Breakfast Cereal in Flakes Form Based on Millet Flour and Snakehead Fish Koya

RBK Anandito¹, Siswanti² and L Purnamayati³

¹Department of Agricultural Product Technology, Vocational School, Sebelas Maret University, Jl. Ir. Sutami No.36A, Kentang, Surakarta, Indonesia
²Department of Food Science and Technology, Faculty of Agriculture, Sebelas Maret University, Jl. Ir. Sutami No.36A, Kentang, Surakarta, Indonesia
³Department of Fisheries Post Harvest Technology, Faculty of Fisheries and Marine Sciences, Diponegoro University, Jl. Prof. Sudarto, SH, Semarang, Indonesia

Email: rbaskara@staff.uns.ac.id

Abstract. The purpose of this research was to determine the formulation of flakes made from millet flour and snakehead fish Koya based on its physical, chemical, and sensory properties. The ingredients used were millet flour, snakehead fish koya, sugar, margarine, skim milk and egg. Koya is a savory powder and usually added to traditional Indonesian foods such as Soto and noodles. The initial formulation was determined with a mass balance of the ingredients. The variations of millet flour and snakehead fish koya were 100:0, 80:20, 60:40, and 40:60. All treatments were carried out sensory evaluation using a hedonic test, proximate analysis, calories analysis using bomb calorimetry methods, and physical analysis using a texture profile analyzer. The Compensatory model was used in this study to determine the best formula based on all parameters. The results of this study showed that the best formula of flakes had compositions of millet flour 60% and snakehead fish koya 40%. The physical properties showed that its hardness, fracturability, crispness, and crunchiness in milk values respectively were 1.41 N, 1.02 N, 39.90, and 8.09 minutes. Chemical properties showed that its moisture, ash, protein, fat, carbohydrate, and total calorie content were 2.23%, 3.18%, 14.01%, 19.32%, 61.25%, and 240.81 kcal/50 g, respectively. Sensory analysis showed a brownish color, fishy aroma, fishy taste, and crunchy texture.

1. Introduction
Koya is a powdery food additive, usually added to soup and Soto as a complement and flavor enhancer. Shrimp crackers as raw material for koya contain high carbohydrates, ranging from 77-83%, compared to other nutritional components consisting of protein, fat, ash, and water, ranging from 17-23% [1]. High carbohydrates can lead to the risk of Type Two Diabetes, a common disease suffered globally. One of the factors that affect this disease is dietary habits [2]. Therefore, the intake of high carbohydrate and calorie foods is recommended to be minimized [3]. Koya from snakehead fish is considered one of the efforts to increase the nutritional content of koya.
Snakehead (Channa striata) is a fish containing a high protein ranging from 16.37-18.49%, low-fat content of 0.67-3.32%, and a high content of amino glutamic acids ranging from 10.00-11.47% [4]. The amino glutamic acid is known to have the ability as a flavor enhancer [5]. Therefore, snakehead fish has the potential to be used as raw material for fish koya. Fish koya in powder form has disadvantages, such
as easily absorbing moisture during storage. If the moisture content increased to reach water activity for microbial growth, the microbes would be active and cause damage to fish koya products [6]. Recently, globalization had an impact on the lifestyle of the younger generation, particularly on dietary habits that prefer ready-to-eat foods [7]. Ready-to-eat food does not require an additional cooking process hence it is more practical, fast, and easy to prepare. Besides, the demand for healthy food is also increasing [8, 9]. Therefore, innovation is needed to consume koya fish-based foods that are practical to eat, easy to store, resistant to environmental humidity, and healthier. One of them is processing fish koya into flakes.

Flakes is a fast food prepared with milk for breakfast. Usually, flakes are made from wheat or oats and processed by extrusion [10]. Fish koya needs to be combined with ingredients that contain high carbohydrates with low calories to produce a healthy flakes for consumption without worrying about diabetes. Millet is a native Indonesian food ingredient, rich in complex carbohydrates in the form of starch of 59.00-72.00% and dietary fiber of 102-106 mg/100 g. Dietary fiber components are beneficial for digestive health and controlling blood sugar levels. Apart from that, millet also contains phenolic components that are beneficial for health [11]. Research showed that the addition of millet flour to bread dough could increase the hardness and chewiness [12]. This property is needed where the flakes is immersed in milk and still has a texture when bitten [13]. Yet, research on flakes that have carried out including, flakes made from banana flour and broken rice [14], flakes from sorghum [15], and flakes made from cornflour and cassava [16]. Research on the flakes made from a combination of fish koya and millet flour has not been carried out. Therefore, this study aimed to determine the effect of various combinations of snakehead fish Koya and millet flour on the organoleptic, physical, and chemical characteristics of the flakes produced.

2. Material and Methods
2.1 Material
The main ingredients used in this study were fresh snakehead fish obtained from Cengklik Reservoir, Boyolali, Central Java, Indonesia. The meat was separated, then steamed and ground. White millet, soy flour, skim milk, eggs, sugar, margarine, and herbs (garlic, shallots, lemongrass, salt, coriander) were obtained from a local market in Surakarta.

2.2 Making fish koya
Fish koya was produced based on Anandito et al., [6]. First sauteed the spices until they release flavor then add ground fish and stir. The soy flour was then added and stirred again until it turned brownish. The koya dough was then blended until it became powder.

2.3 Making flakes
Flakes was produced based on Surahman et al., [16] with modification. Millet flour and snakehead fish koya with a ratio of 100:0 (K0), 80:20 (K1), 60:40 (K2), and 40:60 (K3) respectively were mixed with skim milk, eggs, margarine and water then stirred evenly. The dough was then molded in a baking sheet and steamed for 5 minutes. After that, the dough was printed in a square with a size of 2 cm x 2 cm x 2 cm and then baked at 150 °C for 10 minutes.

2.4 Analysis
The analysis was carried out on organoleptic analysis, which includes the physical and chemical organoleptic analysis by hedonic test using 5 scale: 1 = not liked, 2 = somewhat disliked, 3 = neutral, 4 = somewhat like, 5 = like [17]. Physical analysis using a texture analyzer (Universal Testing Machine, Brookfield, USA) on brittleness, hardness, crispness. In addition, endurance tests were also carried out in milk [13]. Chemical properties analysis includes proximate analysis [18] and total calories [19].
2.5. Statistics
This study was conducted using a completely randomized design with three replications. The data obtained were analyzed by ANOVA then continued with Duncan if there are significant differences. Data were analyzed using SPSS 23 software.

3. Results and Discussions

Organoleptic Characteristics

Table 1. Sensory Properties of Flakes

| Formula | Color     | Aroma   | Taste     | Texture | Overall  |
|---------|-----------|---------|-----------|---------|----------|
| K0      | 4.13 ± 0.82a | 3.60 ± 0.84a | 3.40 ± 0.96ab | 4.05 ± 0.75a | 3.48 ± 0.85a |
| K1      | 3.60 ± 0.93b  | 3.65 ± 0.77a  | 3.60 ± 0.84a  | 3.60 ± 0.93b | 3.58 ± 0.71i  |
| K2      | 2.75 ± 0.93c  | 3.48 ± 0.93a  | 3.28 ± 0.20ab | 3.63 ± 0.84b | 3.38 ± 0.71i  |
| K3      | 2.33 ± 0.94d  | 3.43 ± 0.93a  | 3.13 ± 1.04b  | 3.38 ± 0.71ab | 3.00 ± 0.88b  |

Note: The same alphabet notation in the same column shows no significant difference at significance level of 5%.

Based on Table 1, the results of the sensory test have an average value of the panelists' preference for color attributes ranging from 2.33 – 4.13, with a range from slightly dislike to somewhat like. The final flakes have a yellow to dark brown color, along with a higher proportion of the snakehead fish-soybean koya. The brown color produced on the flakes was due to the addition of snakehead fish koya. Factors that influenced the color, apart from the materials used, were also influenced by the Maillard reaction. The Maillard reaction occurred between the aldehyde group of reducing sugars and the amine groups of amino acids. It was a result of the processing process. The Maillard reaction caused the food to change color to brown at temperatures of 150-260 °C [20]. In this study, the Maillard reaction was due to the roasting process, causing the flakes to have a yellow to brown color.

The level of panelists' preference for the aroma attributes ranged from 3.43 to 3.65 with a range of neutral to like and not significantly different. The combination of snakehead fish koya and millet flour did not affect the flakes’ aroma. In the taste attributes, the average panelists' preference level ranged from 3.40 to 3.60, with a range of neutral to like. The flavor produced on the flakes has a slightly bitter after-taste but is still accepted by panelists. The average value of the panelists' preference for texture attributes ranged from 3.60 to 4.05, with a range of slightly like to like value range. The texture produced on these flakes was crunchy and affected by moisture content. The high moisture content of the ingredients caused the consistency to be less crunchy [21].

Physical Characteristics

Table 2. Physical Characteristics of Flakes

| Formula | Hardness (N) | Fracturability (N) | Crispiness | Crunchiness in Milk (minutes) |
|---------|--------------|--------------------|------------|-----------------------------|
| K0      | 3.25 ± 0.13a | 3.22 ± 0.16a       | 56.09 ± 1.14a | 6.23 ± 0.14a               |
| K1      | 1.41 ± 0.18b | 1.02 ± 0.21b       | 39.90 ± 7.02a | 8.09 ± 0.08b               |
| K2      | 2.01 ± 0.13c | 1.82 ± 0.26c       | 36.83 ± 2.60a | 8.54 ± 0.09c               |
| K3      | 2.46 ± 0.06d | 2.54 ± 0.21d       | 38.50 ± 12.84a| 9.11 ± 0.03d               |

Note: The same alphabet notation in the same column shows no significant difference at significance level of 5%.

Hardness is the maximum force required to change shape. The higher the hardness value, the greater the pressure needed to change the shape of the product [22]. Flakes with the addition of snakehead fish koya and millet flour have a hardness value ranging from 1.41 - 3.25N. Based on the results, the hardness value decreased along with the increasing number of snakehead fish Koya added to the flakes. This
hardness value is related to moisture content. Food with a moisture content of less than 10% has the frangible characteristic [23]. It also deals with fracturability. Fracturability is defined as the load required to cause a fracture in food products. It also can be defined as the minimum force that caused a fracture in the first bite [22]. The value of fracturability also decreased with increasing concentrations of snakehead fish koya.

The crispiness is the quotient between the hardness level value and the mean value of all points [22]. The crispness of the flakes is inversely proportional to fracturability. Table 2 shows that the addition of snakehead fish koya did not affect the crispness of the flakes, with a value of 0.36 - 0.55 N.

The crunchiness in milk is the time for the flakes to stay afloat on the surface until the texture is not crunchy enough [13]. Flakes, as one of instant cereal, are expected to have a crunch time of more than three minutes. In general, they are combined with milk when consumed to complement the protein content of the flakes. When soaked in milk, the flakes absorb the milk until they become too mushy and tasteless. The results of the physical analysis of flakes for crunchiness in milk ranged from 6.23-9.11 minutes. The higher the concentration of snakehead fish koya, the longer it will take to remain crunchy in milk. The value of crunchiness in milk will increase along with the hardness value.

### Chemical Characteristics

**Table 3. Chemical Properties of Millet Flour and Snakehead Fish Koya**

| Chemical Component | Millet Flour | Snakehead Fish Koya |
|--------------------|--------------|---------------------|
| Moisture (% wb)    | 11.46 ± 0.02 | 5.10 ± 0.03         |
| Ash (% db)         | 1.65 ± 0.06  | 5.59 ± 0.07         |
| Fat (% db)         | 5.75 ± 0.19  | 15.26 ± 0.64        |
| Protein (% db)     | 11.72 ± 0.04 | 48.75 ± 0.31        |
| Carbohydrate (% db)| 69.42 ± 0.20 | 25.30 ± 1.01        |

**Table 4. Chemical Properties of Flakes**

| Formula | Moisture (% wb) | Ash (% db) | Fat (% db) | Protein (% db) | Carbohydrate (% db) | Total Calories (kcal / 50g) |
|---------|-----------------|------------|------------|----------------|----------------------|----------------------------|
| K0      | 3.37 ± 0.01     | 1.94 ± 0.01| 13.46 ± 0.21| 9.93 ± 0.02     | 71.29 ± 0.23         | 229.76 ± 2.35             |
| K1      | 2.23 ± 0.15     | 3.18 ± 0.13| 14.01 ± 0.08| 19.32 ± 0.12    | 61.25 ± 0.29         | 240.81 ± 0.82             |
| K2      | 2.90 ± 0.69     | 3.42 ± 0.09| 16.01 ± 0.20| 20.28 ± 0.14    | 57.38 ± 0.30         | 245.98 ± 0.14             |
| K3      | 3.12 ± 0.17     | 3.59 ± 0.07| 17.09 ± 0.27| 21.49 ± 0.32    | 54.71 ± 0.81         | 246.30 ± 1.68             |

Note: The same alphabet notation in the same column shows no significant difference at significance level of 5%

Flakes have a moisture content ranged from 2.23-3.37% according to the standard of moisture content of cereal, namely maximum at 3% [24]. The greater the concentration of snakehead fish koya, the higher the moisture content. It showed that the flakes’ ability to bind water would increase along with the amount of snakehead fish koya added. This water absorption happened because of the protein contained in koya. Protein in food will be hydrophilic if there are polar side chains along the peptide chain, namely the carboxyl and amino groups [25]. Besides that, the moisture content of the flakes was influenced by the process. In the flakes production, the steaming process was carried out at 100 °C for 15 minutes. This process will add more water to ingredients.

The ash content of the flakes ranged from 1.94-3.59%, following the standard of cereal ash content with a maximum of 4% [24]. The factor that influences the ash content of the flakes is raw materials. The ash content of snakehead fish koya was 5.59%, which higher than the ash content of millet flour, which was 1.65%. The ash content of the flakes increased along with the amount of snakehead fish koya added.
The fat content of the flakes ranged from 13.46-17.09%. The result is higher than the standard cereal fat content of at least 7% [24]. Based on the results, higher snakehead fish koya concentration on the flakes would increase the fat content. It was due to the fat content of snakehead fish koya of 15.26%, higher when compared to the fat content of millet flour, which is 5.75%. Apart from the raw materials used, the fat content is also influenced by supporting materials, such as margarine and eggs, which can also affect the fat content of the flakes. The fat content in margarine was 81%, while eggs were 11.5% [26].

Flakes have protein content ranged from 9.93-21.49%. The protein content of snakehead fish koya was higher than the protein content of white millet flour, namely 48.75% and 11.72%. It indicated that the higher the snakehead fish koya concentration, the higher the protein content in the flakes. The protein content is following the standard cereal protein content, which is at least 5% [24]. Apart from the raw materials used, supporting materials such as margarine and eggs can also affect the protein flakes content. The protein content in skim milk was 3.5%, while eggs were 12.8% [26].

The carbohydrate content ranged from 54.71 to 71.29%. The carbohydrate content is following the standard cereal carbohydrate content, which is at least 60% [24]. Based on the results, the greater the concentration of snakehead fish koya, the lower the carbohydrate content in the flakes. Factors that influence the carbohydrate content include the composition of the materials used, both raw materials and supporting materials, as well as the process. The cooking process would decrease the chemical composition and nutritional substances of food [27].

Based on the protein, fat, and carbohydrate content of the flakes, it has a total calorie of 229.76-246.30 kcal / 50g. This value corresponds to the total calorie for emergency food, which is 233 kcal / 50 g [28].

4. Conclusion

The best flakes formula was flakes with the composition of snakehead fish koya and millet flour 40:60. The physical analysis showed that its hardness, fracturability, crispness, and crunchiness in milk values respectively were 1.41 N, 1.02 N, 39.90, and 8.09 minutes. Chemical analysis showed that its moisture, ash, protein, fat, carbohydrate, and total calorie content respectively were 2.23%, 3.18%, 14.01%, 19.32%, 61.25%, and 240.81 kcal / 50 g. Sensory analysis showed a brownish color, fishy aroma, fishy taste, and crunchy texture.

References

[1] Kolade O Y, Adeyemi Y B and Amusan E E 2014 Continental J Food Science and Technology 8 16–21
[2] Sami W, Ansari T, Butt N S and Ab Hamid M R 2017 International Journal of Health Sciences 11 1-7
[3] Jung C H and Choi K M 2017 Nutrients 9 1-20
[4] Rosmawati, Abustam E, Tawali A B, Said M I and Sari D K 2018 Fisheries Science 84 1081–1089
[5] Bera T K, Kar S K, Yadav P K, Mukherjee P, Yadav S and Joshi B 2017 World Journal of Pharmaceutical Sciences 5 139-144
[6] Anandito R B K, Siswanti, Purnamayati L and Sodiq H 2017 B. Life and Environmental Sciences 54 201–206
[7] Yulia C, Nikmawati E E, and Widiaty I 2017 Innovation of Vocational Technology Education 13 1-7
[8] Vlachos S and Georgantzis N 2016 International Journal of Food and Beverage Manufacturing and Business Models 1 12-27
[9] Patel D and Rathod R 2017 World Wide Journal of Multidisciplinary Research and Development 3 198-205
[10] Carvalho A V, Mattiet R A, Bassinello P Z, Koakuzu S N, Rios A O, Maciel R A and Carvalho R N Ciênc. Tecnol. Aliment. Campinas, 32 515-524
[11] Devi P B, Vijayabharathi R, Sathyabama S, Malleshi N G and Priyadarisini V B 2014 J Food Sci Technol 51 1021-1040
[12] Li Y, Lv J, Wang J, Zhu J and Shen R 2020 Applied Sciences 10 1-13
[13] Papunas M E, Djarkasi G S S and Moningka J S C 2013 *Jurnal Cocos* 3 1-10
[14] Fitriani V, Permana L and Setiaboma W 2019 *IOP Conference Series: Earth and Environmental Science* **258** 1-9
[15] Chavan U D, Patil S S, Dayakar Rao B and Patil J V 2015 *European Journal of Molecular Biology and Biochemistry* **5** 49-58
[16] Surahman D N, Rahayu R P, Desnilasari D, Ekaefitri R, Cahyadi W and Rahman T 2019 *IOP Conference Series: Earth and Environmental Science* **251** 1-8
[17] Setyaningsih D, Ariyantono A, and Maya Puspita S 2010 *Analisis Sensor* IPB Press Bogor
[18] AOAC 2002 *Official Methods of Analysis* Association of Official Analytical Chemists, Washington DC
[19] Mulyaningsih Y and Rosida J 2002 Temu Teknis Fumgsional Non Peneliti
[20] Tamanna N and Mahmood N 2015 *International Journal of Food Science* 1-7
[21] Tunick M H, Onwulata C I, Thomas A E, Phillips J G, Mukhopadhyay S, Sheen S, Liu C K, Latona N, Pimentel M R, and Cooke P H 2013 *International Journal of Food Properties* **16** 949–963
[22] Bourne M 2002 *Food Texture and Viscosity: Concept and Measurement* Elsevier Science & Technology Books, London
[23] Blahovec J 2007 *International Agrophysics* **21** 209-215
[24] Badan Standardisasi Nasional 1996 SNI 01-4270-1996 *Sereal* Jakarta
[25] Banach M, Fabian P, Stapor K, Konieczny L and Roterman I 2020 *Biomolecules* **10** 1-20
[26] Badan Pengawasan Obat dan Makanan (BPOM) 2006 *Surat Keputusan tentang Kategori Pangan* Jakarta
[27] Abraha B, Admassu H, Mahmud A, Tsighe N, Shui X W and Fang Y 2018 *MOJ Food Processing & Technology* **6** 376–382
[28] Zoumas B E, Armstrong L E, Backstrand J R, Chenoweth W L, Chinachoti P, Klein B P, Lane H W, Marsh K S and Tolvanen M 2002 *High-Energy, Nutrient-Dense Emergency Relief Food Product National Academy Press, Washington DC*