the residual sesame seeds were then measured to volume (V2). The difference between the volume of sesame seeds (V1 - V2) was the volume of the sample before frying. After that, the sample was fried at 170-180 °C for 5 minutes. The sample will be used to find the volume in the same way. The volume of the sample after frying (V1-V3) was obtained. The Swelling ratio is the volume of sample after frying divided by sample volume before frying.

$$\text{Swelling ratio} = \frac{\text{Volume of the sample after frying}}{\text{Volume of the sample before frying}} = \frac{V_1 - V_3}{V_1 - V_2}$$

V_1 = Volume of the cup to be used the swelling ratio
V_2 = Volume of the residual sesame seed (sample before frying)
V_3 = Volume of the sample after frying (sample after frying)

2.2 Content of moisture and fat adsorption

The cracker samples were analyzed for fat adsorption and moisture content following AOAC method (AOAC, 2012)

2.3 Sensory evaluation

The sensory evaluation panel consisted of 15 trained testers were consume fish cracker regularly. Prior to testing, each cracker sample was individually sealed in a pouch and codded with a three-digit number. Drinking water was provided for mouth rinsing between samples. Panelists required to evaluated the appearance, color, taste, crispness and overall preference of the cracker, using 9-point hedonic scale (1=dislike extremely, 9=like extremely). The experiment design was Randomize Complete Block Design (RCBD).One way analysis of Variance (ANOVA) and Duncan's New Multiple Rage test were used to establish the significance of differences at 95% confidence levels.

3. Chemical composition of fish cracker from surimi supplemented with pumpkin

The cracker samples that have been accepted in step 2.3 were brought to analyzed the moisture, protein, lipid, carbohydrate and ash content, following AOAC method (AOAC, 2012)

4. Study the level of consumer's preference for fish cracker from surimi supplemented with pumpkin

The cracker samples that have been accepted in step 2.3 was prepared for consumer test with 200 respondents. Sensory test were used to determine consumer preference of color, odor, taste, crispness and overall preference of the cracker, using 5-point hedonic scale (1=dislike extremely, 5=like extremely). Analyze data from percentage of consumer rating.

RESULTS AND DISCUSSION

1. The formulation of fish cracker production from surimi

Sensory evaluation of 40 untrained panelists was performed to check the quality of fish cracker. In present study, fish meat was replaced by surimi (*Nemipterus hexodon*). The result of the sensory score assessment includes panelists' acceptability in appearance, color, odor, taste, crispness and overall preference from 1 (disliked very much) to 9 (extremely liked). From the result obtained, all sensory scores were higher than the required criteria of 80% (data not show). A high 90% acceptance scores were the taste, crispness and overall preference which were important attributes of the cracker products (Figure 2). The acceptance cracker was consisted of the following ingredients; surimi 58.0% (The initial proximate analyses of the surimi sample is also presented in Table 1), cassava starch 38.0%, salt 2.0%, sugar 1.5% and monosodium glutamate (MSG) 0.5%.

Table 1. Proximate composition of surimi sample.

Chemical compositions	(%)
Moisture	79.15±0.12
Protein	20.25±0.22
Lipid	0.18±0.16
Ash	0.42±0.28

Each value is presented as mean±standard deviation (n=5)

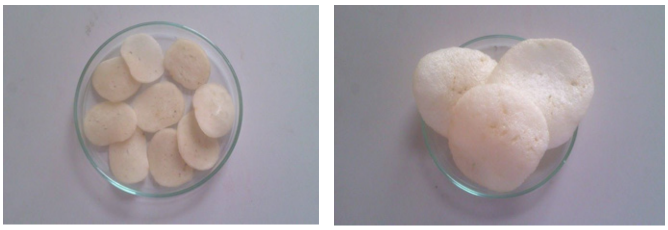

Figure 2. Fish cracker prepared from surimi (*Nemipterus hexodon*)

2. The replacement of cassava starch with pumpkin to produce fish cracker from surimi

The replacement of cassava starch with pumpkin at 5 different ratios including 93:7, 89:11, 85:15, 81:19 and 77:23 (%w/w).

2.1 Physical characteristics

2.1.1 Determination of color

Pumpkins is excellent dietary sources of carotenoids (Gross, 1991), especially ß-carotene (3,100 μg/100g pumpkin (Koh and Loh, 2018). The color of the cracker is based on the particular carotenoid content. In present study, the result for color measurement is shown in Table 2. There were significant differences ($p<0.05$) for all 5 ratios of pumpkin. Increasing of pumpkin resulted in decreased the L* value and increased the a* and b* value since the pumpkin has its own yellow color pigment. (Figure 3).

Further, the increased value of a* and b* of fried cracker may be due to browning of protein and carbohydrate in pumpkin undergoing of mailard reaction (Pornchalermpong, 2013.) Accordance with the research of Suriya et al. (2011) who studied of the use of Burma bean to replace cassava starch in cracker. It was found that Increasing of Burma bean resulted in decreased the L* value while the a* and b* value increased as the beans were light yellow and cassava starch was white. The beans also had higher protein content than cassava starch.

Table 2. Color of surimi fried cracker prepared using different levels of pumpkin.

Cassava starch: pumpkin	Color		
	L*	a*	b*
93:7	$59.35^{a}\pm0.36$	$2.16^{d}\pm0.65$	$19.58^{c}\pm0.14$
89:11	$58.14^{a}\pm0.34$	$2.69^{d}\pm0.50$	$21.03^{b}\pm0.47$
85:15	$55.92^{b}\pm1.65$	$4.88^{c}\pm0.75$	$21.03^{b}\pm0.46$
81:19	$54.72^{b}\pm0.78$	$6.50^{b}\pm0.22$	$21.22^{b}\pm0.60$
77:23	$51.52^{c}\pm0.73$	$8.98^{a}\pm0.52$	$22.68^{a}\pm0.82$

Each value is presented as mean±standard deviation (n=3)
Different superscripts in the same column indicate significant differences ($p < 0.05$)

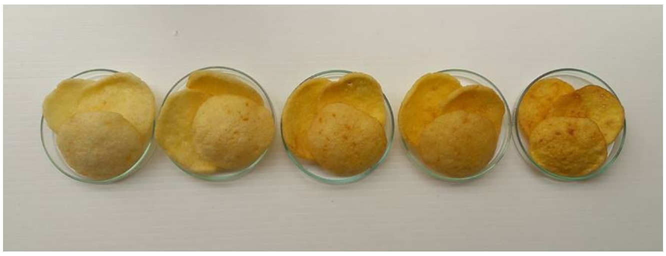

Figure 1. Fish crackers from surimi supplemented with pumpkin The ratio of cassava starch to pumpkin as following (A) 93:7, (B) 89:11, (C) 85:15, (D) 81:19 and (E) 77:23

2.1.2 The hardness and crispness of fish cracker

Hardness and crispness of surimi fish cracker prepared from different levels of pumpkin were significantly different ($p<0.05$) as shown in Table 3. The highest hardness value was obtained from 89:11, indicating the cracker became harder and crispier when adding more starch. Crispness can be affected by the nature of the material and the structure that the material form (Zzaman et al, 2017). The texture of the cracker was the result of the swelling of the structure which had starch as ingredients and the amount of amylose and amylopectin that were the constitutes of the flour. According to Chainui (2007), the use of cassava starch as a mixture of higher quantities result in high amylose content, which made hard sheet structure. Consequently, the characteristics that affect consumers' acceptance are both of crispness and hardness.

Table 3. Hardness, Crispness and Fat absorption of fish cracker from surimi supplemented with pumpkin

Cassava starch : pumpkin	Hardness (g)	Crispness	Swelling ratio	Fat absorption (%)
93:7	$1,232.87^{a}\pm$ 112.83	$14.13^{b}\pm$ 4.07	9.27 ± 0.41^{a}	$38.61^{a}\pm$ 0.072
89:11	$1,048.20^{b}\pm$ 120.14	$22.33^{a}\pm$ 4.69	7.55 ± 0.50^{b}	$37.33^{b}\pm$ 0.004
85:15	$796.89^{d}\pm$ 161.33	$14.40^{b}\pm$ 3.11	7.30 ± 0.53^{b}	$35.34^{c}\pm$ 0.013
81:19	$932.92^{c}\pm$ 181.92	$12.13^{b}\pm$ 2.29	5.17 ± 0.53^{c}	$35.18^{d}\pm$ 0.003
77:23	$916.21^{c}\pm$ 149.08	$7.00^{c}\pm$ 2.00	3.31 ± 0.38^{d}	$34.44^{e}\pm$ 0.007

Each value is presented as mean±standard deviation (n=3)
Different superscripts in the same column indicate significant differences ($p < 0.05$)

2.1.3 Microstructure of the cracker

Figure 4. show surface as well as cross sectional morphologies of the formulated crackers. Marked changes were observed by incorporating the pumpkin. With the increase in pumpkin incorporation, the smaller air cells and thicker pore walls obtained in crackers and the surface structure became rougher and more distorted surrounding structures. The addition of pumpkin up to 15% result in the formation of smaller pore size and less dense structure. The result coincides with the study of Cheow et al. (1999) who reported that in less swollen cracker the microstructure tends to have aggregates of protein. This would hamper the expansion of the dough when fried, leading to a dense cracker structure. Texture of crackers is influenced by pore size distribution and pore wall thickness (Kaewmanee et al., 2015).

2.1.4 Swelling ratio

The fish crackers that were produced in the present study showed significantly difference in swelling ratio ($p<0.05$) (Table 3). The swelling ratio decreased with increasing of pumpkin pulp since the high sugar content and moisture content when used as cassava starch substitute, resulted in water uptake of starch granules and gelatinization of starch in crackers which cause the swelled and expanded decreased when frying. According to the research of Suriya et al. (2011) who reported that the increase of the Burma beans for replacement of cassava starch decreased the expanding ratio due to the protein interferes with the water absorption of the starch granule As a result, the fried cracker is not as good swelling (Winaikul, 2007)

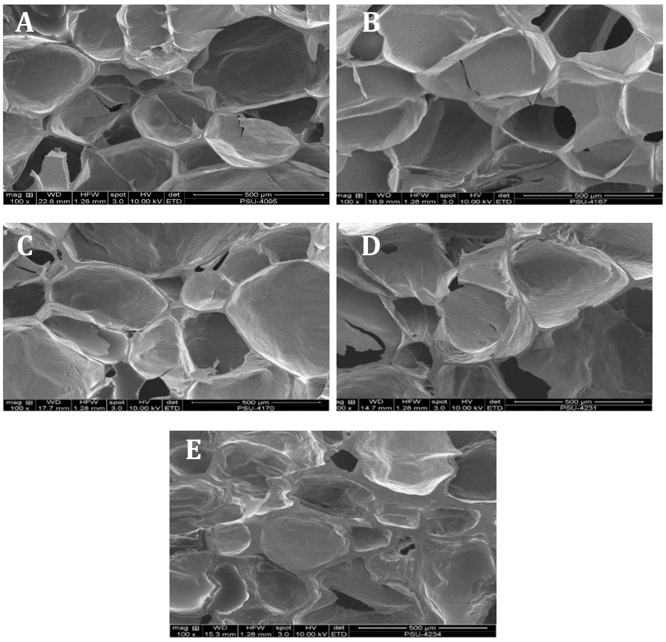

Figure 4. SEM micrographs (100x) of snack crackers. The ratio of cassava starch to pumpkin as following (A) 93:7, (B) 89:11, (C) 85:15, (D) 81:19 and (E) 77:23

2.2 Content of moisture and fat adsorption

Moisture content is an important property of fried food product quality. During the frying process, the moisture evaporates at the product surface and leaves the product due to the different partial vapour pressure between the product and the frying oil (Moreina, 2003). Determination of moisture content is the most frequent analysis performed in cracker products and it is quiet significant in many aspects (Isengard, 2001). Moisture content affects many others, both of physical and chemical nature. Additionally, its content affects microorganism growth by affecting the stability and shelf life of foodstuffs. The moisture content are very important as these contents limit the storage of the material. The standard of moisture content as the Thai Community Product Standards (TCPS: 107/2003) was defined that the moisture content should not more than 4%. The moisture of the cracker sample is 2.00% (Table 5).

Apart from concerns resulting from increasing health awareness by consumers, the high oil content also affects the rancid odor and flavor and shortens the shelf life of the product during storage. Fat and oil in cracker can result in discoloration, burning and out of specification of product. Fat adsorption is happen when the starch gelatinize, it produces air bubbles that later absorb the oil when frying (Cheow et al., 1999). In this present study, the value of fat absorption of the fish cracker was significant difference ($p<0.05$). Increasing of pumpkin resulted in decreased fat absorption (38.61-34.44%) and expanding ratio (9.27-3.31%) (Table 3). However, since the water is replaced by hot oil (Fellows, 2000) after the frying process, the oil content in the final fried products is relatively high up to approximately 35% (Shachat and Raphael, 1990). A higher rate of fat absorption gives higher ratio of expanding due to the fat will replace the moisture and move out of the product during deep-frying (Prikbunjan, 2004).

2.3 Sensory evaluation of fish cracker

Sensory evaluation was performed to check overall acceptability of cracker reported in Table 4. The test includes panelists' acceptability in color, odor, taste, crispness and overall preference of the cracker rated from 1 (dislike extremely) to 9 (like extremely). From the result obtained, all characteristics were significantly difference with all different formulations. The overall acceptance was the crackers made from cassava starch and pumpkin

Table 4. Sensory evaluation of fish cracker from surimi supplemented with pumpkin

Cassava starch: pumpkin	Appearance	Color	Odor	Taste	Crispness	Overall preference
93:7	7.06^{ab}±0.96	6.66^{b}±1.17	7.00^{ab}±1.00	6.93^{bc}±0.79	7.20^{ab}±1.20	7.00^{b}±1.30
89:11	7.13^{ab}±0.83	6.73^{b}±0.96	7.26^{ab}±1.03	7.20^{b}±0.94	7.33^{ab}±1.23	7.46^{ab}±1.06
85:15	7.40^{a}±1.24	7.46^{a}±0.99	7.53^{a}±0.63	7.73^{a}±0.88	7.60^{a}±0.63	8.33A±0.81
81:19	6.60^{bc}±0.82	6.20^{bc}±0.67	6.66^{b}±0.97	7.26^{ab}±0.88	7.26^{ab}±0.96	6.66^{b}±1.04
77:23	5.93^{c}±0.59	5.66^{c}±0.61	6.53^{b}±0.99	6.26^{c}±1.09	6.66^{b}±0.97	5.60^{c}±1.24

Each value is presented as mean±standard deviation (n=200)
Different superscripts in the same column indicate significant differences ($p < 0.05$)

Table 5. Chemical composition of the fish cracker from surimi

Chemical composition (%)	Cracker from surimi supplemented with pumpkin	Fish cracker*	Anchovy fish cracker**
Moisture	2.00	0.48	1.70
protein	11.82	10.86	8.90
Lipid	35.34	26.11	40.6
Ash	3.00	2.64	4.00
Carbohydrate	47.84	59.91	44.00

Source: *(Cristiane et al., 2011) ** (Chai-Mongkol et al., 2011, pp.23) at the ratio of 85:15. Many panelists prefer the bright color of the crackers and its tasty flavour. The cracker has a yellowish color of pumpkin and the smell of pumpkin is quite clear. Incidentally, adding large quantities of pumpkin also may accelerate browning of the cracker due to the content of sugar in the pumpkin pulp. A burning sensation will remove the smell of cracker thus the odor score decrease.

3. Chemical composition of fish cracker from surimi supplemented with pumpkin

The cracker that have been accepted in step 2 (85% cassava and 15%pumpkin) were then analyse the chemical composition of the cracker. The results revealed that moisture, protein, fat, ash and carbohydrate content were 2.00%, 11.82%, 35.34%, 3.00% and 47.84%, respectively. (Table 5)

From table 5, moisture content of the fish cracker from surimi supplemented with pumpkin was similar to the moisture content of anchovy cracker (1.7%), was reported by Chai-Mongkol et al. (2011). According to the Thai Community Product Standards (TCPS: 107/2003), the moisture content in fish cracker must contain maximum of 4%. There were differences in protein for these three types of crackers. The variation in the protein content is most probably due to the difference in the amount of fish used. The fat content in fish cracker from surimi supplemented with pumpkin was higher than the cracker due to the swelling ratio. For the ash content, the fish cracker from surimi supplemented with pumpkin was found to be less than that of the anchovy fish cracker because as the ingredient in the production. Therefore, the cracker had higher ash value

4. Consumer's preference for fish cracker from surimi supplemented with pumpkin

Sensory scores of the finish products were also evaluated. The study tested the consumer's acceptance by the tester using 5 point hedonic scale (1-dislike very much and 5-like very much) was conducted with 200 respondents. 71.0% of consumers were females and 44.5% males, in the 21-40 age range. The testers mostly rate the highest score of the crispness at 4.65 point. The characteristics of taste, color, odor and overall preference were 4.56, 4.35, 4.23 and 4.60, respectively. Therefore, the production of fish cracker from surimi supplemented with pumpkin for commercial distribution is highly feasible.

CONCLUSIONS

A new cracker product was successfully created using cassava starch, surimi, and pumpkin pulp. It was found that the suitable amount of surimi for substitutes of fish meat was 58% of all ingredients. The pumpkin substitutes can be added at the ratio of 85:15 (cassava starch: pumpkin). The products differed in color from the traditional fish crackers, which made them meet the needs of the consumers. This new product can provide consumers with a healthy snack that fits into modern diets which stress an increased intake of protein (11.8%) and reduce intake of carbohydrates. The fish cracker from surimi supplemented with pumpkin received the high ratings for all attribute and were considered acceptable by consumers. This product appears to have a great potential for the healthy snack food market.

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