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The Effect of Catfish Bone Flour (*Pangasius Hypophthalmus*) Substitution on The Characteristics of Corn Flakes

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A B S T R A C T

Catfish (Pangasius hypophthalmus) bones contain micro substances including calcium and phosphorus. Indonesian people's consumption of calcium and phosphorus is still low. Catfish bones are processed into catfish bone flour and added to the process of making corn flakes. This research aims to determine the effect of catfish bone flour substitution on the quality characteristics of corn flakes and determine the best concentration for the level of consumer preference. Fresh catfish bones are processed into fish bone flour which will then be added to make corn flakes. The experimental design used was a random design complete with the substitution treatment of catfish bone flour in the corn flour. The concentration of catfish bone flour used was 0%, 4%, 6% and 8%. The variables studied were hedonic test, water content, calcium content, phosphorus content, hardness, water absorption and dryness resistance in milk. The substitution treatment for the concentration of catfish bone flour 4% is most preferred because the corn flakes produced have a typical corn flakes taste with a slight fish taste, a typical corn flakes aroma with a slight fish aroma, yellow color, texture that is still crunchy with an average hedonic value of $4,44 < \mu < 4,66$, water content 4,19%, calcium content 1,05%, phosphorus content 0,58%, hardness 6,44 N, water absorption capacity 58% and resistance to crispness in milk for 15,32 min.

Keywords: *catfish, fish bone flour, corn flakes, calcium, hardness*

1. Introduction

Catfish (*Pangasius hypophthalmus*) is a fresh-water fish with a solid aquaculture potential in Indonesia. The Indonesian Ministry of Marine Affairs and Fisheries stated that in 2021 there was 332.022 tons of catfish produced in Indonesia. Catfish, who is mainly processed to take the fillet parts, can produce some waste such as head, bones, fins, and viscera. Fishbone flour is one of the ways to process catfish bones waste. Fishbone flour is potentially good as a source of calcium and phosphorus in diet because it contains 25,6% of calcium and 15,1% of phosphorus (Nur *et al.* (2018). Calcium and phosphorus can prevent osteoporosis, stunting, and other various illness caused by minerals deficit in human body.

Fishbone flour is made from fish bones within a continuous process such as boiling and pressure-cooking, followed by drying, grinding, and sieving. Fishbone flour has commonly used for animal feed mix, but there were also some of researches about the use of fishbone flour as an additional substance for fulfilling calcium intake in human body. Fish bones can be used as the source of calcium and phosphorus in form of nutrition supplementary. This way, the waste of fish bones could be used in other good purposes so it can indirectly reduce environment pollutions caused by the fish waste.

Corn flake is one of the most popular types of food in Indonesia, especially amongst children because it is easy to serve. Corn flakes are a form of breakfast foods made from corn flour that comes in the form of thin sheets. This study aims to examine the effect of substitution of catfish bone flour in corn flakes on the quality characteristics with different concentrations. This study also aims for determine the best catfish bone flour concentration based on consumer preference for corn flakes.

2. Materials and Methods

2.1 Material

The raw materials for catfish bones used in this study were obtained from the catfish fillet industry from Central Java, Indonesia. The sample were put into a cool box with ice to maintain the freshness of the catfish bones. The equipment used in this study includes autoclaves, analytical scales, ovens, stopwatches, sieves and thermometers.

2.2 The Making of Catfish Bone Flour

The process of making catfish bone flour starts with boiling the catfish bones in almost-boiling water (±80°C) for 1 hour. The making of fish bone flour follows the procedure of Jannah *et al*. (2020). The first step boiling is done to make it easier to clean the catfish bones from the remaining meat and dirt.

The catfish bones are then drained and washed using running water to separate the remaining meat. The catfish bones are boiled again for the second time at a temperature of 80°C for 1 hour. The second boil is done with the aim of removing fat from the fish bones. The catfish bones are then pressure-cooked at a temperature of 121°C for 1 hour, which aims to soften the catfish bones. After being pressure-cooked, the fish bones are dried in an oven at a temperature of 50°C for 9 hours. The dried fish bones are then crushed using a blender and then sifted using a 100-mesh sieve to produce fish bone flour.

2.3 The Making of Corn Flakes

The making of flakes follows the procedure carried out by Paramita and Putri (2015). The ingredients are weighed according to the treatment. The ingredients are mixed together with a mixer (at speed 1) for 10 minutes and then kneaded. The treatment given in this study was by substituting corn flour with fish bone flour. The comparison made (w/w) was 150: 0, 144: 6, 141: 9 and 138: 12 in grams or if in percentage form then 0%, 4%, 6% and 8% of corn flour. Other ingredients used were powdered sugar, salt, powdered milk, vanilla and water. The dough is steamed for 15 minutes at a temperature of 100°C. Steaming process is done to improve the quality of food because of the gelatinization process that will form a compact dough. The dough is then flattened using a noodle maker machine (scale 3) with a thickness of ±1 mm and then moulded to a size of 1,5 x 1 cm. The dough is then baked for 20 minutes at a temperature of 120°C.

2.4 Sample preference test

The preference test for the sample was carried out using a hedonic test. The evaluation was conducted using a five-point hedonic scale (5 for 'like very much' and 1 for 'dislike very much'). The analysis was performed according to the guidelines provided by the International Organization for Standardization (ISO, 2017). The parameters tested are taste, aroma, color and crispiness.

2.5 Water content analysis

Water content test was measured by oven drying (AOAC, 2012). Constant cup was weighed. Sample was weighed and put into the dried cup. Sample and cup were put into oven at 105ºC for 6 hours. Cup was cooled and weighed, then dried again until constant weight was obtained.

2.6 Calcium content analysis

Corn flakes are ground and weighed as much as 5 grams into a porcelain crucible. Put it in a muffle furnace and heat it until it becomes ash and cooled (Sudarmadji et al., 1997). The sample is then prepared until ready to be titrated using a standard $KMnO_4$ solution of 0.1 N until the color changes to purple. Record the titration volume. Calcium content is calculated using the calcium content formula (%) equal to the titration volume multiplied by the dilution factor multiplied by 0.002 divided by the sample weight (grams) multiplied by 100%.

2.7 Phosphorus content analysis

Phosphorus content by spectrophotometric molybdophosphate method (AOAC, 1998).

2.8 Hardness analysis

Hardness testing was carried out based on Pratiwi et al., (2021). Texture testing was carried out using a Universal Testing Machine (UTM) penetrometer. The level of hardness is seen from the maximum force used by the penetrator needle to penetrate the center of the sample until it reaches the base.

2.9 Water absorption analysis

The sample was weighed 2 g then soaked in water for 2 minutes then weighed again (Astarini et al., 2014). Water absorption (%) was calculated from the formula final weight minus initial weight divided by initial weight then multiplied by 100%.

2.10 Crispiness resistance evaluation in milk

1.5 g of sample was put into a bowl then poured with 70 ml of liquid milk with 2% of fat content. The time the flakes can stay on the surface of the milk until the texture is not crunchy is calculated as the resistance time in the milk. (Medina et al., 2011).

2.11 Statistics Analysis

The research was conducted in experimental laboratories using a Complete Random Design. The treatment factor is the substitution of catfish bone meal in corn flakes. The research was carried out in 3 repetitions. Parametric data were analysed using Analysis of Variance (ANOVA), followed by the Honestly Significant Difference (HSD) test to determine the differences between each treatment. Non-parametric data obtained were analysed using the Kruskal-Wallis test followed by the Mann-Whitney test.

3. Results and Discussions

3.1 Catfish Bone Flour Analysis

The yield of catfish bone flour was 30.06%. The yield produced in this study was still low compared to the study by Pangestika *et al.* (2021) which produced 38.6% of yield for catfish bone flour. The difference is due to the use of boiling time. The longer the time used in the fish bone boiling process, the lower the yield produced.

The result of the calcium content in catfish bone flour was 40.43%. This result is lower than the study conducted by Angraini *et al.* (2019), where catfish bone flour was made using the extraction method using NaOH produced a calcium content of 51.3%. The result of the calcium content in this study was higher than the study conducted by Nemati el al., (2017), where the calcium content produced from tuna bone was approximately 38.16± 0.147.3 g/100g. This difference is thought to be due to differences in the process of making catfish bone flour. The use of lower boiling temperatures can produce high calcium levels.

The resulting catfish flour has a phosphorus content of 14.42%. This result is lower than the study conducted by Angraini *et al.* (2019), where catfish bone flour was made using the extraction method using NaOH produced a phosphorus content of 35.7%. The result of the phosphorus content in this study was higher than the study conducted by Novianti et al., (2024), where the phosphorus content produced by *Pangasius* sp was 13.126±0.027%. This difference is thought to be due to them in terms of organic material research, differences in raw materials can reduce the large differences in the resulting chemical composition.

3.2 Hedonic Test Results

The results of the hedonic test are as shown in Table 1. The results of hedonic evaluation on corn flakes with different substitution concentrations of catfish bone flour showed significantly different results. The confidence interval value for each treatment showed that the control corn flakes and 4% catfish bone flour substitution were included in the criteria preferred by the panelists, while corn flakes with 6% and 8% catfish bone flour substitution were in the neutral criteria by the panelists. The results of the hedonic test of corn flakes can be concluded that 4% catfish bone flour substitution is the most preferred corn flakes result based on all sensory attributes with the highest confidence interval of $4.44 < \mu < 4.66$.

The results of the hedonic test of corn flakes on the taste attribute obtained the highest value with a substitution of 4% catfish bone flour with a value of 4.67, while the lowest value is corn flakes with 8% substitution of catfish bone flour with a value of 3.13. The treatment of 4% catfish bone flour substitution produced a delicious taste with a subtle hint of catfish bone flour. Substitution of 6% and 8% catfish bone flour caused the resulting taste to be slightly chalky and had a fishy taste. This is caused by the fishy taste from the catfish bone material. According to Syarafina et al. (2022), catfish bone flour has a very high calcium and phosphorus content so that it provides a slightly chalky aftertaste.

Table 1. Hedonic evaluation of corn flakes with different catfish bone flour concentrations.

Treatment	Sensory Attributes				Confidence Interval (CI)
	Taste	Aroma	Color	Crispiness	
Control	$4,27 \pm 0,74^{b}$	$4,07 \pm 0,78^{b}$	$4,17 \pm 0,70^{b}$	$4,10 \pm 0,66^{b}$	$4 < \mu < 4,27$
4%	$4,67 \pm 0,48^{c}$	$4,47 \pm 0,57^{c}$	$4,57 \pm 0,63^{c}$	$4,50 \pm 0,68^{c}$	$4,44 < \mu < 4,66$
6%	$3,6 \pm 1,22^{a}$	$3,4 \pm 0,86^{a}$	$3,57 \pm 0,68^{a}$	$3,5 \pm 0,73^{a}$	$3,3 < \mu < 3,70$
8%	$3,13 \pm 1,36^{a}$	$3,13 \pm 1,07^{a}$	$3,30 \pm 0,60^{a}$	$3,13 \pm 1,48^{a}$	$2,95 < \mu < 3,41$

Notes:

- Data are the mean of 30 panelists ± standard deviation.
- Data followed by different lowercase letters in the same column indicates a significant difference ($p<5\%$).

The results of the hedonic evaluation of corn flakes on the aroma attribute obtained the highest value in the substitution of 4% catfish bone flour with a value of 4.47 and the lowest in the substitution of 8% catfish bone flour with a value of 3.13. The substitution of 6% and 8% catfish bone flour resulted in a stronger fish aroma and a reduced corn flour aroma. Substitution of fish bone flour with a higher percentage will result in a decrease in the panelists preference for the aroma of corn flakes because the fishy aroma from the raw material increases. Panelists preferred corn flakes in the 4% catfish bone flour substitution treatment because the aroma was leaning towards a strong corn flour aroma rather than the fishy aroma. This is supported by research by Muzaki et al., (2021), which stated that the more fish flour substitutions caused the level of panelists preference for the aroma of the resulting product to decrease. This is because the more fish flour used in making the product causes the aroma of the choux pastry to smell of dried fish, so that the level of preference decreases.

The results of the hedonic evaluation of corn flakes on the color attribute obtained the highest value in the substitution of 4% catfish bone flour with a value of 4.57, and the lowest value in the substitution of 8% catfish bone flour with a value of 3.30. The color of the corn flakes with a substitution of 8%

catfish bone flour is darker or brownish yellow compared to corn flakes without fish bone flour substitution. Substitution of fish bone flour with a higher percentage will make the color of the corn flakes produced tend to be brown. The color preferred by the panelists was the control corn flakes and with 4% catfish bone flour substitution because the color was golden yellow. According to Marviana et al. (2022), the addition of flour with a high calcium source will cause a dark color in the resulting product.

The results of the hedonic evaluation of corn flakes on the crispiness parameter obtained the highest value in the substitution of 4% catfish bone flour with a value of 4.50, while the lowest value was in the substitution of 8% catfish bone flour with a value of 3.13. Control corn flakes and with a substitution of 4% catfish bone flour were crispier than the substitution of 6% or 8% catfish bone flour. The crispiness occurs due to the thickness used in the making process of corn flakes and the type of flour used in this study (namely, corn flour and catfish bone flour). Corn flour does not have gluten which can make the resulting product crispier, while catfish bone flour has a high calcium content which will make the resulting product become hard. According to Ananda and Anggraeni (2021), the more fish bone flour added to a product, the resulting product will have the harder texture. This is related to the high calcium and phosphorus content in fish bone flour, so that the crispiness of the resulting product also changes according to the amount of concentration of fish bone flour added.

3.2 Water Content test result

The results of the water content values are presented in Figure 1. The highest water content value was obtained in the control treatment, while the lowest was in the catfish bone substitution treatment with a concentration of 8%. The average water content value obtained has met the Indonesian standard (SNI 4270-2021) about the quality requirements for cereal drinks, which has 8% water content for the maximum value. The water content of corn flakes shows that the higher the concentration of catfish bone flour substitution and the decreasing percentage of corn flour used will cause the decrease of the water content.

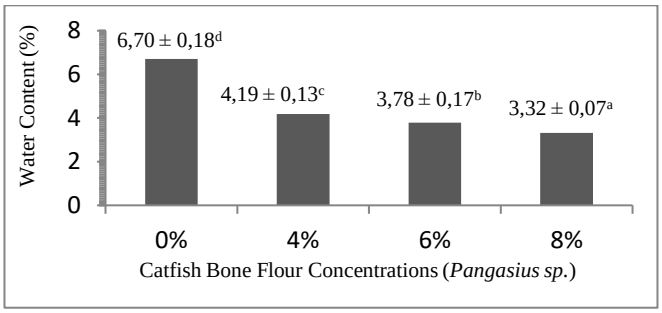

Figure 1. Water content of corn flakes with different catfish bone flour concentrations.

The water content value can be influenced by the ingredients used. The ingredients used are corn flour which has a starch content that can absorb water, while fish bone flour has a calcium content that will inhibit the absorption of water which ultimately causes the water content in the product to decrease. According to Liaqat et al., (2022), the decrease in water content is also caused by the addition of fish bone flour so that there is an addition of Ca^{+} particles that can bind OH particles which are part of the H_2O so that the water content decreases along with the addition of fish bone flour.

3.3 Calcium Content

The results of the calcium level test are as shown in the figure 2. The highest calcium content was obtained in the treatment of 8% catfish bone flour substitution, while the lowest calcium content was in the control treatment without catfish bone flour substitution. The calcium content of the corn flakes added with 4% catfish bone flour substitution contained 1050 mg/100 gr of calcium. One meal with corn flakes requires approximately 30 grams per serving, which means that selected corn flakes contain 315 mg of calcium per serving. The fulfillment of Angka Kebutuhan Gizi (AKG) or Indonesian Dietary Recommendation (per day per serving) is 31.5%, which means that the product is a source of calcium per day and has met the dietary recommendation per day. Recognition of calcium's many health benefits, has led to interest in how best to meet calcium needs. Foods are the preferred source of calcium (Miller et al., 2001). A product is classified high in calcium if the calcium content of the product is at least 30% of the dietary recommendation. According to the Indonesian Minister of Health Regulation (2019), the Indonesian Dietary Recommendation (AKG) for school children is 1000 mg/day.

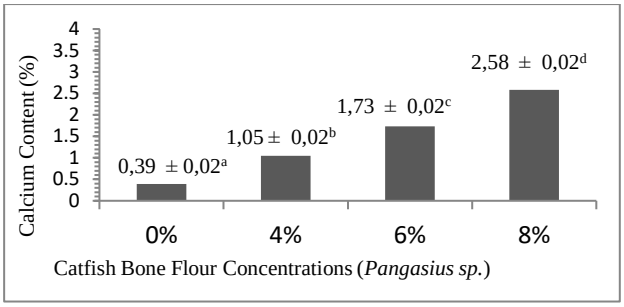

Figure 2. Calcium content of corn flakes with different catfish bone flour concentrations.

The calcium content of corn flakes shows that the higher the concentration of catfish bone flour substitute used, the higher the calcium content will be. This is because the calcium content of the catfish bone flour produced is high, which is around 40.43%. Fish bone flour will be dissolved completely when added with other ingredients so that the ingredients are evenly dispersed in the dough, which causes the calcium content in products to increase (Nawaz et al., (2020). Fish bones contain minerals and calcium so that they will affect the calcium value of a product made with the addition of fish bone meal. The higher the concentration of fish bone meal added to the product, the higher the calcium content that will be produced.

3.4 Phosphorus Content

The results of the phosphorus content test are as shown in Figure 3. The highest phosphorus content was obtained in the treatment of 8% catfish bone flour substitution, while the lowest calcium content was in the control treatment without catfish bone flour substitution. The results of the calcium and phosphorus content of selected corn flakes (4% catfish bone flour substitution) were 1.05% and 0.58%. The resulting calcium:phosphorus ratio was less than 2:1. The research conducted produced a calcium content value that was greater than the phosphorus content, which means that phosphorus does not inhibit the absorption of calcium when digested in the body so that it has the potential to be used as an alternative food source of calcium that is good for the body. This is in accordance with the statement by Syah et al. (2018), namely the results of the calcium content analysis in crackers found that each treatment showed a higher value compared to phosphorus.

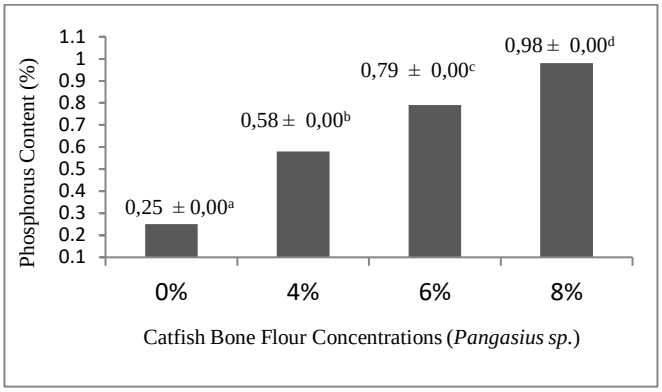

Figure 3. Phosphorus content of corn flakes with different catfish bone flour concentrations.

The result indicates that phosphorus in crackers does not inhibit the absorption of calcium when digested in the body so that it has the potential to be used as an alternative food source of calcium that is good for the human body. A good calcium absorption process requires a ratio of calcium and phosphorus in the intestinal cavity ranging from (1:1) to (3:1). A ratio higher than 3:1 will inhibit the calcium absorption. Higher phosphorus consumption can inhibit calcium absorption because phosphorus in alkaline conditions forms calcium phosphate, which is insoluble in water.

3.5 Hardness

The results of the sample hardness test are as shown in Figure 4. The highest hardness value was obtained in the treatment of 8% catfish bone flour substitution, while the lowest was in the control treatment without catfish bone flour substitution. The results of the analysis of hardness showed that the higher the concentration of catfish bone flour substitution used will cause the increase of the hardness value. Hardness is related to the water content produced. The water content produced in this study decreased within the increasing concentration of catfish bone flour. Lower water content will lead to the harder product texture. According to Manganti et al. (2021), the final product texture is influenced by its water content. The higher the water content, the lower the product hardness level will be. High water content will make the texture of the food material softer.

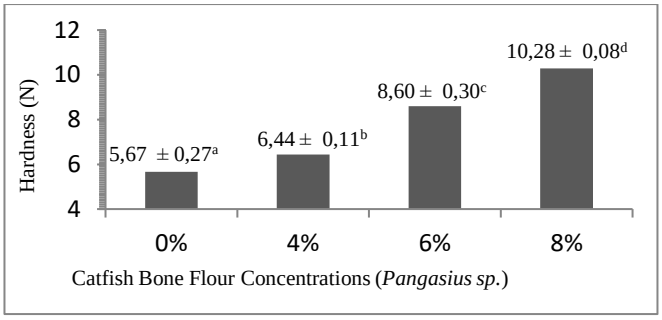

Figure 4. Hardness value of corn flakes with different catfish bone flour concentrations.

The hardness value can be influenced by the ingredients used, which are catfish bone flour and corn flour. Catfish bone flour has a high calcium content, which will cause the texture of the corn flakes to be harder. On the other hand, corn flour has a higher amylopectin content than amylose, which will make the corn flakes have a crispy texture. According to Augustyn et al. (2019), corn flour consists of starch with a proportion of 25-30% amylose and 70-75% amylopectin. This is in accordance with the statement of Fountes et al., (1999), corn flour has a high amylopectin content which causes the texture to be crispier. According to Wardah (2022), the addition of fish bone flour can increase the hardness value of a product.

3.6 Water Absorption Capacity

The results of the water absorption test of corn flakes are presented in Figure 5. The highest water absorption capacity was obtained in the control treatment without catfish bone flour substitution, while the lowest water absorption was in the 8% concentration of catfish bone flour substitution. The results of the analysis of the water absorption of corn flakes showed that the higher concentration of catfish bone flour substitution will cause the decrease of the water absorption in corn flakes. The decrease was caused by the decrease in amylose and amylopectin levels of the product along with the substitution of catfish bone flour. The calcium content in catfish bone flour will inhibit water absorption in the product. According to Shkembi and Huppertz (2021), calcium (Ca) will enter the starch granules, replacing the hydroxyl groups of starch molecules and then new bonds will be formed between the starch components or molecules, which will cause the water absorption to decrease.

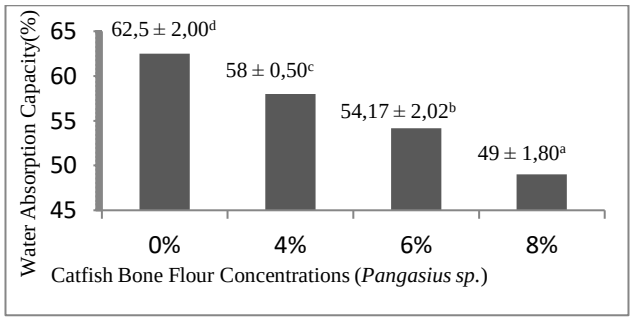

Figure 5. Water absorption capacity of corn flakes.

Another factor that affects the water absorption capacity of corn flakes is the porosity of the material. This is thought to be due to the low porosity of fish bone flour because the increasing concentration of fish bone flour causes the resulting corn flakes to be harder, thus the water absorption capacity will decrease. According to Meulisa et al. (2021), fish bone flour is composed of minerals, such as calcium and phosphorus, which have low porosity values. According to Astuti et al. (2019), hard food products have low porosity, which causes the water absorption capacity of the product to be low.

The air cavities in the product also affect the water absorption value. The cavities produced by the corn flakes become smaller due to the increasing concentration of catfish bone flour given. Smaller air cavities will absorb less water. This is aligned up with the research conducted by Kelana et al., (2024), where the addition of food additive will produce gas in the dough and make the dough light and porous because the air trapped in the dough and water vapor will expand. This happens because mackerel bone flour contains a lot of calcium and protein content, which inhibits the starch gelatinization process. The starch gelatinization process will form the air cavities.

3.7 Crispness Resistance Evaluation in Milk

As seen in Figure 6, the highest crispness resistance value in milk was obtained in the treatment of 8% catfish bone flour substitution, while the lowest was in the control treatment without catfish bone flour substitution. The results of the analysis of crispness resistance in milk showed that the higher concentration of catfish bone flour in the corn flakes will lead to the higher the crispness resistance.

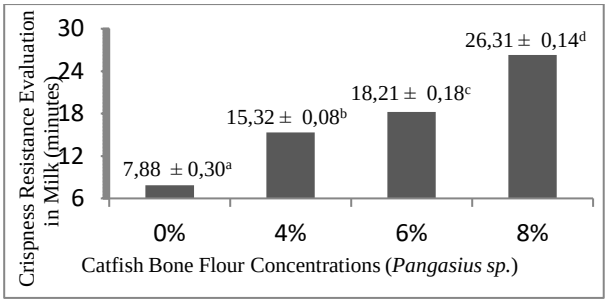

Figure 6. Crispness resistance evaluation in milk of corn flakes with different catfish bone flour concentrations.

The value of crispness resistance can be influenced by hardness and water absorption. The harder texture and lower water absorption of the corn flakes will result the longer crispness resistance in milk. According to Susanti et al. (2017), higher the water absorption value lead to the faster the product will soften in water. If the water absorption is too low, the product will be hard and not easily softened perfectly. According to Komala et al. (2017), crispness resistance in milk is inversely proportional to crispness. The crispier the texture of the flakes, the faster it takes for the flakes to lose their crispness in milk. Flakes with a slight crunchy texture will have low crunch resistance, while flakes with hard texture have a higher texture crunch resistance. According to Patil (2017), cereals that are considered as a good quality are those that can maintain their crunchiness for 15 minutes from the start of soaking process until the cereal sinks and disintegrates in the milk.

4. Conclusion

Substitution of catfish bone flour with different concentrations significantly affected the quality characteristics of corn flakes. The results showed that the higher addition of catfish bone flour concentration will lead to the higher calcium content, phosphorus content, hardness, and crispness resistance in milk, but in the other hand will decrease the water content and water absorption capacity of corn flakes. The corn flakes formulation with the most preferred acceptance was corn flakes with a 4% concentration of catfish bone flour substitution. The treatment of 4% catfish bone flour concentration substitution was the most preferred because the resulting corn flakes had a distinctive taste of corn flakes with a slight fishy taste, a distinctive aroma of corn flakes with a slight fishy aroma, yellow in color, and a texture that was still crunchy. The substitution of catfish bone flour with a concentration of 4% showed quality characteristics with an average hedonic value of $4.44 < \mu < 4.66$, water content of 4.19%, calcium content of 1.05%, phosphorus content of 0.58%, hardness value of 6.44 N, water absorption of 58%, and resistance to crispness in milk for (15.32 minutes).

5. Acknowledgement

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