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The Potential of Tilapia Bone *(Oreochromis Nilotikus)* to Meet Calcium Sufficiency

Potensi Tulang Ikan Nila (Oreochromis Niloticus) untuk Memenuhi Kecukupan Kalsium

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ABSTRACT

Background: Calcium is an essential nutrient that plays a role in the human biological system, especially bones. The study results in Benin showed that the calcium intake of pregnant women was low, and Kinshella reported that the calcium intake of low-income pregnant women was very low. In Indonesia, the calcium intake of pregnant women is 403.5±343.1 mg/day from 1200 mg/day. The source of calcium is milk and its processed products.
Objectives: This study aims to obtain fishbones rich in calcium from fish processing waste. Fishbones can be an alternative source of calcium other than milk and are cheaper.
Methods: This study was conducted using two laboratory experiment methods. The fishbone sample is a fish skeleton that is fish processing waste. The first method was to press the fishbones for 2 hours and dry them in a cabinet dryer for 20 hours at 60°C. In the second method, the fishbones were soaked using as much as 30 ml per kg of vinegar acid for 10 minutes. Next, it was dried in a cabinet dryer for 4 hours at 60°C. These two methods tested the levels of proximate and calcium in fishbone meal.
Results: The moisture content of the two flours was almost the same, the protein, fat, and calorie content was higher in the first experimental fishbone meal. The second trial of fishbone meal has a higher ash and carbohydrate content. Meanwhile, the calcium level of the fishbone meal in the second trial was four times that of the first.
Conclusions: To achieve daily calcium sufficiency, one should consume 10 g of calcium flour. Further research is needed to determine calcium absorption in the body and the development of consumption in food applications.

INTRODUCTION

The human biological system, particularly the bones, depends on calcium, an important vitamin. If bone health is to be regarded, calcium is an essential vitamin. The addition of calcium to foods from a variety of sources is greatly valued[1]. Individual calcium is acknowledged to be insufficient based on many research studies. As far as we know, milk and its processed products are the source of calcium. However, because there are few lactose-free calcium-rich dietary options, lactose sensitivity may contribute to people's poor calcium intake[2] . When lactose intolerance is combined with decreased milk consumption or avoidance, it can result in brittleness fractures and decreased bone density. There is a weak but substantial correlation between milk consumption and bone health, particularly in children, according to recently published human trials and meta-analyses. Building and preserving bones throughout life requires consuming enough calcium. Calcium requirements might change during life, and adequate food intake is essential for bone growth and metabolism[3].

The phrase "fishbone" refers to the axial, appendicular, and fishbone components of a fish's body, which make up roughly 10% to 15% of its overall weight[4]. Compared to other calcium salts, fishbones are a bioavailable calcium source. The food's gritty texture and decreased calcium bioavailability are caused by the huge size of the bones. Therefore, to attain the desired features, the size of the bones must be reduced. The two main inorganic materials found in fishbones are hydroxyapatite and calcium phosphate. As a result, fishbones are thought to be a possible supply of calcium, which is necessary for human health[5]. Red snapper bone flour yielded an average of 68.27g (24.64%), with an average moisture content of 2.54%, ash content of 83.82%, and calcium content of 92.30%, according to Research[6] Based on SNI 01-3158-1992, the study's findings show that the quality of calcium produced using the alkaline method (NaOH) is included in the quality of calcium quality one.

In North Sumatra, Serdang Bedagai Regency, a business processes Tilapia fillet (*Oreochronis Niloticus*), which is kept in Lake Toba. From the results of the filet processing, Tilapia skeleton waste is produced. This

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tilapia skeleton can be processed into a very valuable source of calcium. Becoming an alternative source of calcium for people with lactose intolerance or other individuals. The potential of tilapia skeleton byproducts can be maximized by processing it into a nutrient-rich fishbone meal. Nutrient-rich fishbone meal can be an alternative to calcium-rich food products to replace milk, especially for people with lactose intolerance. This research aims to obtain fishbones that are rich in calcium and can be an alternative source of calcium other than milk and at a cheaper price obtained from fish processing waste.

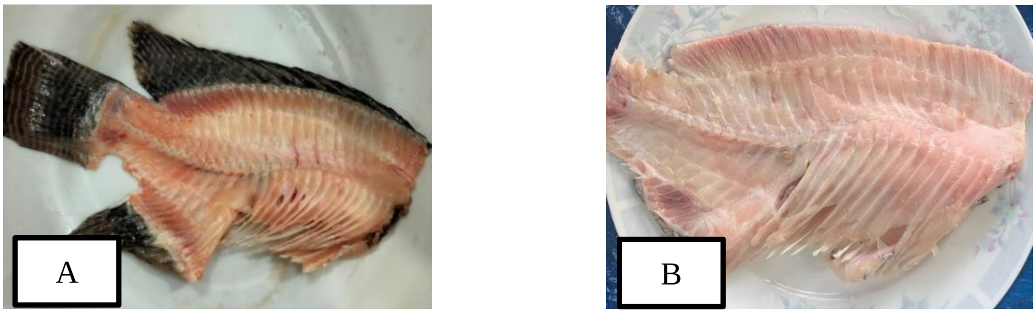
A corporation in Serdang Bedagai Regency, North Sumatra, is involved in the production, processing, and exportation of tilapia, also known as Indonesian tilapia (Oreochronis Niloticus). Making nutrient-rich fishbone flour from tilapia skeleton by-products helps optimize their potential. For those who are lactose intolerant, nutrient-rich fishbone flour can serve as a substitute for milk in calcium-rich dietary items. This research aims to obtain fishbones that are rich in calcium and can be an alternative source of calcium other than milk and at a cheaper price obtained from fish processing waste.

METHODS

This study was a laboratory experiment that uses two methods. The first method processed the Tilapia bones and the remaining meat on the skeleton. In contrast, the second method separated the tilapia meat from the skeleton to obtain clean tilapia bones. This research was carried out from January to July 2024.

Fish Sample

Tilapia bones as fish skeletons resulting from fish processing waste were purchased from the PT Aquafarm Cooperative of Serdang Bedagai Regency. Vinegar acid is purchased from the Lubuk Pakam market. Fishbone processing occurs at the Food Technology Laboratory, Department of Nutrition, Medan Health Polytechnic, Ministry of Health. Meanwhile, chemical analysis was carried out in the Laboratory of the Faculty of Agricultural Product Technology (FTHP) University of Brawijaya Malang and the Mbrio Food Laboratory Bogor.



(A) Tilapia Skeleton From Factory Waste, (B) Fish Skeleton After Cleaning and Ready to be Processed
Figure 1. Tilapia Skeleton

Making Tilapia Bone Flour

The headless skeleton was cleaned using the first method, and the fins and tail were separated, washed, and dried. The fishbones are pressed for 2 hours and then dried in a cabinet dryer for ± 20 hours at 60°C. After drying, it is mashed using a blender and sifted using a 40-mesh flour sieve. The yield obtained was 10.38%. In the second method, the fishbones as headless skeletons are cleaned, separated from the tail of the fins, washed, and dried. Fishbones are soaked in a vinegar solution of 30 ml per kilogram of fishbones for 10 minutes. Next, the fishbones were boiled for 1 hour. The meat still left on the fishbones was separated to obtain clean fishbones. Fishbones were pressure-cooked: for 1 hour, then arranged on a tray and dried in a cabinet dryer for ± 4 hours at 60°C. After drying, it is mashed using a blender and sifted using an 80-mesh flour sieve.

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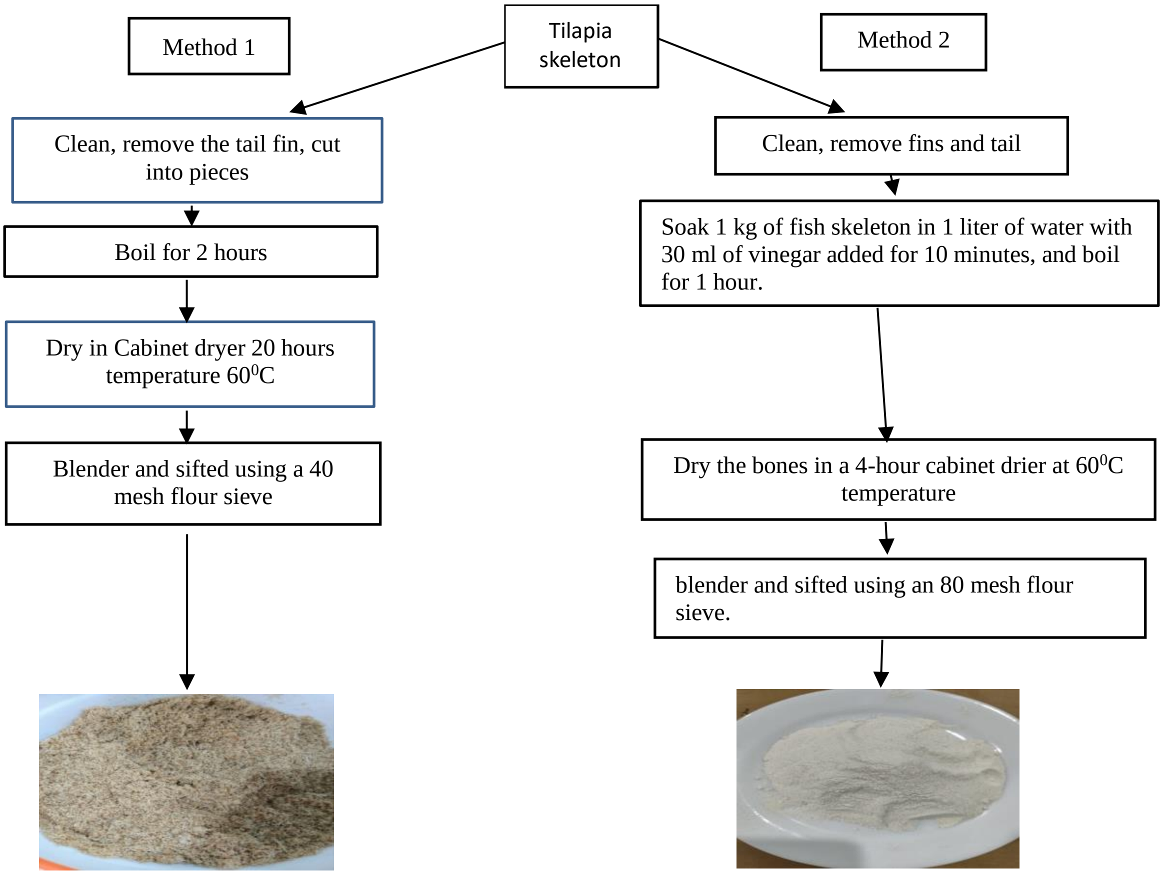

Figure 2. Processed Fishbone Flour Methods 1 and 2

Chemical Analysis

The proximate test was one of the chemical tests that were analyzed. The ash content was measured using the gravimetric method (AOAC, 2005), the water content was analyzed using the same method (AOAC, 2005), the carbohydrate content was analyzed using the difference method (AOAC, 2005), and the protein content was analyzed using the Kjeldahl method (AOAC, 2005). Fat analysis was carried out using the Soxhlet method (AOAC, 2005). AAS (Atomic Absorption Spectrophotometer) method for measuring calcium levels (AOAC, 2005). Magnesium levels are determined using the AAS (Atomic Absorption Spectrophotometer) method, while phosphor levels are determined using the spectrophotometric method (AOAC, 2005). The first experimental chemical analysis was conducted at the Agricultural Product Technology Laboratory, Universitas Brawijaya (UB). Meanwhile, the second experimental chemical analysis was carried out at the Mbrio Food Laboratory in Bogor. The implementation of this chemical test is carried out by sending samples to Malang through a delivery service.

Data Processing and Analysis

The data that has been collected was examined and processed using a computer with the SPSS prog version 24, Data on the nutritional content of milk flour and its processed milk were obtained from[7]. The data was presented descriptively. This research has received ethical approval from the Ethics Committee of the Medan Health Polytechnic of The Ministry of Health. Ethical Statement Number: 01.25 735 /KEPK/POLTEKKES KEMENKES MEDAN 2024. The effective date was May 8th, 2024 to May 8th, 2025.

RESULTS AND DISCUSSIONS

Based on the results of the water content, ash, protein, fat, and carbohydrate tests that have been carried out, it was known that the moisture content of fishbone flour is almost the same, which was <5%, as well as the carbohydrate content was not much different. While the ash content of fishbone flour was double that of fishbone flour 1. The protein and fat content of fishbone flour 1 was higher than fishbone flour 2 (Figure 3). Study[8] reported a catfish bone moisture content of 7.72%.

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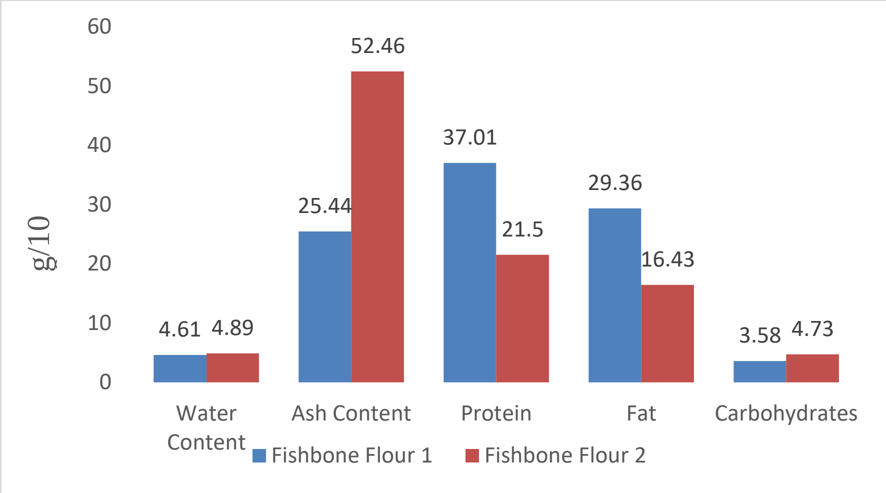

Figure 3. Proximate Analysis of Fishbone FLour 1 and 2

Another study reported that the moisture content of red snapper bone flour obtained was 2.54%[6]. The red snapper bone flour in the results of this study showed a low moisture content and was still below the standard set by SNI. Based on the Indonesia National Standard (SNI 7994:2014), fishbone flour has a maximum moisture content of 10.0% quality I and quality II 10.0%. Compared to the ash content of red snapper bone flour obtained from the study[6], which was 83.82%, the results of this study are still lower.

The energy content of fishbone flour 1 and 2 can be seen in Figure 4. It can be seen that the energy content of fishbone flour 1 was higher than that of fishbone flour 2. This showed that fishbone flour 1 was quite high in energy content.

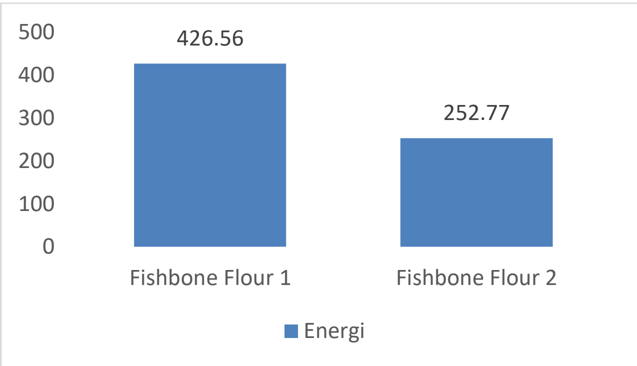

Figure 4. The Energy Content of Fishbone Flour 1 and 2

The calcium content of fishbone flour 1 in 100 g was 2,573 mg, while the calcium content of fishbone flour 2 was much higher, almost five times (Figure 5). Previous research reported that the calcium level of Belida fishbones was 30.93%[9]. The results of the study[6] reported that the calcium content of red snapper bone was 74.9%, and the calcium content of red snapper bone flour obtained was 92.30%.

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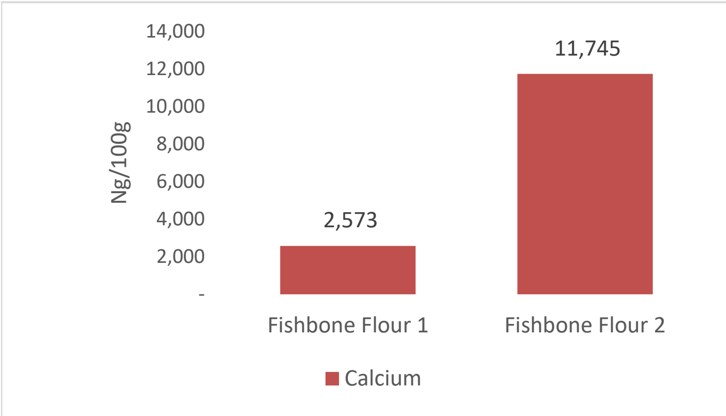

Figure 5. Calcium Content of Fishbone Flour 1 and 2

Based on the results obtained from the chemical analysis of fishbone flour 1 and 2, in Figure 4 it can be seen the comparison of water content, ash content, protein content, fat content, and carbohydrate content of fishbone flour 1 and 2 with milk and its processed products, namely powder milk, skimmed milk powder, cheese, sweetened condensed milk, and fresh yogurt. The highest moisture content was fresh yogurt, while the highest ash content was fishbone flour 2. The protein content of fish flour 1 with skimmed milk flour looks the same. The fat content of fishbone flour 1 with milk flour was almost the same, while the carbohydrates of skimmed milk flour and sweetened condensed milk were nearly the same (Figure 6).

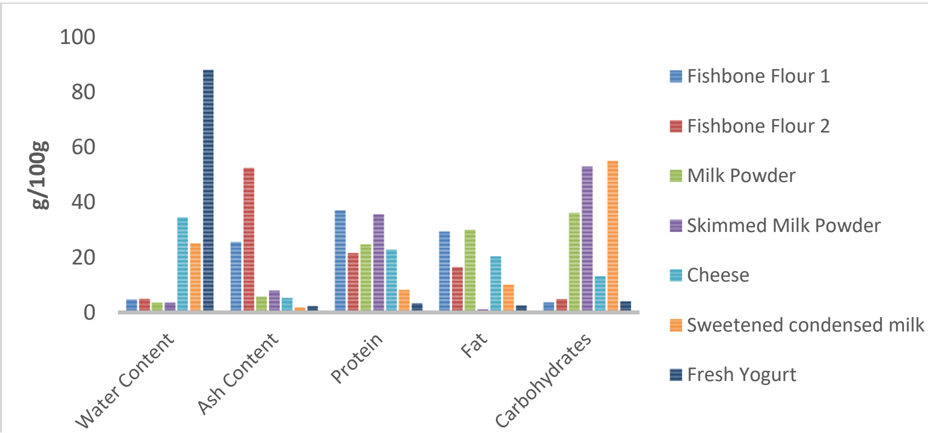

Figure 6. Comparison of Fishbone Flour Nutrients with Milk and Processed Products

The energy content of fishbone flour 2 was below fishbone flour 1. Compared to milk powder, the energy content of fishbone flour 2 was far below that of milk powder. The highest energy content was milk powder, while the lowest was fresh yogurt (Figure 7).

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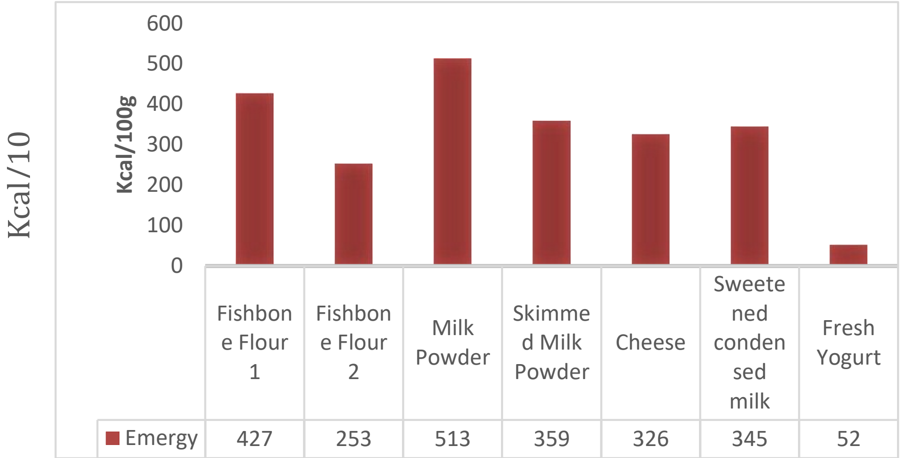

Figure 7. Comparison of Energy Content of Fishbone Flour with Milk and Processed Products

The comparison of calcium levels of fishbone flour 1 and 2 with milk and processed results can be seen in Figure 6. It can be seen that the highest calcium levels were in fishbone flour 2 compared to fishbone flour 1, milk powder, skimmed milk powder, sweetened condensed milk, and fresh yogurt. The calcium content of skimmed milk flour is the highest among milk and its processed products. When comparing the calcium content of fishbone flour 1 with milk, the calcium content of fishbone flour 1 was almost two times that of milk. In contrast, it can be compared to the calcium level of fishbone flour 2, and the calcium content is nearly ten times. In line with these results, results from[10] indicated that fishbones were an attractive alternative to traditional sources of calcium, such as dairy products—the results concluded that calcium supplementation from tuna bone flour effectively prevented maternal osteopenia. Tuna bones, a waste product of the fishing industry, are an alternative source of calcium supplements that can increase the bone density of the mineral in breastfeeding mothers and newborns. Another study cited their findings showing that the natural calcium produced from salmon bones is a cost-effective and environmentally friendly source of calcium[11]. In addition, reported calcium digestibility in vitro was 37% for optimized samples, higher than natural calcium salts[12]. The results of 14 studies tested on model mice concluded that fishbone nanoparticles have a higher bioavailability of calcium than salmon bone microparticles.

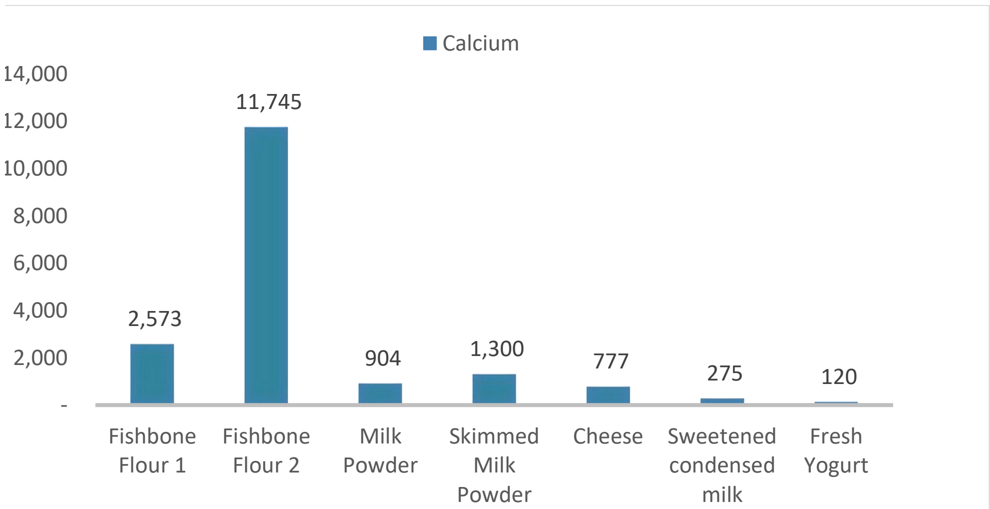

Figure 8. Comparison of Calcium Content of Fishbone Flour with Milk and Processed Products

Increased consumption of nutrient-dense foods by people in low- and middle-income countries is one of the dietary adjustments necessary to achieve Sustainable Development Goal 2—the eradication of hunger and malnutrition by 2030. Achieving Sustainable Development Goal 2—the eradication of hunger and malnutrition by 2030—will need dietary changes, including increased intake of nutrient-dense foods by populations in low- and middle-income countries. Fish is the main animal source of food in many low- and middle-income countries in the southern region of the world, and it may be obtained through aquaculture and fisheries[14].

Fish byproducts can help create goods with significant market value and stimulate economic expansion[15]. Fishbones are rich in calcium carbonate, making them a low-cost alternative calcium source of calcium[11]. Fishbones can serve as raw materials for the production of high-value-added compounds that can be used in various sectors including the agrochemical, biomedical, food, and pharmaceutical industries[16]. Calcium is a fundamental mineral necessary to human well-being, particularly bone well-being. Marine organic calcium could be an acknowledged copious asset with a complex dynamic structure. Marine treatment waste is often considered futile; in any case, it could be an abundant and low-cost source of calcium. Reusing by-products from marine living beings can increase calcium's included esteem and diminish the chance of natural contamination[5].

Fishery waste such as heads, bones, scales, and fins can be processed into fishbone flour with an added value of[17]. The processing of fishbone flour depends on the chemical composition and the availability of existing technology. The properties that determine the quality of fishbone flour are moisture content, ash content, protein content, and fat content. The quality standard of fishbone flour refers to the Indonesia National Standard 01-3158-1992, which had 8% moisture content and 3-6% fat content. Based on several studies, drying time and temperature affect the physicochemical characteristics of fishbone flour. High temperatures and extended drying times will increase ash levels and protein content and decrease moisture and fat content[18]. The bone of knifefish (Chitala sp.) has not been used to its full potential and may pollute the ecosystem. One method to add value and lessen environmental damage is to process it into fishbone flour. It can be utilized to fortify food products with calcium[19]. Fishbone flour in various processed food products can meet daily calcium needs. Ten gs of fishbone flour two will meet the daily calcium needs. Applying fishbone flour in different food products will increase its potential as a cheap source of calcium. Multiple products have been made by adding calcium fishbones, such as analog rice[20] and crackers[21]. In addition, it is necessary to have a cost-effective fishbone extraction and processing strategy[22].

This research produced a brown fishbone meal and then used method 2 to obtain a fishbone meal. Method 2 Fishbone meal is white and smooth like wheat flour, so it is easy to apply to various food products. The disadvantage of this study is that the research method for making a fishbone meal needs to be perfected to get a better fishbone meal.

CONCLUSIONS

The high calcium content in fishbone flour peppered in this study can be used as a food additive to increase the calcium content in food. The potential of fishbone flour 1 and 2 as a source of calcium is undoubted. Daily calcium adequacy will be enough by consuming 10 g of calcium flour. Furthermore, further research is needed to determine calcium absorption in the body and the development of consumption in food applications.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

The author stated that there was no conflict of interest. This research was funded by a grant from the Medan Health Polytechnic, box number 154.5/PPK-I/BAP/III/2024, dated April 18th, 2024.

AUTHOR CONTRIBUTIONS

NT: original draft, conceptualization, investigation, methodology, supervision, writing review and editing; US: methodology, formal analysis, original draft writing, editing.

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