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Processing of Catfish Bones into Flour: Yield and Chemical Characteristics

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Abstract

Utilizing catfish bones to produce flour is an effort to increase the value of fishery by-products. This study aimed to produce catfish bone flour and evaluate its yield, as well as its moisture, ash, and fat content. The processing steps involved washing the bones, heating them for 15 minutes, pressure-cooking them for 1.5 hours, drying, grinding, and sieving. Yield was determined by the ratio of flour mass to initial bone mass, while chemical characteristics were analysed using AOAC methods. The results showed that 210 g of bones yielded 85 g of flour, representing a yield of 40.48%. The resulting flour had a moisture content of 7.45%, ash content of 63.29%, and fat content of 2.95%. The high ash content indicates a significant inorganic fraction, whereas the fat content was relatively low compared to other fish bone flours reported previously. The study demonstrates that processing via heating, pressure-cooking, drying, and grinding yields bone flour with measurable chemical characteristics. These findings can serve as baseline data for process optimization and the development of catfish bone utilization into value-added products.

Keywords: Fishery by-products, Chemical characteristics, Yield, Catfish bone meal.

Introduction

Fish bone is a byproduct of fish processing whose utilization remains limited. Rich in inorganic fractions, fish bone has the potential to be processed into value-added flour (Yusrina et al., 2021). Such utilization can reduce waste while creating opportunities for food product development. Murillo et al. (2022), reported that catfish bone flour can be incorporated into food products while maintaining consumer acceptance.

Fish bones have the potential for re-valorisation due to their high mineral content, particularly calcium phosphate, as well as organic components such as protein and lipids. This composition allows fish bones to be processed into flour or mineral-based materials with added value (Ho Khanh Hy et al., 2021; Nawaz et al., 2020). Their utilization also supports sustainable fishery by-product management by converting underutilized materials into more

valuable products. In the food sector, fish bone meal has also been developed as a mineral fortification ingredient in various products (Riany Eris et al., 2020).

Yield refers to the percentage of the final product obtained relative to the initial raw material after processing, thereby reflecting the output of a given process (Yusrina et al., 2021). The characteristics of bone flour are influenced by species, raw material composition, and processing conditions. Heat treatment, processing methods, and boiling temperatures can affect both the yield and the physicochemical properties of the resulting product (Kondolele et al., 2022; Nawaz et al., 2020; Savlak et al., 2020; Yusrina et al., 2021). Kusumawati et al. (2022), also demonstrated variations in proximate composition and nanocalcium characteristics across six fish species. Meanwhile, bone powder from **Siganus lineatus** has been reported to contain 6.29% moisture, 50.74% ash, and 3.50% lipid (Uventhikka et al., 2023). These findings confirm that the type of raw material and the processing method play a crucial role in determining the chemical characteristics of fish bone flour (Paramita et al., 2022; Uventhikka et al., 2023).

The utilization of fish bones represents a form of fishery by-product valorization aimed at producing value-added goods and supporting sustainable resource use (Nawaz et al., 2020; Thirukumaran et al., 2022). Their mineral content particularly calcium, allows fish bones to be processed into flour or nanocalcium for use as food fortificants (Junianto et al., 2022; Kusumawati et al., 2022). Studies indicate that incorporating these materials into various food products can enhance calcium content while maintaining good consumer acceptance in specific formulations (Anggresani et al., 2021; Hasibuan et al., 2022; Liaqat et al., 2022; Murillo et al., 2022). Consequently, characterizing yield and chemical composition is essential for the development of fish bone flour intended for food applications.

The utilization of fish bones has been extensively studied, particularly regarding nanocalcium development, mineral analysis, and applications in food products (Kusumawati et al., 2022; Murillo et al., 2022). However, research on the yield and basic chemical characteristics of catfish bone flour derived from simple processing methods remains limited. The novelty of this study lies in the comprehensive characterization of bone flour processed through pre-heating, pressure cooking for 1.5 hours, drying, and milling, with a focus on yield and chemical properties. Therefore, this study aims to produce catfish bone flour and evaluate its yield, as well as its moisture, ash, and fat content. The findings are expected to serve as baseline data for process optimization and the further development of catfish bone flour utilization in future research.

Method

Materials and Tools

The primary research material was catfish; 4 kg of fish yielded 210 g of bones prior to the pressure-cooking process. These bones served as the raw material for flour production, representing an effort to utilize fishery by-products to create value-added products (Murillo et al., 2022; Yusrina et al., 2021). Processing equipment included a stainless steel pot, a pressure cooker, a scale, a knife, a blender, drying equipment, and a sieve. Analyses of moisture, ash, and fat content were conducted using an oven, a muffle furnace, a Soxhlet apparatus, an analytical balance, and supporting laboratory equipment.

Procedure for Producing Catfish Bone Flour

Fish bones are washed under running water to remove impurities and adhering tissue, then heated for 15 minutes and cleaned again. Subsequently, the bones are pressure-cooked for 1.5 hours, sun-dried, pulverized, and sieved to obtain bone flour (Suryaningsih et al., 2023). The stages of cleaning, heating, drying, and size reduction can influence the characteristics of the

resulting flour, while pressurized heat treatment helps soften the bones, making them easier to pulverize (Nawaz et al., 2020; Paramita et al., 2022; Yusrina et al., 2021).

Determination of Yield

The yield is calculated as the percentage of bone flour mass relative to the mass of the bone prior to pressure cooking, using the following equation:

$$\text{Yield (\%)} = \frac{\text{bone meal mass (g)}}{\text{initial bone mass (g)}} \times 100$$

The initial bone mass basis needs to be stated clearly because processing stages can cause changes in material mass (Paramita et al., 2022; Yusrina et al., 2021).

Moisture Content Analysis

Moisture content was determined gravimetrically in accordance with (Latimer, 2023). Samples were oven-dried to a constant weight, and moisture content was calculated based on the mass loss during the drying process. The gravimetric approach is also commonly used in the proximate analysis of fish products and fish bone meal (Kabir et al., 2022).

Ash Content Analysis

Ash content was determined in accordance with (Latimer, 2023). The sample was ashed using a muffle furnace until a stable ash residue was obtained, then the residue was weighed to determine the ash content as the inorganic fraction of the sample. The ashing method using a muffle furnace is also used in the proximate analysis of fish products and fish bone meal (Kabir et al., 2022).

Fat Content Analysis

Fat content was determined using the Soxhlet extraction method according to (Latimer, 2023; Suryaningsih et al., 2023). After the extraction process, the solvent was separated and the fat residue was determined gravimetrically. The Soxhlet method is also used in the analysis of lipid content in fish products and fish bone meal (Kabir et al., 2022).

Data Analysis

The data were analyzed using descriptive quantitative methods. Yield was calculated based on the ratio of flour mass to the initial bone mass, while moisture, ash, and fat contents were expressed as percentages. The obtained results were then compared descriptively with previous studies, taking into account differences in species, raw material characteristics, and processing conditions and stages that could influence the characteristics of the fish bone flour (Nawaz et al., 2020; Paramita et al., 2022; Yusrina et al., 2021).

Result and Discussion

Catfish Bone Flour Yield

Fish bone flour yield and processing method compared with findings from previous research (Table 1).

Table 1. Comparison of fish bone processing yield and methods with previous studies.

Research	Raw Materials	Main process	Final product	Yield
This Research	Catfish bone	Heating, pressure cooking for 1.5 h, drying, grinding, and sieving	Bone flour	40,48%
Savlak et al. (2020)	<i>Seabream (Sparus aurata)</i>	Water/chemical treatment and bone processing	Fish bone powder	59.39% in the water treatment
Nawaz et al. (2020)	<i>Grass carp (Ctenopharyngodon idella)</i>	Autoclaving and size reduction	Fish bone powder	Not used as the primary basis for yield comparison.
Paramita et al. (2022)	Catfish (<i>Clarias</i> sp.)	NaOH treatment, washing, drying, pulverization	Catfish bone meal	<50%
Kusumawati et al. (2022)	Tilapia, catfish, grouper, snapper, tuna, mackerel	Preparation and alkaline extraction/purification	Nano-calcium	Varies between species

A gradual reduction in mass occurs during processing due to the detachment of tissue, moisture loss, and material loss during washing, drying, pulverizing, and sieving. Heat and pressure treatments also soften the bones, facilitating size reduction. Consequently, the yield is influenced by raw material characteristics and processing conditions, including pretreatment, temperature, extraction, and drying (Kondolele et al., 2022; Wulandari & Kusumasari, 2019; Yusrina et al., 2021). Variations in processing stages, temperature, and heating duration have also been reported to affect the characteristics of the resulting bone flour (Novianty et al., 2024).

In this study, 210 g of catfish bone yielded 85 g of flour—a yield of 40.48%—following washing, heating, pressure cooking for 1.5 hours, drying, pulverizing, and sieving. This value is lower than the 59.39% yield of *Sparus aurata* bone powder (Savlak et al., 2020), but remains comparable to the catfish bone flour yield of less than 50% (Paramita et al., 2022). Such differences may be attributed to species and processing conditions. Boiling temperatures and autoclave treatments can influence yield while simultaneously softening the bones, making them easier to pulverize (Kondolele et al., 2022; Nawaz et al., 2020). Stepwise purification processes—such as protein and lipid removal, bleaching, and grinding—can also reduce mass and alter the characteristics of the final product (Sriket, Niwet, Kuimalee, et al., 2023; Sriket, Niwet, Pui, et al., 2023).

The level of purification also determines the yield, as certain bone components may be lost during the process. The yield and characteristics of bone-based products also vary across fish species (Kusumawati et al., 2022; Novianty et al., 2024). Therefore, the 40.48% yield reflects the processing conditions applied in this study and cannot be directly compared to nanocalcium or biocalcium products that undergo more complex purification processes. Comparisons of yields across studies must take into account the species, raw material conditions, processing methods, calculation bases, and product purity levels (Kondolele et al., 2022; Kusumawati et al., 2022; Paramita et al., 2022; Savlak et al., 2020).

Chemical Characteristics of Catfish Bone Flour

The chemical characteristics of the fish bone flour obtained in this study were compared with the results of previous studies (Table 2).

Table 2. Comparison of the chemical characteristics of fish bone flour with previous studies.

Research	Fish bone type/treatment	Water (%)	Ash (%)	Fat (%)
This Research	Catfish, bone meal	7,45	63,29	2,95
Kusumawati et al.2022	Tilapia, coarse bone meal	1,66 ± 0,39	56,21 ± 2,91	10,16 ± 1,31
Kusumawati et al. 2022	Catfish, coarse bone meal	2,16 ± 0,74	58,07 ± 4,49	8,91 ± 1,88
Kusumawati et al. 2022	Grouper, coarse bone meal	1,81 ± 0,36	64,08 ± 0,40	6,66 ± 0,24
Kusumawati et al. 2022	Snapper, coarse bone meal	2,02 ± 0,19	64,99 ± 1,88	7,09 ± 0,64
Kusumawati et al. 2022	Tuna, coarse bone meal	2,47 ± 0,33	64,94 ± 0,15	5,08 ± 0,33
Kusumawati et al. 2022	King mackerel, coarse bone meal	1,73 ± 0,23	56,51 ± 1,15	21,26 ± 0,56
Kondolele et al. 2022	Spanish mackerel, boiling treatment at 100°C	1,36	28,74	20,37

Catfish bone flour has a moisture content of 7.45%, ash content of 63.29%, and fat content of 2.95%. Differences in composition compared to other fish bone meals may be attributed to species, raw material conditions, and processing and extraction methods (Husna et al., 2020; Nemati et al., 2017).

Moisture content. The value of 7.45% is higher than the 1.66–2.47% range observed in six fish species—including catfish at $2.16 \pm 0.74\%$ (Kusumawati et al., 2022). For comparison, eel bone meal has a moisture content of 5.98% (Ahmil et al., 2021), while NaOH-extracted triggerfish bone meal ranges from 3.79% to 4.15% (Husna et al., 2020). tha et al. (2019) also reported moisture contents of 1.09–2.71% for water extraction and 3.41–5.96% for alkaline extraction. The relatively higher moisture content in this study is thought to be associated with sun drying, a method where drying conditions are more difficult to control than in oven drying.

Ash content. The ash content of 63.29% falls within the 56.21–64.99% range reported by Kusumawati et al. (2022), and is close to the values found in grouper (64.08%), snapper (64.99%), and tuna (64.94%). Tha et al. (2019), reported ash contents of 57.41–70.54% for water extraction and 84.35–87.60% for alkaline extraction, whereas Husna et al. (2020), obtained values of 87.52–90.05% following NaOH extraction. This difference indicates that the removal of organic components during processing can increase the relative proportion of the inorganic fraction. Consequently, the ash content in this study reflects a predominance of the inorganic fraction, although the specific types and quantities of minerals require further analysis.

Fat content. The fat content of 2.95% is lower than the 5.08–21.26% range observed in six fish species, including catfish ($8.91 \pm 1.88\%$) (Kusumawati et al., 2022). Eel bone flour has been reported to contain 9.14% fat (Ahmil et al., 2021), whereas triggerfish bone flour

obtained via NaOH extraction contained only 0.10–0.12% (Husna et al., 2020). Alkaline extraction has also been reported to yield lower fat content compared to water extraction (Nemati et al., 2017; tha et al., 2019). The low fat content observed in this study is likely attributable to the sequence of washing, heating, pressure cooking, drying, and milling, although the specific impact of each stage was not evaluated individually.

Overall, the produced catfish bone flour is characterized by a dominant inorganic fraction and relatively low fat content. Variations in composition compared to previous studies confirm that the chemical characteristics of bone flour are influenced by species, raw material conditions, and processing methods (Ahmil et al., 2021; Husna et al., 2020; Kusumawati et al., 2022; Nemati et al., 2017; tha et al., 2019).

Conclusion

Catfish bones can be processed into flour through washing, heating, pressure cooking, drying, and milling stages. A total of 210 g of bones yielded 85 g of flour, with a yield of 40.48%, a moisture content of 7.45%, an ash content of 63.29%, and a fat content of 2.95%. These results demonstrate the potential of utilizing catfish bones as a value-added product. Future research should focus on optimizing processing conditions and evaluating the mineral composition, physicochemical properties, safety, and potential applications of catfish bone flour in food products.

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Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

Author Contributions

Author 1 designed the study, supervised and conducted experiments, collected and analyzed data, interpreted results, and drafted and revised the manuscript. Author 2 contributed to the execution of experiments, data collection and analysis, and manuscript drafting. Author 3 contributed to data analysis and interpretation, the literature review, and manuscript revision. Author 4 contributed to translating the manuscript into English, proofreading, grammatical editing, compiling and verifying references, and manuscript revision. All authors have read and approved the final version of the manuscript.

References

- Ahmil, A., Mulyati, H., & Mananta, O. (2021). Analisis Kandungan Zat Gizi Tepung Tulang Ikan Sidat (*Anguila* sp). *Ghidza: Jurnal Gizi Dan Kesehatan*, 5(1), 36–44. <https://doi.org/10.22487/ghidza.v5i1.138>
- Anggresani, L., Sari, Y. N., & Rahmadevi, R. (2021). Hydroxyapatite (HAp) From Tenggiri Fish Bones As Abrasive Material In Toothpaste Formula. *Jurnal Kimia Valensi*, 7(1), 1–9. <https://doi.org/10.15408/jkv.v7i1.19165>
- Hasibuan, L. N., Junianto, ., Pratama, R. I., & Rostini, I. (2022). Acceptance Level of Spring Rolls Wrapper with the Addition of Patin Fish (*Pangasius* Sp) Bone Flour as a Source of Calcium. *Asian Journal of Fisheries and Aquatic Research*, 12–20. <https://doi.org/10.9734/ajfar/2022/v18i530452>

- Ho Khanh Hy, L., Viet Ha, D., Xuan Ky, P., Phuong Anh, N., Bao Vy, P., & Thi Thiet, D. (2021). Preparation of Nano-hydroxyapatite Obtained from Lates Calcarifer Fish Bone by Alkaline Hydrolysis Method. *American Journal of Chemical and Biochemical Engineering*, 5(1), 32. <https://doi.org/10.11648/j.ajcbe.20210501.15>
- Husna, A., Handayani, L., & Syahputra, F. (2020). Pemanfaatan tulang ikan kambing-kambing (*Abalistes stellaris*) sebagai sumber kalsium pada produk tepung tulang ikan. *Acta Aquatica: Aquatic Sciences Journal*, 13–20. <https://doi.org/10.29103/aa.v7i1.1912>
- Junianto, ., Brainerd, E., Maghfira, R., Suyono, M. L. A., Rizki, A. F., Pratama, R. L., & Barkah, S. M. (2022). Utilization of Fish Bone Waste for Food. *Asian Journal of Fisheries and Aquatic Research*, 46–56. <https://doi.org/10.9734/ajfar/2022/v20i2493>
- Kabir, Md. I., Ove, T. A., Kamal, Md. M., Karim, S., Hasan, S. M. K., Haque, Md. R., & Akhter, Most. J. (2022). Production and Evaluation of Quality Characteristics of Edible Fish Powder from Tilapia (*Oreochromis mossambicus*) and Silver Carp (*Hypophthalmichthys molitrix*). *Journal of Food Quality*, 2022, 1–11. <https://doi.org/10.1155/2022/2530533>
- Kondolele, S. L., Asikin, A. N., Kusumaningrum, I., Diachanty, S., & Zuraida, I. (2022). Pengaruh Suhu Perebusan terhadap Karakteristik Fisikokimia Tepung Tulang Ikan Tenggiri (*Scomberomorus commerson*). *Media Teknologi Hasil Perikanan*, 10(3), 177–184. <https://doi.org/10.35800/mthp.10.3.2022.34938>
- Kusumawati, P., Triwitono, P., Anggrahini, S., & Pranoto, Y. (2022). Nano-calcium Powder Properties from Six Commercial Fish Bone Waste in Indonesia. *Squalen Bulletin of Marine and Fisheries Postharvest and Biotechnology*, 17(1), 1–12. <https://doi.org/10.15578/squalen.601>
- Latimer, G. W. . (2023). *Official methods of analysis of AOAC International* (Jr. George W. Latimer, Ed.; 22nd ed.). Oxford University Press.
- Liaqat, S., Ahmed, Z., Ali, Q., Akbar, A., & Khalid, N. (2022). Development, characterization, and principal component analysis of fish bone-based fortified refined wheat flour tortilla and its organoleptic attributes. *Journal of Food Processing and Preservation*, 46(11). <https://doi.org/10.1111/jfpp.17051>
- Murillo, S., Ardoin, R., Watts, E., & Prinyawiwatkul, W. (2022). Effects of Catfish (*Ictalurus punctatus*) Bone Powder on Consumers' Liking, Emotions, and Purchase Intent of Fried Catfish Strips. *Foods*, 11(4), 540. <https://doi.org/10.3390/foods11040540>
- Nawaz, A., Li, E., Irshad, S., HHM, H., Liu, J., Shahbaz, H. M., Ahmed, W., & Regenstein, J. M. (2020). Improved effect of autoclave processing on size reduction, chemical structure, nutritional, mechanical and in vitro digestibility properties of fish bone powder. *Advanced Powder Technology*, 31(6), 2513–2520. <https://doi.org/10.1016/j.apt.2020.04.015>
- Nemati, M., Huda, N., & Ariffin, F. (2017). Development of calcium supplement from fish bone wastes of yellowfin tuna (*Thunnus albacares*) and characterization of nutritional quality. In *International Food Research Journal* (Vol. 24, Number 6).
- Novianty, H., Sefrienda, A. R. S. R., & Jasmadi, J. (2024). Analyzing the Characteristics of Fishbone Powder Derived from *Pangasius* sp., *Thunnus tonggol*, and *Thunnus albacares* as Food Fortificant. *AgriTECH*, 44(1), 90. <https://doi.org/10.22146/agritech.79972>
- Paramita, B. L., Sahubawa, L., & Ratnawati, S. E. (2022). Physicochemical Properties and Sensory Evaluation of Wheat-Mocaf-Based Dried Noodles Enriched with Catfish Bone Flour (*Clarias* sp.). *Indonesian Food and Nutrition Progress*, 18(2), 60. <https://doi.org/10.22146/ifnp.68032>
- Riany Eris, F., Munandar, A., Anggraeni, D., & Ageng Tirtayasa Jalan Raya Jakarta Km, S. (2020). Utilization of Milkfish (*Chanos chanos*) Bone Powder in Making of Rengginang, Local Food of Baduy Tribe. *Food Sciencetech Journal*, 2(1).

- Savlak, N., Çağındı, Ö., Erk, G., Öktem, B., & Köse, E. (2020). Treatment Method Affects Color, Chemical, and Mineral Composition of Seabream (*Sparus aurata*) Fish Bone Powder from by-Products of Fish Fillet. *Journal of Aquatic Food Product Technology*, 29(6), 592–602. <https://doi.org/10.1080/10498850.2020.1775742>
- Sriket, C., Niwet, J., Kuimalee, S., Benjakul, S., Yarnpakdee, S., Karnjanapratum, S., & Senphan, T. (2023). A comprehensive study of diverse techniques for enhanced physicochemical and structural properties of bio-calcium from hybrid catfish bone. *Food Bioscience*, 56, 103398. <https://doi.org/10.1016/j.fbio.2023.103398>
- Sriket, C., Niwet, J., Pui, L. P., Yarnpakdee, S., & Senphan, T. (2023). Effects of different processes on characteristics and properties of bio-calcium from hybrid catfish (*Pangasianodon gigas* × *Pangasianodon hypophthalmus*). *International Journal of Food Science & Technology*, 58(4), 2161–2169. <https://doi.org/10.1111/ijfs.16252>
- Suryaningsih, S., Muslim, B., & Djali, M. (2023). Physicochemical and Characterization Nano-Calcium Catfish Bone Flour (<i>Clarias gariepinus</i>). *Journal of Biomimetics, Biomaterials and Biomedical Engineering*, 62, 43–50. <https://doi.org/10.4028/p-e0djpD>
- tha, A., Raju, C. V., Lakshmisha, I. P., Kumar, P. A., Sarojini, A., endra, G., & Pal, J. (2019). Nutritional Composition of Fish Bone Powder Extracted from Three different Fish Filleting Waste Boiling with Water and an Alkaline Media. *International Journal of Current Microbiology and Applied Sciences*, 8(02), 2942–2948. <https://doi.org/10.20546/ijcmas.2019.802.342>
- Thirukumaran, R., Anu Priya, V. K., Krishnamoorthy, S., Ramakrishnan, P., Moses, J. A., & Anandharamakrishnan, C. (2022). Resource recovery from fish waste: Prospects and the usage of intensified extraction technologies. *Chemosphere*, 299, 134361. <https://doi.org/10.1016/j.chemosphere.2022.134361>
- Uventhikka, S., Sivashanthini, K., Thayalini, T., Jasotha, P., & Velauthamurthy, K. (2023). Proximate and Mineral Composition of Fish Bone Powder of *Siganus lineatus* Collected from Waters Around Jaffna Peninsula, Sri Lanka. *Sri Lankan Journal of Applied Sciences*, 1(2), 14–17. <https://doi.org/10.4038/vingnanam.v13i1>
- Wulandari, P., & Kusumasari, S. (2019). Effect of extraction methods on the nutritional characteristics of milkfish (*Chanos chanos* Forsskal) bone powder. *IOP Conference Series: Earth and Environmental Science*, 383(1), 012035. <https://doi.org/10.1088/1755-1315/383/1/012035>
- Yusrina, A., Rochima, E., Handaka, A. A., & Rostini, I. (2021). Fishbone Flour (Definition, Analysis of Quality Characteristics, Manufacture): A Review. *Asian Journal of Fisheries and Aquatic Research*, 18–24. <https://doi.org/10.9734/ajfar/2021/v13i430271>