

PHYSICOCHEMICAL CHARACTERISTICS OF DAGGERTOOTH PIKE CONGER FISH (*Muraenesox cinereus*) BONE MEAL AS A CALCIUM SOURCE

Karakteristik Tepung Tulang Ikan Malong (*Muraenesox cinereus*) Sebagai Sumber Kalsium

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ABSTRACT

The utilization of daggertooth pike conger fish bone waste has not yet been implemented or published. Fish bones represent a form of solid waste that can serve as a valuable source of calcium. This study aims to describe the physicochemical characteristics of daggertooth pike conger fish bone meal (*Muraenesox cinereus*) as an effort to utilize bone waste into a value-added product. The processing process involves repeated boiling, heating, drying, grinding, and sieving. Proximate analysis included the determination of moisture, ash, fat, protein, carbohydrate, and crude fiber content, as well as yield analysis, to assess the physicochemical characteristics of daggertooth pike conger fish bone meal. The results showed a bone meal yield of 13.40% with a pH of 6.96. The proximate composition includes 60.77% ash, 0.51% water, 4.12% fat, 26.54% protein, 5.75% carbohydrate, and 2.29% crude fiber, with a calcium content of 4.62%. These values indicate that malong fish bone meal has a high mineral composition and organic content, making it suitable for various industrial applications. This study provides an initial overview of the development of bone meal as an additive in food, feed, and other derivative products.

Keywords: Daggertooth Pike Conger Fish, Fish Waste, Minerals, Proximate Composition, Bone Meal

ABSTRAK

Pemanfaatan limbah tulang ikan malong masih belum dilakukan dan belum terpublikasikan. Tulang ikan malong merupakan salah satu limbah padat yang memiliki potensi sebagai salah satu sumber kalsium. Penelitian ini bertujuan untuk menggambarkan karakteristik fisikokimia tepung tulang ikan malong (*Muraenesox cinereus*) sebagai upaya pemanfaatan limbah tulang menjadi produk bernilai tambah. Proses pengolahan dilakukan melalui tahap perebusan berulang, pemanasan, pengeringan, penghalusan, dan pengayakan. Analisis proksimat meliputi

kadar air, abu, lemak, protein, karbohidrat, serat kasar, analisis rendemen untuk mengetahui karakteristik fisikokimia dari tepung tulang ikan malong. Hasil penelitian menunjukkan bahwa rendemen tepung tulang yang diperoleh sebesar 13,40% dengan nilai pH sebesar 6,96. Kandungan proksimat meliputi kadar abu 60,77%, air 0,51%, lemak 4,12%, protein 26,54%, karbohidrat 5,75%, dan serat kasar 2,29% serta nilai kalsium yang didapatkan adalah 4,62%. Nilai-nilai tersebut menunjukkan bahwa tepung tulang ikan malong memiliki komposisi mineral yang tinggi serta kandungan organik yang sesuai untuk berbagai aplikasi industri. Studi ini memberi gambaran awal untuk pengembangan tepung tulang sebagai bahan tambahan pada pangan, pakan, dan produk turunan lainnya.

Kata kunci: Ikan Malong, Limbah Ikan, Mineral, Proksimat, Tepung Tulang

INTRODUCTION

Malong fish (*Muraenesox cinereus*) is one of the economically important fish species found in tropical and subtropical waters of Asia, including Indonesian waters. This species is known for its elongated body resembling an eel and has a chemical composition including protein, fat, ash, carbohydrate and water levels with sequential values of 12.273%, 4.96%, 1.17%, 1.12% and 80.49% with the dominant macro minerals being potassium (K) 170.20 mg/100 g, Ca 90.75 mg/100 g, and Na 80.15 mg/100 g. Amino acids (AA) that play a crucial role in the flavor and texture of fish meat are glutamic acid (2.68%), lysine (1.57%), leucine (1.25%), aspartic acid (1.54%), and arginine (1.04%). Fatty acids include eucosapentane (EPA) (0.6%), docosahexaenoic acid (DHA), linoleic acid (0.2%), oleic acid (1.4%), and linolenic acid (1.0%) (Laksono *et al.*, 2019).

In Indonesia, this fish has various local names, such as malong, remang, and cunang, and has been reported in the waters of West Kalimantan, Riau, the Riau Islands, Bangka Belitung, and Natuna. Regionally and globally, *M. cinereus* has also been recorded in the waters of Malaysia, the Philippines, and Japan (Genisa 1999; Ridho *et al.*, 2004; Satapoomin 2011). Its elongated body shape gives this fish a larger proportion of meat than flat-bodied fish. Marichamy *et al.*, (2012) reported that this fish, measuring 70–80 cm, can have an edible portion of up to 52.75%, making it a significant potential raw material for the processing industry. However, there is no information regarding its physicochemical characteristics.

Malong fish is often used as a raw material for processed products due to its white flesh, easy-to-process texture, and good consumer acceptance. However, fish processing generally generates large amounts of waste. The FAO (2020) states that waste from fish processing activities can account for up to 70% of the total fish biomass, including heads, bones, fins, tails, and viscera. Fish bone is a waste fraction with significant potential due to its content of essential minerals, particularly calcium (Ca) and phosphorus (P), which can be utilized as raw materials for food, feed, and value-added non-food products. One approach to increasing the added value of fish bone waste is processing it into bone meal. Fish bone meal has unique chemical characteristics, particularly its high mineral content, which makes it potentially useful in various applications, such as food fortification, feed additives, a natural phosphate source, and even a base material for gelatin and collagen production. Furthermore, utilizing fishery waste to produce economically valuable products supports the concept of sustainable and environmentally friendly fishery product processing.

Malong fish, a commodity abundantly available in several regions of Indonesia, offers significant potential for development as a raw material for bone meal. However, scientific information regarding the chemical, physical, and functional characteristics of malong fish bone meal is still limited. Therefore, research on the physicochemical characteristics of malong fish bone meal is necessary to obtain baseline data for proximate analysis and mineral (calcium) content, which will enable it to become a potential application in various industries. The results

of this study are expected to be a reference for developing the utilization of fishery waste and encouraging an increase in the economic value of malong fish through product diversification.

RESEARCH METHODS

This research was conducted at the Fisheries Laboratory of the Agribusiness Department of the Sambas State Polytechnic for fish bone meal processing and physical characteristics. Chemical testing was conducted at the Fisheries Cultivation Laboratory of the Marine and Fisheries Science Department of the Pontianak State Polytechnic; and macro mineral (Ca) testing was conducted at the Pontianak Industrial Standardization and Services Center.

Tools and Materials

The materials used in this study were malong fish bones obtained from the fish market in Pemangkat. Other materials used were water, aluminum foil. The tools used included an autoclave, desiccator, drying oven, porcelain cup, electric furnace, pH meter, glassware, Kjeldhal flask, water bath, Atomic Absorption Spectrophotometer (AAS), UV-Vis Spectrophotometer, flouring machine, sieve, analytical balance, stove, knife, boiling pot, pressure cooker, strainer, spatula. blender.

Research methods

The research method was an experimental one with two stages: the production of malong fish bone meal and the sample analysis stage. The data obtained were analyzed qualitatively according to the test parameters. The data were presented in tabular form, discussed descriptively, and compared with secondary data obtained from scientific articles, books, and other scientific writings.

Research Stages

The bone meal processing process used in this study is a modification of the method used by Suad and Novalina (2019). The malong fish bones were thoroughly washed, then cut into small pieces and boiled in water at 60°C for 45 minutes. The bones were then washed to remove any remaining dirt from the first boiling stage. The second boiling stage was followed by four boiling stages at 80°C for 30 minutes, with the water changed between each repetition. The fish bones were then pressure-cooked for 4 hours at 1 atm. The fish bones were then dried in an oven at 60-80°C for 12 hours, followed by grinding using a blender and flouring machine, followed by sieving to obtain a fine flour.

Test Parameters

The test parameters include several parameters, namely calculating the yield value, pH value, proximate test (analysis of water content, ash content, protein, fat, carbohydrate, and crude fiber) using the AOAC 1992 method. Meanwhile, for calcium content analysis, the Atomic Absorption Spectrophotometer method is used.

RESULT

Yield

Physically, malong fish bone meal appears as a fine powder with a brownish-yellow color. Yield is a crucial parameter for determining the economic value and effectiveness of a product or material process (Husna *et al.* 2020). The yield calculation in this study was obtained by comparing the dry weight of malong fish bone meal to the wet weight of the raw fish bone material. The weight of the fish bone was 8,580 g and the weight of the fish bone meal was 1,150 g, resulting in a yield of 13.40%. This yield data can be seen in Table 1.

Table 1. Malong Fish Bone Meal Yield

Bone weight malong (g)	Weight of malong bone meal (g)	Yield (%)
8.580	1.150	13,40

Proximate composition

Proximate analysis is an analytical method for determining the nutritional value of a food ingredient, including water, protein, fat, carbohydrates, and ash (Hidayat & Insafitri, 2021). The proximate composition of malong fish bone meal can be seen in Table 2.

Table 2. Results of proximate content analysis of malong fish bone meal

Sample	Parameter	Average (%)
fish bone meal	ash	60,775±0,08
	water	0,515±0,04
	fat	4,125±0,04
	protein	26,54±0,35
	carbohydrate	5,755±0,21
	crude fiber	2,29±0,3

DISCUSSION

Yield

Yield is an important indicator in assessing the effectiveness of a processing process and the economic value of the resulting material (Husna *et al.*, 2020). This term refers to the ratio of the usable fraction to the total weight of the starting material. In practice, yield is used to estimate the proportion of a material suitable for processing or consumption as a food product. In this study, the malong fish bones used had an initial weight of 8,580 g and yielded 1,150 g of bone meal. Based on this comparison, the bone meal yield obtained was 13.40%. This percentage is lower than the results of Rozi & Ukhty's (2021) study on yellowfin tuna bones, which reported a yield of 19.37% when the drying process was carried out at 110°C. Prolonged heating (90 minutes) can cause protein degradation in the bones, resulting in a decrease in the bone meal yield (Wijayanti *et al.*, 2021).

Husna *et al.*, (2020) explained that the combination of temperature and drying duration significantly determines the water content and the amount of bone meal produced. According to Suntornsaratoon *et al.*, (2018), heating at 90–95 °C for 60 minutes can deactivate enzymes, thereby affecting the yield of the resulting fish bone meal. Furthermore, the boiling process also affects the yield, as during heating, residual meat and fat attached to the bones can dissolve into the boiling water. The low yield found in this study is thought to be related to differences in processing, particularly since several previous studies conducted repeated boiling processes, releasing more organic components and resulting in a higher bone meal yield. Fish bone meal yields can be influenced by several factors, such as the interaction between protein extraction, lipid preservation, and bone composition, all of which are influenced by the duration and conditions of the heating treatment (Wijayanti *et al.*, 2020 and Hilmarsdottir *et al.*, 2020).

Proximate Composition

Ash Content

Ash content analysis is a crucial step in characterizing fish bone meal because it reflects the total mineral residue remaining after the material has undergone a combustion or extraction process. Ash in food products serves as an indicator of inorganic content, which includes essential minerals such as calcium, phosphorus, magnesium, and other microelements that

contribute to the nutritional value of the product. Determining ash content also provides insight into the quality of the raw material and the effectiveness of the processing process, considering that loss or degradation of inorganic components can occur during heating or other treatments.

Based on the analysis results, malong fish bone meal showed an average ash content of 60.77%. This percentage reflects that most of the remaining components in the product are minerals. However, this ash content is still lower than the research results of Muslimin (2023), which reported an ash content of 83.82% for red snapper bone meal. This difference can be influenced by various factors, including the type of fish, differences in bone structure and density, the pretreatment technique used, and the duration of drying or baking, which can potentially increase or decrease the amount of remaining inorganic components. Thus, the variation in ash content between studies shows that the characteristics of the raw materials and processing methods play a major role in determining the final mineral composition of the bone meal produced (SNI 7994:2014).

Water Content

The moisture content of a food product indicates the amount of water retained within the material and is a crucial component in determining the product's quality, stability, and durability during storage (Mathlouthi, 2001). Analysis of the moisture content of fish bone meal is conducted to ensure the product's dryness and to assess whether the processing process has been effective. This study found that malong fish bone meal had a moisture content of 0.515%. This percentage is significantly lower than the research conducted by Muslimin (2023), which found a moisture content of 6.64% for red snapper bone meal. This significant difference may be due to the heating process used, where the high temperature during calcination causes most of the organic components and water bound in the bones to evaporate or break down. As a result, the remaining material after the process is minimal.

Sipayung *et al.*, (2015) explained that the time and temperature used in the cooking process of fish meal can influence the reduction in moisture content. These results are consistent with the findings of Meulisa *et al.*, (2019) reported that drying yellowfin tuna bone meal at 120°C resulted in a moisture content that met SNI standards. Products with low moisture content tend to have better storage stability because low moisture content can suppress microbial activity and slow chemical reactions that cause quality degradation (Putranto *et al.*, 2015).

Fat content

Fat content analysis in fish bone meal is conducted to assess the proportion of lipid fraction remaining after a series of extraction and processing processes. This parameter is important because fat content is directly related to chemical stability, sensory quality, and product shelf life. A relatively low fat content is generally desired in bone meal, considering that a high lipid fraction can trigger various degradation reactions, particularly fat oxidation, which leads to oxidative rancidity. This oxidation process not only produces undesirable aromas and flavors but also has the potential to darken the product color due to the formation of oxidative degradation compounds. Therefore, the quality of fish bone meal is greatly influenced by the success of the degreasing process and the stability of the remaining lipids.

In this study, malong fish bone meal showed a fat content of 4.125%. This content is still relatively higher than the report by Husna *et al.*, (2020), who found a fat content of 0.64% for goat fish bone meal. These differences can be explained by several determinants, including biological variation between species, the composition of osseous tissue and residual tissue attached to the bone, the efficiency of the boiling or calcination process, and differences in the extraction and defatting techniques used in each study. Furthermore, the presence of residual organic tissue or bound lipids in the bone structure can also affect the final measured values.

Variations in lipid content between fish species and between processing processes confirm that optimization of preparation methods, particularly at the degreasing and drying stages, is a critical aspect in producing bone meal with stable chemical quality and a longer shelf life.

Protein Content

The analysis results showed that malong fish bone meal had a protein content of 26.54%, a relatively high value for a fish bone-based raw material. This content is higher than the report by Rozi & Ukhty (2021), which only found a protein content of 12.65% for yellowfin tuna bone meal. The significant differences between these studies indicate that the protein content in fish bone meal is significantly influenced by the preparation technique and processing conditions used. Kusumaningrum *et al.*, (2016) explained that factors such as boiling time, frequency of removal of meat scraps, and heating method can affect the organic protein fraction remaining in the bone structure.

Recent research also supports this finding. Soemadi *et al.*, (2024) reported variations in protein content in catfish bone meal influenced by extraction and drying methods, while Setyarini *et al.*, (2024) found that differences in material preparation processes can result in different protein characteristics when bone meal is used as a food fortification ingredient. Similar findings were also reported by Marasabessy *et al.*, (2024), which showed that the protein content of pelagic and demersal fish bone meal can differ significantly even though they come from the same body part, due to differences in biomineral composition and processing treatment. This variability in protein content confirms that the processing process plays a critical role in determining the nutritional quality of fish bone meal. Thus, the relatively high protein content of malong fish bone meal in this study may indicate that the preparation method used still retains most of the organic components of the bone, resulting in a product with superior nutritional value compared to several previous studies.

Carbohydrate content

The carbohydrate content in this study of malong fish bone meal was 5.75%, a high value compared to the results of the study of tilapia bone meal by Nurhayati *et al.*, (2020), which found a carbohydrate content of only around 0.1-0.3%. The carbohydrate content in fish bone meal is generally very low because the bone structure is dominated by minerals and collagen protein. In proximate analysis, the measured carbohydrate fraction is usually residual organic components not included in other major nutrient categories. This small fraction can originate from mucopolysaccharides, glycosaminoglycans, or soft tissue residues that were not completely removed during the boiling or washing stages.

Nielsen (2010) emphasized that animal foods essentially contain almost no storage carbohydrates, so the detected carbohydrate value only reflects minor organic residues. This opinion aligns with Park *et al.*, (2007), who stated that carbohydrates in fish bone primarily come from collagen matrix components in very small amounts. Hui (2006) also explained that the presence of carbohydrates in bone meal is usually related to connective tissue that is not completely degraded during the heating process.

Several studies have consistently shown low carbohydrate levels in fish bone meal products. Zulfahmi *et al.*, (2019) reported carbohydrate levels in snakehead fish bone meal of 0.25–0.40%, while research on tilapia bone by Nurhayati *et al.*, (2020) showed values of 0.1–0.3%. In tuna bone meal, Suryaningrum *et al.*, (2017) recorded carbohydrate levels of less than 1%.

Crude Fiber

The analysis results showed that Malong fish bone meal had a crude fiber content of 2.29%. This value is above the range reported by Yuliati *et al.*, (2018), which is 1.12–1.45%.

The low value is thought to be related to the boiling process, which reduces the organic connective tissue content. This finding is also slightly higher than the 1.9% found in Rachmawati & Hastuti's (2019) study on catfish meal. Variations in crude fiber values between species and between studies are generally associated with differences in bone structure, collagen content, and processing methods such as boiling, washing, and milling.

Essentially, the crude fiber in fish bone meal is an insoluble organic fraction that includes residual connective tissue, collagen, and other matrix components. Nielsen (2010) explains that this fraction is the portion that remains after the material has undergone strong acid-base chemical treatment, thus reflecting components that are difficult to decompose. In line with this, Hui (2006) stated that the presence of collagen which is not completely damaged during cooking also contributes to the crude fiber value.

Calcium Levels

The calcium content test aimed to determine the calcium content of malong fish bone meal. The results of the analysis of malong fish bone meal calcium content were obtained at 4.62%. The results obtained in this study were not much different from the results of research conducted by Suad & Novalina (2019), which found that the calcium content of mackerel and mackerel bone meal was 4.2% and 4.9% of the total weight of the fish bone meal. Similar results were obtained in the study by Suarsa *et al.*, (2020) which found that the calcium content of tuna bone meal was 5.35%. However, these results are quite low compared to several studies, such as goat fish bone meal, which has a calcium content ranging from 31.83 to 35.75% (Husna *et al.*, 2020), and red snapper fish bone meal, which has an average calcium content of 44.82% (Kaliky *et al.* (2024). The calcium content values found in this study meet SNI (7994:2014), where the calcium content for fish bone meal is set at a maximum of 11% for grade I and a maximum of 13% for grade II.

This difference in calcium content can be influenced by various factors. Taufiq *et al.*, (2020) stated that differences in sex, species, biological cycles, and body parts analyzed have an effect, as well as ecological factors such as fish rearing habitat, season, and the amount of nutrients from available food. Heating factors during processing can affect mineral composition, especially phosphorus, calcium, potassium, and zinc, resulting in a decrease (Bagau, 2012). Furthermore, the low calcium content is thought to be related to processing methods such as removing protein content using alkaline extraction with NaOH and techniques calcium analysis used (Suad & Novalina, 2019).

CONCLUSION

Based on the research results, it can be concluded that malong fish bones have great potential to be processed into bone meal with competitive chemical characteristics. The yield of 13.40% indicates that the processing process is able to convert some bone waste into ready-to-use products. The results of the study showed that the proximate content includes ash content of 60.77%, water 0.51%, fat 4.12%, protein 26.54%, carbohydrates 5.75%, and crude fiber 2.29%, calcium content of 4.62%. The chemical composition of malong bone meal is dominated by mineral fractions, especially calcium and phosphorus, which is reflected in the high ash content. Overall, malong fish bone meal is suitable as an alternative raw material for food, feed, or non-food products that require mineral supplies.

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