

Research Article

Chemical composition, colour and linear expansion properties of Malaysian commercial fish cracker (keropok)

Nurul Huda*, Ang Li Leng, Chung Xian Yee and Herpandi

Fish and Meat Processing Laboratory, Food Technology Division, School of Industrial Technology, Universiti Sains Malaysia, Minden 11800 Malaysia.

*Author to whom correspondence should be addressed, email: nrlhd@usm.my

Abstract

The objective of this study was to compare and contrast the physicochemical properties of fish crackers from different producers in Malaysia. About 28 samples of fish crackers from several states in Malaysia were purchased and analyzed. The results showed that the samples were significantly different ($p < 0.05$) in their chemical composition, colour and linear expansion. The moisture content ranged between 9.37 and 13.83%, whereas fat and ash content ranged from 0.85 to 3.38% and 3.39 to 5.94%, respectively. However, the protein content, which was 5.53-15.80%, differentiates products with high fish content and those with low fish content. The carbohydrate content varied between 53.62 and 80.43%, reflecting high use of starch in the formulation. The calcium (Ca) content in fish crackers varied between 9.75 and 381.50 mg/100 g, indicating that a small amount of fish was used or that bony fish were used in the crackers. Furthermore, sodium (Na) content was between 1183 and 1888 mg/100 g. The L^* , a^* and b^* values of fish crackers ranged from 18.69-47.99, 1.03-5.89 and 7.77-20.62, respectively. The linear expansion of samples varied between 37.55 and 145.95%, which is inversely proportional to the protein content but linearly correlated with the carbohydrate content. These results showed that Malaysian fish crackers produced by different manufacturers were significantly different in chemical composition, colour and linear expansion properties.

Keywords: snack food, testing, physicochemical properties, protein content

Introduction

Fish crackers or 'keropok' are a popular snack food in Malaysia and other Asian countries [1]. More than 100 small-scale processors are engaged in this business. The crackers are made by mixing minced fish meat with sago flour, tapioca flour, salt and monosodium glutamate. The mixture is then molded into cylinders, steamed, cooled, sliced and sun-dried [2]. The sliced, dried product is fried in cooking oil before it is eaten as a snack food or together with rice and other daily dishes [3].

Unfortunately, the fish cracker industry still follows traditional manufacturing practices, which may lead to variations in the quality of product produced. Many studies have developed new technologies to improve the quality of fish cracker production. Yu [4], Kyaw *et al.* [5] and King [6] studied the effect of the fish to starch ratio on fish cracker properties, whereas Peranginangin [7] and Jamilah *et al.* [8] studied the effects of food additives to fish crackers. Furthermore, Huda *et al.* [9] studied fish crackers with surimi powder substitution for flour to improve the nutritional value of the crackers. The objective of this study was to identify the physicochemical properties of fish crackers from different producers in Malaysia.

Materials and Methods

Fish crackers

The fish crackers were purchased from various sources from several states in Malaysia. Altogether, 28 samples from different manufacturers from different states in Malaysia were collected. However, only 14 samples, which were selected randomly by state, were analyzed for the chemical composition and mineral analysis.

Chemical composition

The chemical composition was determined according to AOAC [10] methods. The carbohydrate content was estimated by subtracting the sum of percentage of moisture, crude fat, crude protein and ash contents from 100%.

Calcium

To determine the Ca using Atomic Absorption Spectrometer (Analyst 100, Perkin Elmer), the sample must be digested first. First, 50 mL of deionized water was added to 58.64 g of lanthanum oxide (La_2O_3). Then, 250 mL of HCl was added, and the mixture was topped up to 1 L using deionized water in a volumetric flask. Six milliliters of HNO_3 and 1 mL of 30% (v/v) H_2O_2 were added to 1 g of ground sample. Then, this mixture was digested in a microwave digester for 15 minutes. After digestion, 20 mL of lanthanum oxide solution was added to each sample and was diluted to 100 mL with deionized water. A series of calcium standard solutions with concentrations of 0, 1, 2, 3, 4 or 5 ppm were made from the calcium stock of 100 ppm. By using AAS, the absorbance for the standards and samples were measured. If the absorbance was too high for the sample, then the sample was diluted again.

Sodium

For Na content, the samples were also digested first. To about 1 g of ground sample, 6 mL of HNO_3 and 1 mL of 30% (v/v) H_2O_2 were added. Then, they were digested in a microwave digester for 15 minutes. After digestion, each sample was diluted to 100 mL with deionized water. A series

of sodium standard solutions with concentrations of 0, 0.2, 0.4, 0.6, 0.8 or 1 ppm were made from a stock of 100 ppm sodium. If the absorbance was too high for the sample, then the sample was diluted again (5x) in 50-mL volumetric flask.

Linear expansion

The percentage linear expansion was measured according to the method of Yu (4) as follows:

$$\text{LE (\%)} = \frac{\text{Length after puffing} - \text{length before puffing}}{\text{Length before puffing}} \times 100$$

Colour

The colour of ground, fried cracker samples was measured using a colorimeter (Minolta spectrophotometer CM 3500d, Japan). The colour reading includes lightness (L^*), redness (a^*) and yellowness (b^*). The equipment was standardized with a white colour standard.

Statistical analysis

Data obtained from all the tests were analyzed by using one-way analysis of variance (ANOVA) and followed by Duncan multiple range test of the Statistical Package for Social Science version 12.0 (SPSS inc., Chicago, Illinois, U.S.A). Statistical significance was indicated at the 95% confidence level.

Results and Discussion

The chemical composition of fish crackers are listed in Table 1. As a dried product, fish crackers are expected to have low moisture content. Commercial fish crackers studied had moisture contents between 9.37 and 13.83%. Yu [4], King [6] and Nurul *et al.* [3] reported moisture content of fish crackers of 12, 12 and 9%, respectively. Control of moisture in crackers is necessary to optimize the quality of the product and the production process. Mohamed [11] concluded that insufficient water may lead to incomplete gelatinization of starch during the steaming process. Thus, fish crackers do not expand well. Furthermore, excess water causes a decrease in expansion and results in thinner fish crackers after drying. In addition, too much moisture also results in dough that is too soft and difficult to slice.

From the results, samples 3, 4, 15 and 20 were found to contain significantly ($P < 0.05$) higher protein content than the other samples ($> 15\%$). This finding is in agreement with regulation No. 168 in the Malaysian Food Regulations 1985, which requires 15% as the minimum amount of protein. According to Yu [4], King [6] and Nurul *et al.* [3], the more fish used in fish crackers, the higher the protein content of fish crackers. Thus, the low content of protein indicates low fish content in the formulation.

King [6] found that fish crackers prepared from 40% fish with 60% starch yielded crackers with a protein content of 10%. This finding suggests that those crackers containing protein of more than 10% were probably made with more than 40% fish in their formulation. However, different producers may use different types of fish with different protein contents. Furthermore, Nurul *et al.* [3] reported that fish crackers with ratios of fish to flour that were 2 to 1 and 2.5 to 1 had protein contents of 18.23% and 23.81%, respectively.

Table 1. Chemical Composition of Fish Crackers for Selected Samples

Sample	Moisture (%)	Protein (%)	Fat(%)	Ash (%)	CHO(%)
1	11.58±0.04 ^e	13.15±0.68 ^{e,f,g,h}	1.92±0.10 ^{c,d}	4.03±0.29 ^{b,c}	69.32±0.78
2	9.37±0.08 ^a	5.53±0.66 ^a	1.04±0.47 ^{a,b,c}	3.62±0.05 ^{a,b}	80.43±1.14 ^g
3	9.93±0.18 ^b	29.91±0.95 ⁱ	0.60±0.17 ^a	5.94±0.17 ^f	53.62±1.19 ^a
4	10.83±0.02 ^{c,d}	15.28±2.99 ^{f,g,h}	2.72±0.20 ^{d,e}	5.51±0.29 ^{e,f}	65.66±3.07 ^b
15	12.11±0.25 ^f	15.80±2.15 ^{g,h}	2.52±0.78 ^{d,e}	4.15±0.05 ^{c,d}	65.42±2.31 ^b
16	13.83±0.32 ^h	9.87±1.38 ^{b,c,d}	1.7±0.45 ^{b,c,d}	3.39±0.05 ^a	71.18±0.86 ^{d,e,f}
17	13.01±0.35 ^g	9.65±1.34 ^{b,c}	1.82±0.50 ^{c,d}	4.58±0.15 ^d	70.94±1.94 ^{d,e,f}
19	11.20±0.10 ^{d,e}	10.96±0.50 ^{b,c,d,e}	1.95±0.89 ^{c,d}	3.98±0.07 ^{b,c}	71.91±1.32 ^{e,f}
20	10.41±0.45 ^c	16.17±1.85 ^h	0.85±0.04 ^{a,b}	5.34±0.05 ^e	67.23±1.50 ^{b,c}
22	12.10±0.12 ^f	12.85±3.08 ^{d,e,f,g}	1.46±0.42 ^{a,b,c}	4.29±0.14 ^{c,d}	69.30±3.58 ^{c,d,e}
23	11.34±0.50 ^e	14.81±2.08 ^{f,g,h}	2.02±0.57 ^{c,d}	5.92±0.46 ^f	65.91±1.28 ^b
26	12.43±0.33 ^f	8.53±0.29 ^b	1.90±0.64 ^{c,d}	4.11±0.05 ^c	73.04±0.44 ^f
27	13.32±0.12 ^g	11.48±1.15 ^{b,c,d,e}	2.68±0.83 ^{d,e}	4.42±0.43 ^{c,d}	68.10±1.39
28	10.43±0.41 ^c	12.59±1.57 ^{c,d,e,f}	3.38±0.18 ^e	5.69±0.46 ^{e,f}	67.92±1.39

*Means within a column with different letters are significantly different (P < 0.05).

The fat content in the fish crackers ranged between 0.85 and 3.38%. The fat content in fish crackers may depend on the amount, fat content or the particular parts of fish or raw materials used. This result is in agreement with the findings of Yu [4], who reported that the higher the fish meat ratio used, the higher the fat content of the fish crackers. King [6] also reported fat content of 0.5-1.9% for fish meat contents from 40-60%. The fat content of the crackers may increase after frying as a consequence of oil absorption during frying; thus, the final fat composition of the crackers is probably higher than that estimated by the composition analysis of the dry crackers.

The ash content observed ranged between 3.39 and 5.94%, which was similar to the 4.2% reported by Tee *et.al.* [12]. Samples 3, 4, 15, 17, 20, 22, 23, 26, 27 and 28 exhibited significantly higher ash content compared to the other samples (P < 0.05). The variation in the ash content is most probably due to the difference in the amount and type of fish used. The higher the amount of fish used, the higher the ash content is. King [6] found that ash content increased linearly with an increase in fish content.

The fish used in the fish cracker production are probably processed by mechanical deboning, which tends to yield fish meat with a higher ash content than fish meat deboned by hand. This difference is due to the preparation of mechanically deboned meat, which uses mechanical pressure to remove the meat away from vertebra; thus, there are some bones incorporated into the meat that contribute to the high ash content [13]. The variability in the amount of bone incorporated into the mechanically deboned meat depends on many factors such as the type of bones incorporated, their brittleness and the ratio of bone to meat in the raw material used [14].

From the results obtained, some samples were found to have a carbohydrate content of more than 70%: samples 2, 16, 17, 19, and 26. Some reported values of carbohydrate are 66% (12) and 64 to 68.3% (9).

Samples which are high in ash content are also high in calcium and sodium contents (Table 2). The samples analyzed had calcium content ranging between 9.75 and 381.50 mg/100 g. The samples with calcium content greater than 200 mg/100 g were samples 3, 4, 20, 22, 23, 27 and 28. Tee *et.al.* [12] reported a higher content of calcium in fish crackers (329 mg/100 g) than the fish crackers studied. The variations in calcium content among the samples may be due to differences in fish species and in the amounts of fish used. The variation may also be due to the variable use of bony fish, whole fish, only the fish meat or deboned fish. The calcium content of the samples was found to have a linear relationship with the protein content. This linear relationship may be due to the use of whole fish rather than the deboned fish. However, for samples 1 and 15, although they had low calcium contents, they had relatively high protein contents. These differences might be due to the use of non-bony fish or only the fish meat. Chemical composition of fish crackers depends on formulation [15].

Table 2. Sodium and Calcium Content of Fish Crackers

Sample	Ca (mg/100g)	Na (mg/100 g)	Sample	Ca (mg/100 g)	Na (mg/100 g)
1	28.77±8.58 ^a	1493.05±41.86	19	37.09±2.16 ^a	1645.67±59.89 ^{b,c}
2	16.92±1.85 ^a	1853.41±326.27	20	321.51±47.24 ^{d,e}	1573.20±303.39
3	293.40±7.71 ^{c,d}	1352.17±80.19	22	228.64±53.55 ^c	1333.81±36.49 ^{a,b}
4	381.50±41.15 ^c	1669.61±141.91	23	304.15±66.74 ^d	1887.83±130.68 ^c
15	37.22±5.62 ^a	1615.82±395.57	26	9.75±3.00 ^a	1612.49±218.91 ^b
16	121.03±20.61 ^b	1355.34±42.06	27	295.40±83.16	1183.14±42.05 ^a
17	32.66±7.90 ^a	1876.85±223.46	28	250.54±61.16	1762.83±436.53

*Means within a column with different letters are significantly different (P < 0.05).

The ranges of sodium content among the samples are 1183.14-1887.83 mg/100 g, which is slightly higher than a previous report of 1047 mg/100 g [12]. The addition of salt and monosodium glutamate during the manufacturing process probably contributed to the sodium content in the fish crackers. Both salt and MSG are frequently added to the product. Sample labels that state the use of MSG include samples 4, 5, 8, 14, 16, 20, 24 and 26.

Colour measurements were obtained for 28 samples using the Minolta spectrophotometer. L*, a* and b* values were taken. The L*, a*, and b* values for the samples are shown in Table 3. There are many factors affecting the colour of the fish crackers, such as the amount and type of fish used or the amount and type of starch added [9]. Nurul *et al.* [3] found that the lightness and redness (L* and a* values) tend to decrease with an increase in the ratio of fish meat to tapioca flour, whereas, yellowness (b* value) tends to be higher in samples with low amounts of fish meat. Rosmawaty *et al.* [16] reported that the types of additives used and the thickness of the crackers can also influence the colour of the crackers. Rosmawaty *et al.* [16] also reported that the species of fish used and the proportion of each type of fish used do not have any effect on the colour of

Table 3. Colour Characteristics of Fish Crackers.

Sample	L	a	B
1	47.99±1.91 ^m	2.15±0.16 ^b	20.62±0.26 ⁿ
2	45.60±0.88 ^{l,m}	1.03±0.10 ^a	14.06±0.43 ^{c,d}
3	27.46±3.00 ^b	3.18±0.11 ^{c,d,e}	11.87±0.59 ^b
4	40.60±0.85 ^{h,i,j,k}	3.45±0.31 ^{d,e,f,g,h}	14.69±0.59 ^{c,d,e,f}
5	39.68±0.97 ^{f,g,h,i,j,k}	4.77±0.06 ^{m,n,o}	16.61±0.44 ^{g,h}
6	42.51±0.96 ^{j,k,l}	2.79±0.39 ^c	16.50±0.15 ^{g,h}
7	42.57±0.63 ^{i,j,k,l}	4.18±0.75 ^{i,j,k,l,m}	18.75±0.85 ^{j,k}
8	41.16±1.32 ^{i,j,k}	4.43±0.31 ^{k,l,m}	15.61±0.46 ^{f,g}
9	38.59±0.85 ^{f,g,h,i}	4.32±0.07 ^{j,k,l,m}	17.23±0.51 ^{h,i}
10	45.11±2.56 ^{l,m}	5.33±0.19 ^{o,p}	20.55±1.15 ⁿ
11	45.05±0.99 ^{l,m}	5.15±0.31 ^{n,o}	19.38±1.22 ^{k,l,m}
12	32.78±2.01 ^c	3.65±0.48 ^{d,e,f,g,h,i}	13.90±0.41 ^{c,d}
13	40.40±0.69 ^{h,i,j,k}	5.40±0.07 ^p	19.16±0.40 ^{j,k,l}
14	40.01±0.39 ^{f,g,h,i,j,k}	3.84±0.37 ^{f,g,h,i,j,k}	15.64±0.56 ^{f,g}
15	34.06±2.37 ^{c,d}	5.89±0.33 ^p	14.85±0.13 ^{d,e,f}
16	37.78±1.54 ^{e,f,g,h}	3.39±0.50 ^{c,d,e,f,g}	14.30±0.80 ^{c,d,e}
17	41.42±2.70 ^{i,j,k}	3.72±0.16 ^{e,f,g,h,i,j}	20.47±0.85 ^{m,n}
18	18.69±4.56 ^a	2.18±0.16 ^b	7.77±0.47 ^a
19	42.86±0.16 ^{k,l}	3.04±0.34 ^{c,d}	15.46±0.46 ^{e,f,g}
20	39.41±1.25 ^{f,g,h,i,j}	3.86±0.20 ^{g,h,i,j,k}	15.80±0.28 ^{f,g}
21	40.17±0.49 ^{g,h,i,j,k}	4.68±0.28 ^{l,m,n}	18.18±0.14 ^{i,j}
22	39.12±0.50 ^{f,g,h,i}	3.29±0.05 ^{c,d,e,f,g}	13.54±0.47 ^c
23	46.11±1.69 ^m	4.27±0.12 ^{i,j,k,l,m}	19.93±1.41 ^{l,m,n}
24	35.34±0.48 ^{c,d,e}	4.07±0.63 ^{h,i,j,k,l}	14.27±0.59 ^{c,d,e}
25	38.61±0.09 ^{f,g,h,i}	5.07±0.05 ^{n,o}	17.10±0.60 ^{h,i}
26	37.08±1.03 ^{e,f,g}	3.14±0.67 ^{c,d,e}	14.82±0.96 ^{d,e,f}
27	28.77±0.82 ^b	3.21±0.46 ^{c,d,e,f}	15.40±0.35 ^{e,f,g}
28	36.86±2.32 ^{d,e,f}	4.10±0.21 ^{i,j,k,l}	14.96±0.35 ^{d,e,f}

*Means within a column with different letters are significantly different (P < 0.05).

fish crackers. This finding also in agreement with Yu [4] who reported that the type of fish did not influence acceptability although there was a preference for the lighter colour of jewfish cracker compared to sardine cracker.

Mohamed *et al.* [11] found that the type of flour used in fish crackers affected the clarity of the fish crackers, which in turn affected the colour of the product. Another factor that may also contribute to the colour of fish crackers is the Maillard reaction because some producers do include sugar in the production of fish crackers.

The measurement of linear expansion obtained for 28 samples are shown in Table 4. Yu [4] proposed that linear expansion of fish crackers should be greater than 77% for crispiness. Fifteen out of twenty-eight fish cracker samples in this study showed linear expansion values higher than 77%.

Table 4. Linear Expansion of Fish Crackers

Sample	LE (%)	Sample	LE (%)
1	145.95±21.45 ¹	15	85.73±5.15 ^{d,e,f,g}
2	93.04±7.91 ^{f,g}	16	60.42±19.18 ^{a,b,c,d}
3	56.74±7.00 ^{a,b,c}	17	81.28±14.97 ^{c,d,e,f,g}
4	91.26±5.85 ^{e,f,g}	18	125.78±2.35 ^{h,i}
5	91.15±21.17 ^{e,f,g}	19	70.60±1.76 ^{b,c,d,e,f}
6	61.12±5.98 ^{a,b,c,d}	20	67.71±1.76 ^{b,c,d,e,f}
7	82.13±31.01 ^{c,d,e,f,g}	21	107.75±15.79 ^{g,h}
8	70.16±2.21 ^{b,c,d,e,f}	22	81.09±3.30 ^{c,d,e,f,g}
9	83.03±0.26 ^{c,d,e,f,g}	23	68.81±4.49 ^{b,c,d,e,f}
10	68.95±9.96 ^{b,c,d,e,f}	24	84.68±20.21 ^{c,d,e,f,g}
11	45.68±2.66 ^{a,b}	25	64.69±11.10 ^{b,c,d,e}
12	105.05±12.45 ^{g,h}	26	66.19±2.09 ^{b,c,d,e,f}
13	80.98±6.50 ^{c,d,e,f,g}	27	127.25±31.92 ^{h,i}
14	63.02±1.18 ^{a,b,c,d}	28	37.55±9.95 ^a

The amount and type of fish and flour used contribute to the linear expansion of fish crackers (4; 6; 7; 11). Huda *et al.* [9] reported that increasing the amount of fish used to make the crackers resulted in a decrease in the linear expansion of traditional crackers, indicating a negative correlation between protein content and linear expansion of crackers. This result is also in agreement with a report by Cheow *et al.* [17], who found that linear expansion was significantly ($P < 0.05$) reduced with an increase in fish content from 300 to 800 gkg⁻¹; however, there was also a slight increase in linear expansion of 'keropok' from 200 to 300 gkg⁻¹ fish content due to the available water provided by wet fish for starch gelatinization or due to sufficient protein, which, when heat denatured, may be able to resist collapse during starch expansion. According to

Mohamed *et al.* [11], sufficient available water is needed for optimum linear expansion. Insufficient water causes incomplete gelatinization of the starch during steaming. Additionally, excess water reduces the solid content of fish crackers that have been sliced consistently at a certain thickness. These circumstances prevent the fish crackers from expanding properly. Yu [4] also reported that the type of flour used was the controlling factor in the expansion of fish crackers and found negative and positive correlations between linear expansion and the protein and carbohydrate contents, respectively. Most of the producers use sago flour as one of the fish cracker ingredients. The rest do not mention what types of flour were used. According to Mohamed *et al.* [11], the crackers with the highest linear expansion are those that were made with glutinous rice flour, followed by rice flour, tapioca, corn, sago, wheat and mungbean.

One other factor that may contribute to linear expansion of fish crackers is steaming time. Kyaw *et al.* [5] concluded that a steaming time of 20-30 minutes is sufficient to cook the gel and that excessive steaming time will result in a poor-quality product due to excess water trapped inside the swollen granules. The various linear expansion values of Malaysian commercial fish crackers are probably due to the variable types of ingredients and processing methods used.

Conclusion

The Malaysian commercial fish crackers studied were significantly different ($p < 0.05$) in their chemical composition, colour and linear expansion. These physicochemical properties of fish crackers were affected by the type and amount of each ingredient used. The method of manufacturing process used also contributed to the various values of each parameter studied.

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