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COMPARATIVE ANALYSIS OF PROXIMATE, CALCIUM, AND IRON CONTENT IN FISH POWDER DERIVED FROM SNAKEHEAD (*CHANNA STRIATA*) AND ITS BY-PRODUCT

[Analisis Komparatif Kalsium, Zat Besi, dan Proksimat Bubuk Ikan Berbasis Gabus (Channa striata) dan Hasil Sampingnya]

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ABSTRACT

Snakehead (Channa striata) is a widely fish commodity in Indonesia. This research was conducted to develop fish powder product, that was rich in energy and high-quality micronutrients. This research also aims to observe the nutritional value of fish powder derived from snakehead and its by-products, in order to fulfill nutritional value of food products. The results showed that the bone (BN) was smallest reduction in mass compared to the meat (MT), head (HD), and skin (SK) (p<0.05). The fat content of bone-based fish powder was found to be similar to that of the meat part, and even higher than other parts. The highest calcium and iron content (72108.13 mg/kg) was found in bone-derived fish powder, followed by head-based powder (58295.67 mg/kg) and skin-based powder (34782.12 mg/kg) of snakehead. The lowest iron content was observed in meat-based powder (33.44 mg/kg). However, the iron levels in fish powder made from head, skin, and bones were not significantly different, measuring 67.52 mg/kg, 87.27 mg/kg, and 68.99 mg/kg, respectively. Therefore, the result will be helpful for developing snakehead powder as commercial product.

Keywords: *calcium, fish powder, iron, proximate, snakehead.*

ABSTRAK

Ikan gabus (*Channa striata*) merupakan komoditas yang banyak dimanfaatkan di Indonesia. Penelitian ini bertujuan untuk mengembangkan produk bubuk ikan yang kaya energi dan zat gizi mikro berkualitas tinggi. Pada penelitian ini kami mencoba mengevaluasi potensi bubuk ikan yang berasal dari ikan gabus dan produk turunannya, dalam rangka pemenuhan nilai gizi produk pangan. Hasil penelitian menunjukkan bahwa bubuk tulang (BN) menunjukkan penurunan massa paling kecil selama pengolahan jika dibandingkan bagian daging (MT), kepala (HD), dan kulit (SK) (p<0,05). Kandungan lemak pada bubuk ikan berbahan dasar tulang ternyata sama dengan bagian dagingnya, bahkan lebih tinggi dibandingkan bagian lainnya. Kandungan kalsium dan zat besi tertinggi (72108,13 mg/kg) terdapat pada bubuk ikan yang berasal dari tulang, diikuti oleh bagian kepala (58295,67 mg/kg) dan kulit (34782,12 mg/kg) ikan gabus. Kandungan zat besi terendah terdapat pada bubuk berbahan dasar daging ikan gabus (33,44 mg/kg). Namun kadar zat besi pada bubuk ikan berbahan dasar kepala, kulit, dan tulang tidak berbeda nyata, yaitu masing-masing sebesar 67,52 mg/kg, 87,27 mg/kg, dan 68,99 mg/kg. Hasil penelitian ini dapat berguna dalam pengembangan bubuk ikan gabus sebagai produk komersial.

Kata kunci: bubuk ikan, gabus, kalsium, proksimat, zat besi.

INTRODUCTION

Stunting reduction is one of the main goals in the Global Nutrition Targets for 2025 issued by WHO. In fact, decline in stunting prevalence is the second indicator of the Sustainable Development Goal of Zero Hunger released by the United Nations (Gil et al., 2019). This shows that stunting needs to be considered by each country. Stunting prevalence of more than 30% is a fairly large number (Gowele et al., 2021). COVID-19 is a reason of malnutrition and stunting rising in Indonesia (Kusumaningrum et al., 2022). In 2020, stunting sufferers in Indonesia increased by at least 15% during the COVID-19 pandemic, and it is estimated that around 7 million children under 5 years of age in Indonesia are stunted (Kusumaningrum et al., 2022; Muhafidin, 2022).

Education, sanitation, agriculture and food system, society and culture, economic status of household, and environment are determinants of stunting in Indonesia (Beal et al., 2018; Budiastutik and Nugraheni, 2018). These determinants promote inadequate complementary feeding as a trigger of stunting. Low intake of high-quality micronutrients, low intake of animal-source food, and low-energy complementary food indicate the inadequate complementary feeding (Beal et al., 2021; Ryckman et al., 2021; Stewart et al., 2013). Therefore, consuming animal-source food with high-quality micronutrient and rich of energy are contributed to stunting reduction.

This research was intended to develop fish powder product, which was rich of energy and high-quality micronutrients. This product was expected to apply to many types of food and accessible to all sections of society. In order to produce fish powder, snakehead (*Channa striata*) can be used as a raw material. Snakehead is a freshwater fish containing albumin which functions as an antioxidant and anti-aging (Mustafa et al., 2012). Snakehead is also known as a source of high-quality protein with good fat content for the human body (Puteri and Febriansyah, 2023; Rahayu et al., 2016). Due to its high production in South Sumatra, snakehead is often processed into pempek and other typical South Sumatran food (Surya et al., 2023; Wargadalem et al., 2023). Therefore, a large amount of snakehead by-products is produced during the production of local food. To reduce the occurrence of food waste, the by-products of snakehead, such as skin; head; and bone, were also used as raw material, in addition to the meat partl. These by-products have low economic value but good nutritional content. The presence of essential fatty acids and odd chain saturated fatty acids (OCS-FAs) shows the potential health benefits of snakehead by-product (Puteri and Febriansyah, 2023). Moreover, utilization of these by-products will give a positive impact on the environment.

By this research, we tried to evaluate the potential side of fish powder from snakehead (*Channa striata*) and its by-products, in order to fulfill nutritional value of food products. Therefore, the result will be helpful for developing snakehead powder as commercial product.

MATERIALS AND METHODS

Material

Snakehead (*Channa striata*) was used as main sample. Fish was obtained from a traditional market in Ogan Ilir, South Sumatra.

Research Methods

Fish powder preparation

Fish were cleaned, washed, filleted, and separated into meat (MT), head (HD), skin (SK), and bone (BN). They were dried using a convection oven (GL4802, IONA, Singapore) at 70°C for 24 hours. Each sample group was then grounded with a blender and filtered using a stainless sieve (10 mesh) to produce fish powder (Abbey et al., 2017). The sample was then stored at 4°C until it was ready for further analysis.

Proximate analysis

The proximate analysis of the sample included determination of water content, ash content, protein content, fat content, and carbohydrate content, following the guidelines provided in SNI 01-2891-1992 on Food and Beverage Test Methods. Carbohydrate content (by difference) was calculated by subtracting the results of the other proximate analyses. Moisture content and ash content were determined using gravimetric methods, involving the use of an oven and furnace, respectively. To determine the water content, an empty, clean, and dry moisture dish is weighed (W1). A known amount (2 g) of the sample is then added to the dish (W2). The dish with the sample is placed in a drying oven set at 105° C for 24 hours or until a constant weight is achieved. After drying, the dish is removed, allowed to cool in a desiccator, and reweighed (W3). The water content is calculated using the following formula.

$$\text{Water content }(\%)=\frac{\text{W2-W3}}{\text{W2-W1}}\times 100\%$$

For ash content determination, an empty, clean, and dry crucible is weighed (W1). A known amount of the sample is added to the crucible (W2). The crucible is placed in a muffle furnace at 550°C for 4-6 hours or until a white or light grey ash is obtained. The crucible is then allowed to cool in a desiccator and reweighed (W3). The ash content is calculated using the following formula.

$$\text{Ash content }(\%)=\frac{\text{W3-W1}}{\text{W2-W1}}\times 100\%$$

Protein content was determined using the Kjeldahl method. In the determination of protein content using the Kjeldahl method, an amount (5 g) of the sample is weighed (W). The sample is digested in concentrated sulfuric acid (H_2SO_4) with a catalyst to convert nitrogen into ammonium sulfate. The digest is then neutralized with sodium hydroxide (NaOH), and the released ammonia is distilled into a boric acid solution. The distillate is titrated with a standard acid solution, such as HCl, to determine the amount of ammonia. The protein content is calculated using the following formula.

$$\text{Protein content }(\%)=\text{Total nitrogen }(\%)\times\text{conversion factor}$$

Fat content was determined using the Soxhlet method. To analyze fat content, a known amount (5 g) of the sample is weighed (W). The sample is placed in a thimble, and fat extraction is carried out using a solvent, such as petroleum ether, in a Soxhlet extractor for a specified duration, usually 6-8 hours. The solvent is then removed by evaporation, and the extracted fat is weighed. The fat content is calculated using the following formula.

$$\text{Fat content }(\%)=\frac{\text{weight of extracted fat}}{\text{weight of sample}}\times 100\%$$

Calcium and iron analyses

The content of calcium (Ca) and iron (Fe) were analyzed using the Atomic Absorption Spectrophotometer (AA-7000, Flame-Model, Shimadzu, Japan). Prior to analysis using the instrument, sample was previously destroyed by acid (Barbeş et al., 2021).

Statistical analysis

All experiments were performed in three replicates and expressed as mean ± standard error of mean. Completely Randomized Design (CRD) was applied as experimental design. Then, data were statistically processed using ANOVA (Analysis of Variance) at a significance level of 5%. Significantly different data were then analyzed further by Duncan's Test.

RESULT AND DISCUSSION

Characteristic After Drying

The snakehead was dissected into the meat, head, skin, and bones, as depicted in Figure 1. The head, skin, and bones are typically considered by-products and not used. Approximately 1.2 kg of head, 0.1 kg of bones, and 0.3 kg of skin were obtained from 1 kg of snakehead meat. Subsequently, each part was dried in a drying oven at 70°C for 24 hours. The drying results are presented in Figure 1, which shows a reduction in mass for each part. The mass reduction after drying is further illustrated in Figure 2. The bone (BN) showed the smallest reduction in mass compared to the meat (MT), head (HD), and skin (SK) ($p<0.05$). The mass reduction is closely linked to the water content, as shown in Table 1. To obtain a powdered form, snakehead and its by-products are dried and then processed through milling and sifting, as illustrated in Figure 3.

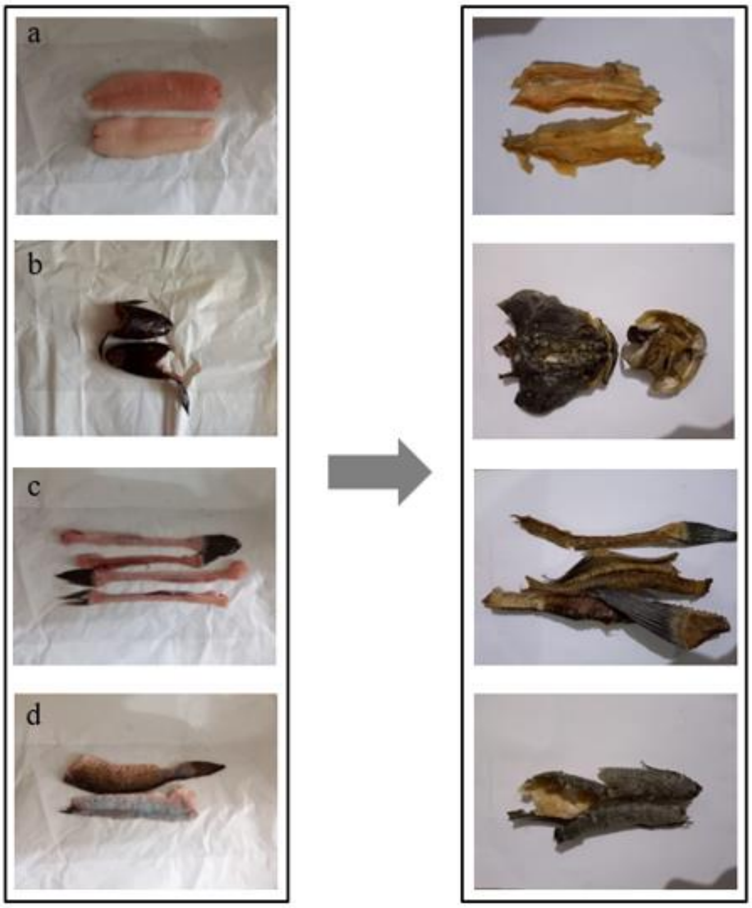

Figure 1. The (a) meat; (b) head; (c) bone; and (d) skin of snakehead

However, the resulting fish powder has a coarse texture. To improve the fineness of the fish powder, advanced preparation steps can be considered. Autoclaving has been studied as an alternative method to optimize the size reduction and produce fish powder with smaller particle sizes (Nawaz et al., 2020; Sarrate et al., 2015). Additionally, steaming or boiling processes yield fish powder with desirable characteristics (Nowsad et al., 2021). The sieving of meat, head, skin, and fish bones also results in by-products that cannot pass through the sifting process. However, due to the large size of the fish powder after drying, the final product yield tends to be low. The addition of autoclaving is also expected to enhance the nutritional value of the final product, particularly by increasing digestibility.

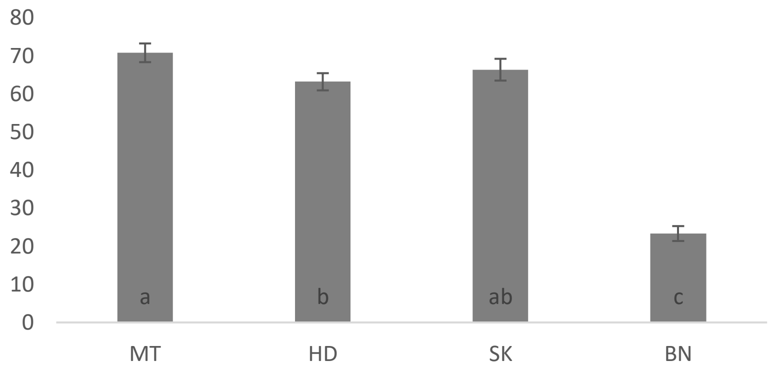

Figure 2. The yield of meat (MT), head (HD), skin (SK), and bone (BN) after drying (%)

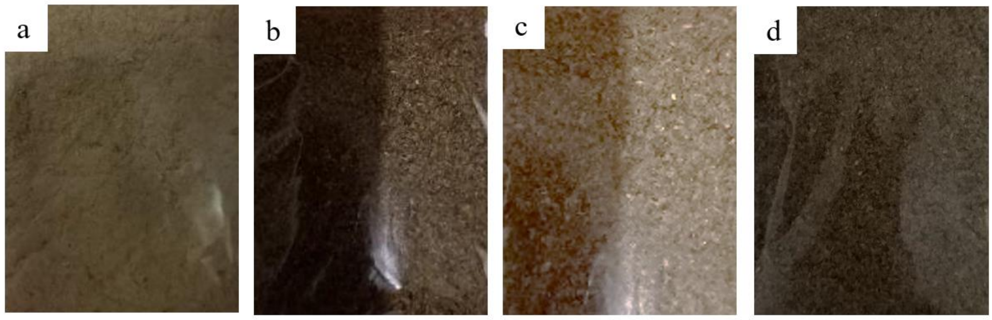

Figure 3. Results of grinding and sieving (a) meat; (b) head; (c) skin; and (d) bone

Proximate Composition

The approximate water, ash, carbohydrate, protein, and fat composition of the snakehead are shown in Table 1. The ash, carbohydrate, protein, and fat contents are shown on a dry basis. This chemical composition may be attributed to several factors, including the physiological functions and compositions of these fish tissues, as well as dietary intake and metabolism.

The water content of fish powder was comparable to that of fish powder made from the head and skin, as there were no significant differences observed. However, the fish powder made from bones had the lowest water content ($p<0.05$). Fish bones naturally contain less water compared to the meat, head, and skin of the fish, which makes them easier to dry. This is the reason behind the lower water content in bone-based fish powder. Furthermore, the fat content of bone-based fish powder was found to be similar to that of head and skin-based fish powder, and even higher than that of the meat part, as illustrated in Figure 1. This can be attributed to the fact that the bone sample group (BN) includes residues of meat and tail, which can impact the chemical composition of the fish powder.

Table 1. Chemical composition of fish powder based on meat (MT), head (HD), skin (SK), and bone (BN) of snakehead

Sample	Moisture (%)	Ash (% bk)	Carbohydrate (% bk)	Protein (% bk)	Fat (% bk)
MT	6.79 ± 0.70^{a}	8.29 ± 0.89^{b}	37.60 ± 7.20^{a}	50.70 ± 8.82^{a}	3.48 ± 0.45^{c}
HD	6.71 ± 0.75^{a}	37.72 ± 5.69^{a}	23.06 ± 4.29^{b}	23.14 ± 1.91^{b}	16.08 ± 1.61^{a}
SK	6.32 ± 0.74^{a}	37.64 ± 3.77^{a}	23.13 ± 4.11^{b}	29.25 ± 1.91^{b}	9.98 ± 1.17^{b}
BN	4.53 ± 0.61^{b}	35.27 ± 2.30^{a}	31.64 ± 5.67^{ab}	23.40 ± 2.73^{b}	12.24 ± 5.86^{ab}

The numbers in the column are followed by the same letter was not significantly different at the 5% test level. Data are mean ± standard deviation.

The analysis of protein content showed that fish powder made from meat had significantly higher protein content compared to other parts ($p<0.05$). This finding is consistent with a previous study which reported that protein was the dominant component in snakehead meat and had a significantly higher composition compared to other component (Molla et al., 2016), because the flesh of fish is primarily composed of muscle tissue. Snakehead protein is known for its good quality, as it can increase albumin levels and promote wound healing (Mustafa et al., 2012; Sindgikar et al., 2017), with striatin being one of the bioactive proteins found in snakehead (Rahayu et al., 2016). Additionally, proline and glycine, which are amino acids mainly found in snakehead, contribute to its protein content (Rosmawati et al., 2018). Despite not having as high protein content as meat, the by-products such as fish heads, skin, and bones contain protein that can be utilised, such as fish skin being a source of collagen (Blanco et al., 2017). This result showed the snakehead-based fish powder is potentially developed as a protein source for food product. Adequate protein intake is crucial during childhood, as it supports tissue growth, including muscle and bone tissues. Protein also plays a role in immune function and repairing damaged tissues. Including high-quality protein as part of a balanced diet may support optimal growth and potentially reduce the risk of stunting (de Onis and Branca, 2016; Fikawati et al., 2021).

Significantly lower fat content ($p<0.05$) was observed in fish powder derived from snakehead meat, in comparison to fish powder derived from snakehead head, skin, and bones. However, snakehead meat is known for containing essential fatty acid components such as EPA and DHA, which have significant health benefits and play a crucial role in brain development (Molla et al., 2016). Adequate intake of essential fatty acids from fish can support cognitive development and may help reduce the risk of stunting. The presence of these high-quality fat components presents a potential for developing snakehead-based fish powder.

The ash content of fish powder based on snakehead head, skin, and bones was significantly higher ($p<0.05$) than that of meat-based fish powder. This suggests a relatively high mineral content in the head, skin, and bones of snakehead, which is consistent with the calcium and iron content analysis results shown in Figures 4 and 5. Snakehead is known to contain various minerals or micronutrient such as sodium, magnesium, phosphorus, sulfur, chlorine, potassium, and calcium (Rosmawati et al., 2018), which are positively correlated with the observed higher ash content in the fish powder derived from these parts. The high prevalence of stunting and anemia is associated with micronutrient deficiencies, infections, and inadequate intake of essential micronutrients. Therefore, the fish powder is potentially to be developed in reducing the prevalence of stunting.

Metabolism in fish affects the levels of fat, protein, and carbohydrates through intricate processes of synthesis and degradation. These processes are regulated by dietary intake, physiological demands, and environmental conditions. Additionally, studies on gilthead sea bream demonstrate that dietary modifications can influence lipid and carbohydrate metabolism, with adaptations in adipose tissue and hepatic enzymes to balance energy utilization and storage (Skiba-Cassy et al., 2013). Investigations on Arctic charr, Eurasian perch, and tilapia show species-specific responses to dietary carbohydrates, with differences in starch digestibility and metabolic effects, emphasizing the importance of considering species variations in metabolic responses to diet composition (Melo et al., 2016).

Calcium and Iron Content

Calcium and iron are important micronutrients for metabolism. Previous studies showed that failure to meet adequate micronutrient intake is responsible to stunting problem of children under 5 years of age (Ernawati et al., 2021; Gowele et al., 2021). Recommended Dietary Allowance (RDA) of calcium and iron for children under 5 years in Indonesia are 1000 mg and 10 mg, respectively (Arini et al., 2022). Calcium is an essential mineral that plays a critical role in various physiological processes, such as bone formation, nerve function, muscle function, and blood clotting. Significant differences in calcium (Ca) levels were observed among the samples (Figure 4). The highest calcium content was found in bone-based fish powder (72108.13 mg/kg), followed by head-based fish powder (58295.67

mg/kg), skin (34782.12 mg/kg), and meat (4451.513 mg/kg) of snakehead. The variation in calcium content among different parts of the snakehead may be attributed to the varying physiological functions and compositions of these fish tissues. Bones are a rich source of calcium, as calcium is a major component of bone tissue in many animals, including fish. Therefore, bone-based fish powder may have the highest calcium content among the analysed parts of the snakehead. The head of fish often contains bones, cartilage, and connective tissues, which may contribute to its calcium content. However, the calcium content in the head-based fish powder may be lower than that in bone-based fish powder, as the head may contain a smaller proportion of bones and other calcium-rich tissues compared to the rest of the fish. The calcium content in the skin may be lower than that in the bones and head due to the relatively lower density of bone tissue in the skin. The meat of fish, which typically includes the flesh, muscles, and internal organs, may have a lower calcium content compared to bones, head, and skin. This is because the flesh of fish is primarily composed of muscle tissue, which may have a lower concentration of calcium compared to bones and other tissues. These results are higher compared to findings from other studies (Marimuthu et al., 2012), indicating the potential of snakehead as a rich source of calcium. Adequate calcium intake during childhood and adolescence, when bone growth is most active, can promote optimal bone mineralisation and density, which may help prevent skeletal deformities and stunted growth. Moreover, calcium also plays a crucial role in muscle function and hormonal regulation.

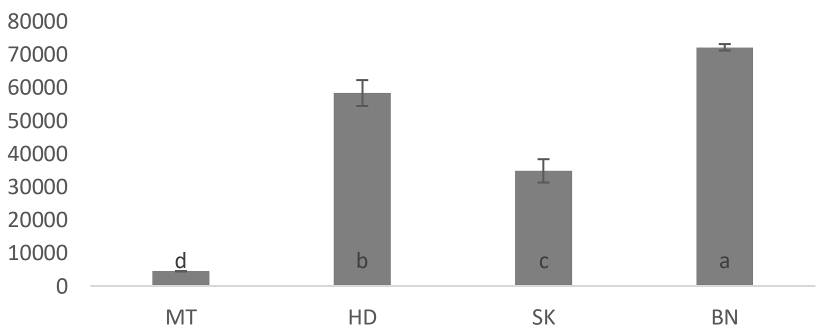

Figure 4. Calcium (Ca) content in meat (MT), head (HD), skin (SK), and bone (BN) of snakehead in mg/kg

On the other hand, the iron (Fe) content in the different sample groups showed a different pattern compared to calcium (Figure 5). The lowest iron content ($p<0.05$) was observed in meat-based fish powder (33.44 mg/kg), while the iron levels in fish powder based on head, skin, and bones were not significantly different, measuring 67.52 mg/kg, 87.27 mg/kg, and 68.99 mg/kg, respectively. The variation of iron content may be attributed to several factors, including the physiological functions and compositions of these fish tissues, as well as dietary intake and metabolism. The head of fish often contains various tissues, including muscles, nerves, and blood vessels, which may contain iron-rich components such as haemoglobin and myoglobin. These tissues may contribute to the higher iron content in the head compared to other parts of the fish. Muscle tissue, in particular, contains relatively high levels of iron due to the presence of myoglobin, which is an iron-containing protein responsible for oxygen storage in muscles. Therefore, the iron content in the meat of the snakehead may be relatively higher. Bones are composed of calcium and phosphorus, and may contain trace amounts of other minerals, including iron. However, the iron content in bones is generally lower compared to other tissues, as bones are primarily made up of mineralised connective tissue rather than soft tissues such as muscles or organs. Iron intake can support the production of haemoglobin, which can help optimize oxygen delivery to tissues and organs, including bone and muscle tissues, thereby promoting proper growth and development. Iron is also essential for optimal brain development and immune function. Adequate iron intake during early childhood can support cognitive development, including learning, memory, and concentration, which may contribute to overall growth and development.

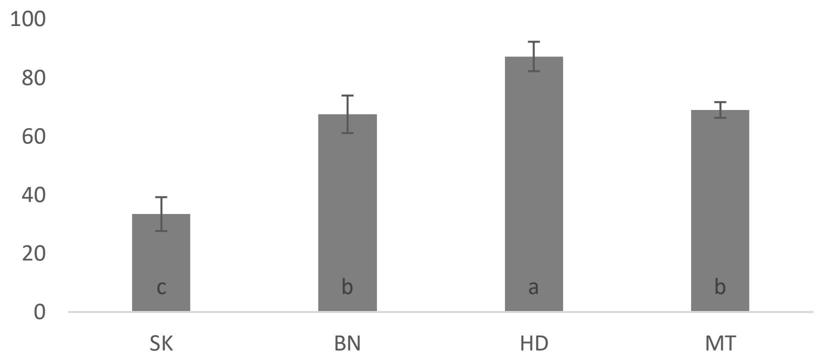

Figure 5. Composition of iron (Fe) in meat (MT), head (HD), skin (SK), and bone (BN) of snakehead in mg/kg

CONCLUSIONS

Snakehead has the potential to be developed into fish powder based on its chemical composition, including its calcium and iron content. However, further research is needed to investigate the physical characteristics of fish powder that may impact its applicability in food products. Additionally, alternative processing methods should be explored to improve the physical properties of fish powder derived from snakehead, particularly with regard to the particle size of the final product. Furthermore, it is crucial to study the characteristics of fish powder obtained from whole snakehead or a combination of different parts of the fish, in order to produce a final product with optimal characteristics for food applications.

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ABBREVIATION

WHO: World Health Organization

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