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Fishbone Flour (Definition, Analysis of Quality Characteristics, Manufacture): A Review

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Authors' contributions

This work was carried out in collaboration among all authors. Author AY wrote the first draft of the manuscript. Authors ER, AAH and IR managed the outline of the manuscript and managed the literature searches. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Fish bones are the largest contributor of waste from the fish processing industry which has not been used optimally. Fish bones have a high calcium content so they can be used as raw material for fish bone flour. This article aims to explain the use of fish bone into fish bone flour, how to process it, and the quality of fish bone flour by physicochemical testing. Fish bone flour can be obtained by extraction using water, alkaline solution and acid solution. The quality characteristics of bone flour can be seen from the water content, ash content, protein content and fat content. Based on several studies, the drying time and temperature affect the physicochemical characteristics of the resulting product.

Keywords: Bone flour; waste; calcium; utilization; quality.

1. INTRODUCTION

Fishery waste can be in the form of residue or waste from a fishery activity, was catching, handling, and processing fishery products that have low economic value. Nugroho et al. [1] stated that the fishing industry is the largest contributor to solid waste. According to Välimaa et al. [2], the amount of waste in fish processing has increased by 70% of the total fish used in

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industrial processes. The industrial waste includes pieces of filet, was skin, head, bones, offal, fins, and tail [3]. The total weight of fish that is not used optimally in the Indonesian processing industry is 23.43-37.3% which is the bones and heads of fish [4]. The high nutritional content of the head and bones has not been used optimally [5]. Bones contain monocalcium and dicalcium phosphate which is the highest availability among other calcium sources [6]. The bone or skeleton is the giver of shape to the body and is a strong and tough tissue because it is composed of a hard organic matrix reinforced with calcium and other mineral salts in the bones. Bone is not easily decomposed by decomposers, so the bone becomes solid waste which is better known as waste that has no economic value [7].

One way to prevent bone waste from polluting the environment is to process it into bone flour [7]. Utilization of fish bone flour by using waste from fish bone as the raw material can increase the economic value of fish bone waste which hasn't been maximally utilized. According to Asikin et al. [8], bone flour is a form of processing fish bone waste that has value-added. Fish bone flour is a dry solid product produced by removing most of the liquid and some or all of the fat contained in fish bones [6]. The utilization of fish bones into fish bone flour must comply with quality requirements. Physicochemical testing according to Sahirman [9] has an important role to know and determine whether there are deviations in material or industrial product. These deviations can be allegedly due to deviations from the production process, resulting in a decrease in quality and non-fulfillment of quality requirements.

2. FISH BONE FLOUR

Fish bone flour is a product of fish waste in the form of dry preservation which is ground into flour [10]. According to Assadad et al. [11], the processing of fishbone flour depends on the chemical composition and the availability of existing technology. The process of making different fish bone flour will affect the characteristics and quality of the resulting fish bone flour. Fishbone flour can be extracted by a simple method, by boiling fish bones with water, treatment with base and treatment with acid or by combination treatment between these treatments [12]. In extraction using NaOH (Sodium hydroxide) and HCl (Hydrochloric acid) solvents according to Ratnawati et al. [4] gave a better effect on ash content, water absorption and whiteness, but not significantly different on protein content in fishbone flour. While the manufacture of fishbone flour using the boiling method will cause bone flour to have less stable physical properties and be easy to separate.

Fishbone flour is the utilization of fish bone waste from the processing industry and has the highest calcium content among fish bodies, this is because the main elements of fish bones are calcium, phosphorus and carbonate. Calcium contained in fish bones is in the form of calcium phosphate as much as 14% of the total bone structure [13]. Calcium phosphate is formed under alkaline conditions by calcium and phosphorus [14]. Calcium levels in various fish bone flour are presented in Table 1.

The difference in calcium levels in various fishbone flour is due to the methods and raw materials used in the process of making fish bone flour. According to Khuldi et al. [15], calcium levels in fishbone flour can be affected by the boiling method used. Differences in species, gender, and the biological cycle of fish will cause differences in the levels of calcium produced [16]. In addition, according to Hapsoro et al. [17], mineral content in fish bodies can be influenced by ecological factors such as season, place of rearing, amount of available nutrients, temperature and water salinity.

Table 1. Comparison of calcium levels in Various fishbone flour

Type of Fish	Bone Flour Calcium Level (%)
Chitala sp. *	29,68
Abalistes stellaris **	35,75
Thunnus sp. ***	41,61

*Source: * Khuldi et al. [15]*
*** Husna et al. [11]*
**** Meiyasa and Tarigan [16]*

3. CHARACTERISTICS OF BONE FLOUR

Fish bone flour must comply with quality requirements. These qualities generally include water content, ash content, fat content (lipid), protein content and carbohydrate content [12]. The quality standard of fish bone flour refers to the Indonesian National Standard 01-3158-1992 [18], which is 8% water content and minimum 3% fat content, maximum 6%. Physicochemical testing according to Sahirman [9] has an important role, one of which is to find out and determine whether there are deviations in material or industrial products. These deviations can be allegedly due to deviations in the production process resulting in a decrease in quality and not meeting quality requirements. One of the important characters related to physical properties is the functional properties of food ingredients or their components. The chemical quality of a food product is determined by the composition of the ingredients (measurement of water content, fat, protein, carbohydrates, vitamins, minerals) and their changes during the processing, including to determine the damage/loss of certain nutrients caused by treatment during the processing [19]. The quality standard of bone flour according to SNI 01-3158-1992 can be seen in Table 2.

4. FISH BONE FLOUR MANUFACTURE

The processing and manufacture of fish flour are very diverse, this depends on the chemical composition and the availability of existing technology [11]. The manufacture of bone flour is divided based on the extraction process. The difference in the extraction process is based on the solution used in the immersion process using water, acid and alkaline solutions.

The processing of bone flour according to Putranto et al. [20], the fish bones are washed and put into an aluminum pan filled with water with a temperature of up to 80°C. Fishbones are then boiled for 30 minutes, then washed with clean water until clean enough and drained. Furthermore, the presto process was carried out for 3 hours and the boiling process was carried out twice for 30 minutes. Boiling the bones is done by boiling 2 liters of water in an aluminum pot at 100°C. The basic extraction process of NaOH is the process of soaking the bones in NaOH solution for 2 hours at a temperature of 60°C. The bones are placed on a filter cloth and rinsed with running water. The fish bones are then placed on a tray that has been lined with aluminum foil. Bones were dried using a drying oven for 48 hours at a temperature of 65°C. The flour is then ground using a blender and then sieved using a flour sieve.

5. CHEMICAL ANALYSIS OF FISH BONE FLOUR

Chemical analysis of fish flour includes water content, ash content, protein content and fat content. Water content is one of the important parameters because it affects the quality of food [21]. The water content in food affects the durability of foodstuffs, determines the acceptability, freshness, appearance, and taste of these foodstuffs [22]. Meanwhile, according to Leviana and Paramita [23], the water content in foodstuffs will affect the resistance of foodstuffs to microbial attack that can be used by microorganisms for their growth. The water content is determined by bound water and free water contained in the material. Products with low water content have a longer shelf life because they contain less water so that spoilage bacteria cannot live on the product [7]. Meanwhile, high water content values will cause faster material damage [24].

Table 2. Quality standard for bone flour SNI 01-3158-1992

No.	Characteristics of Bone Flour	Standard	
		Grade I	Grade II
1.	Water Content, (w/w) (Mav)	8	8
2.	Fat Content (w/w)	3	6
3.	Calsium Content (weight/dry weight) (Min)	20	30
4.	Phosphate Content (as P_2O_5), (weight/dry weight) (Min)	20	20
5.	Phosphorus Content (P), % (weight/dry weight)	8	8
6.	Silica sand fineness, % (weight/dry weight) (Max)	1	1
7.	Fineness (Mesh 25), (weight/dry weight) (Min)	90	90

The ash content in food can indicate the amount of inorganic (mineral) remaining in the product. Analysis of the ash content aims to determine the total ash content and the content of each mineral contained in fishbone flour [7]. According to Imra et al. [24], the ash content in bone flour can describe the total mineral content that does not burn out in the ashing process.

Proteins are polymers of amino acid monomers connected by peptide bonds [25]. Protein is a food substance that contains nitrogen and has important functions in the body [26]. Protein functions as a building block and body regulator which is a source of amino acids containing the elements carbon, hydrogen, oxygen, and nitrogen [27].

Fat or lipid is one of the nutrients that the body needs because it functions to provide energy, dissolve vitamins A, D, E, K and can provide essential fatty acids for the human body [28]. According to Kusumaningrum et al. [14], fat in fish is found in the bone matrix, especially the main bone of fish, which consists of many bone joints. Fats contained in foodstuffs have different amounts of content [29]. Low-fat content can make the quality relatively more stable and not easily damaged [14]. Meanwhile, high-fat content can make fish bones very susceptible to oxidative rancidity [30].

5.1Moisture Content

Moisture content was carried out using the Association of Official Analytical Chemist (AOAC) 2000 [31] method. The cup was placed in an oven and heated to a temperature of 100□C. The cup is cooled in a desiccator and then weighed. The sample is weighed as much as 2 grams and put into a cup. Remove the lid of the cup and put it in the oven at 105□C for 3 hours. Weigh the cup with the lid to a constant weight. The calculation of water content is done by calculating the weight ratio before and after the oven process.

The water content of fishbone flour from the research by Nemati et al. [32] on tuna that is 0.27%, research by Husna et al. [7] on goat-goat fish bone flour which is 4.15% and research by Khuldi et al. [15] on belida fish bone flour which ranged from 4.11 to 3.58%. The water content in fish bone flour has a low value. According to Erni et al. [33], water content is influenced by temperature and drying time factors. Drying will have a very real effect on water transfer in the material because the higher the drying temperature and the longer drying time, the more water molecules evaporate from the dried material so that the water content obtained is lower.

5.2 ASH Content

The ash content was carried out using the AOAC 2000 [31] method. The porcelain dish was put into a kiln and heated at 600□C for 1 hour. The porcelain dish was then cooled in a desiccator and then weighed. The sample is weighed as much as 2 grams and put into a cup. The cup is heated over the flame for 45 minutes. The cup is put in a furnace at a temperature of 600□C for 4 hours or until the ash is whitish. The crucible is cooled in a desiccator and then the crucible is weighed to a constant weight. Calculation of ash content is done by calculating the weight ratio before and after the furnace process.

The ash content of fish bone flour research by Fitri et al. [34] on milkfish bone flour, which is 77.87% and research by Meiyasa and Tarigan [16] on tuna fish bone flour, which is 46.34%. According to Kusumaningrum and Asikin [6], the difference in ash content is strongly influenced by the preparation method in making bone flour. Boiling with heating and drying time significantly affect the ash content because at the time of drying the water content in fish bone flour will decrease and only minerals will remain [7]. The higher the drying temperature and the longer drying time, the ash content will increase because the water that comes out of the material is getting bigger [35].

5.3 Protein Content

The protein content test refers to the AOAC 2000 [31]. The sample is weighed as much as 0.5 grams. The powder sample was put into a Kjeldahl flask. One grain of selenium is put into the tube and 3 ml of H_2SO_4 is added. The tube containing the solution was put into a heater with a temperature of 410°C plus 10 ml of water. The digestion process was carried out until the solution became clear. The clear solution was cooled and then added 50 ml of distilled water and 20 ml of 40% NaOH and then distilled. The distillation results were accommodated in a 125 ml Erlenmeyer containing 25 ml of 2% boric acid (H_3BO_3) containing 0.1% bromcresol green and 0.1% methyl red indicator with a ratio of 2: 1 and the distillate was bluish-green. Titration is carried out using HCl until the color of the solution in the

Erlenmeyer turns pink. The titration volume is read and recorded. The protein content was calculated by calculating the difference in the titration volume times the normality of the HCl blank, 0.014 and the conversion factor, the dilution factor divided by the sample weight multiplied by 100%.

The protein content of Belida fish bone flour research by Kusumaningrum et al. [14] ranged from 9.87% - 15.18%, milkfish bone flour research by Fitri et al. [34] which is 25.13% and yellowfin bone flour research by Talib et al. [36] which is 20.98%. The difference in the value of the protein content produced is thought to be due to the different drying times used. The longer the time used for drying, the higher the protein content [35]. According to Ika [37] in Munthe et al. [38], differences in protein levels can be caused by different types of fish, types of food, body shape and processing carried out.

5.4 Crude Fat Content

The fat content test refers to the AOAC 2000 [31]. A sample of 2 grams is put into filter paper and put into a fat sleeve, then put into a fat flask whose fixed weight has been weighed and connected to a Soxhlet tube. The fat sleeve was inserted into the extractor chamber of the Soxhlet tube and rinsed with fat solvent. The extraction tube was mounted on a Soxhlet distillation apparatus and then heated at 40°C with an electric heater for 6 hours. The fat solvent in the fat flask is distilled until all the fat solvent has evaporated. At the time of distillation, the solvent will be accommodated in the extractor chamber, the solvent is removed so that it does not return to the fat flask, then the fat flask is dried in an oven at 105°C, after which the flask is cooled in a desiccator until the weight is constant. Fat weight is calculated using the formula for the ratio of the initial weight and final weight in percent units.

The value of fat content of fish bone flour research by Amitha et al. [12] in grouper, lencam and barramundi, respectively 9.94%, 10.70% and 7.26%, research by Talib et al. [36] on yellowfin bone flour, which is 6.36% and research by Meiyasa and Tarigan [16] on tuna bone flour, which is 12.57%. According to Riansyah et al. [35], the use of a short drying time will lead to low-fat content. The heating process during drying will cause a chemical reaction in fish bone flour, namely the occurrence of fat oxidation which produces compounds including aldehydes and ketones that can react with one another to form lipid polymers [39].

6. CONCLUSION

Fishery waste such as heads, bones, scales and fins can be utilized by processing them into fish bone flour which has value-added. The processing of fishbone flour depends on the chemical composition and the availability of existing technology. The properties that determine the quality of fish bone flour are water content, ash content, protein content and fat content. The quality standard of fish bone flour refers to the Indonesian National Standard 01-3158-1992, which is 8% water content and 3-6% fat content. Based on several studies, drying time and temperature affect the physicochemical characteristics of fish bone flour. High temperatures and long drying times will increase the ash content and protein content and will decrease the moisture content and fat content.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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