# Meat-to-bone ratio of Nile Tilapia (*Oreochromis niloticus*) in fish sticks: hedonic quality and calcium content

**Ihram Aji Mokoagow[1], Faiza A. Dali[2]*, Sri Rahayu Kalaka[3]**
[1,2,3]Department of Fishery Product Technology, Universitas Negeri Gorontalo, Gorontalo, Indonesia

**Article Info**

***Article history:***

Received : Jun 11, 2026
Revised : Jul 02, 2026
Accepted : Jul 29, 2026

***Keywords:***

Calcium content;
Fish bones;
Fish sticks;
Nile Tilapia;
Sensory quality.

**ABSTRACT**

Fish bones are an underutilized by-product with potential as a calcium-rich ingredient in value-added fish products. However, information regarding the appropriate meat-to-bone ratio that simultaneously improves calcium content and maintains acceptable sensory quality remains limited. Therefore, this study evaluated the effect of different meat-to-bone ratios of Nile tilapia (*Oreochromis niloticus*) on hedonic quality and calcium content of fish sticks. Three formulations were prepared using meat-to-bone ratios of 15:85% (P1), 25:75% (P2), and 35:65% (P3). Hedonic quality was evaluated by 25 trained panelists using a five-point scale covering appearance, aroma, taste, and texture. Calcium content was determined using a titrimetric method. Hedonic quality data were analyzed using the Kruskal–Wallis test followed by the Mann–Whitney test at a 5% significance level, while calcium content was analyzed using one-way analysis of variance followed by Duncan's multiple range test. The results showed significant differences among formulations for all hedonic quality attributes ($p < 0.05$). P3 had the highest appearance score (3.72 ± 1.21), whereas P2 had the highest aroma (3.64 ± 0.95), taste (2.84 ± 0.75), and texture (3.88 ± 0.88) scores. Calcium content differed significantly among formulations and increased with increasing bone proportion, from 0.61 ± 0.14% in P3 to 0.92 ± 0.07% in P1. These results demonstrate that meat-to-bone ratio influences both sensory characteristics and calcium content of Nile tilapia fish sticks. The 25:75% ratio (P2) showed the highest scores for three of the four sensory attributes evaluated, whereas the 15:85% ratio (P1) provided the highest calcium content.



***Corresponding Author:***

Faiza A. Dali
Faculty of Marine and Fisheries Technology, Universitas Negeri Gorontalo
Jl. Jend. Sudirman No.6, Kec. Kota Tengah, Kota Gorontalo, Gorontalo 96128
Email: faizadali@ung.ac.id

## 1. INTRODUCTION

Fish is an important source of animal protein and essential minerals. However, fish processing generates substantial quantities of underutilized parts, including bones, which may contribute to environmental burdens when not appropriately utilized. Fish bones are particularly valuable because they contain abundant minerals, especially calcium and phosphorus, and therefore have considerable potential for food fortification and value-added applications (Puspitasari et al., 2021; Petenuci et al., 2008; Jimenez-Champi et al., 2024; Gawborisut et al., 2024). The valorization of fish-processing by-products has increasingly been recognized as an approach to improve resource efficiency while generating nutritionally valuable food ingredients (Darko et al., 2024; Tarigan & Sitohang, 2024).

Nile tilapia (*Oreochromis niloticus*) is widely consumed and has considerable potential for diversification into value-added food products. In addition to its meat, its bones can be incorporated into processed foods as a mineral-rich component. Petenuci et al. (2008) reported that Nile tilapia bone flour contains substantial mineral components, supporting its potential as a calcium source. Similarly, the incorporation of fish-bone-derived ingredients into food products has been reported to increase calcium content while maintaining acceptable sensory characteristics when used at appropriate levels. Trisnawati et al. (2024), for example, reported that the addition of fishbone biocalcium to Nile tilapia meatballs increased calcium content while maintaining acceptable sensory properties.

Fish sticks are a potential product for utilizing both fish meat and bones because their formulation allows variation in the proportion of fish-derived ingredients. Previous studies have demonstrated that the use of different fish parts can affect the physicochemical and sensory characteristics of fish sticks. Kusumaningrum and Sulistyawati (2024) reported differences in the chemical characteristics of catfish sticks prepared from different fish parts, indicating that raw material composition influences the characteristics of the final product. Studies involving fish meat and bone in fish-stick formulations have also demonstrated that variations in fish-derived ingredients can affect sensory characteristics, particularly aroma and taste (Sari et al., 2019; Siswanti et al., 2017). The use of fish meat and bone has also been investigated as a strategy for developing fish sticks with increased nutritional value, particularly calcium and protein (Fitri et al., 2016).

Despite these findings, information remains limited regarding the use of fresh Nile tilapia meat and bones at different ratios in fish sticks, particularly when hedonic quality and calcium content are evaluated simultaneously. Increasing the proportion of bone may improve the mineral contribution of the product but may also alter its appearance, aroma, taste, and texture. Therefore, the utilization of fish bones as a calcium-rich ingredient needs to be considered together with the sensory characteristics of the resulting product.

This study evaluated the hedonic quality and calcium content of Nile tilapia fish sticks prepared using different meat-to-bone ratios. Specifically, three ratios : 15:85% (P1), 25:75% (P2), and 35:65% (P3)—were examined to determine how changes in meat and bone proportions affect the sensory characteristics and calcium content of the product. The findings are expected to provide information on the potential utilization of Nile tilapia bones in value-added fish-stick products while maintaining desirable sensory characteristics.

## 2. METHOD

### 2.1 Materials

The main materials were Nile tilapia (*Oreochromis niloticus*) meat and bones obtained from freshwater fish farmers in Kota Kotamobagu, Provinsi Sulawesi Utara, Indonesia. Other ingredients included wheat flour, tapioca starch, margarine, salt, water, and seasonings used in the preparation of the fish sticks. The main equipment included a blender, digital balance, cooking utensils, boiling pan, dough roller, fryer, and laboratory equipment for calcium analysis.

### 2.2 Experimental Design and Fish Stick Preparation

The treatment levels were established through a preliminary formulation trial conducted prior to the main experiment. This preliminary trial was intended solely to determine the formulation levels used in the present study. Based on the overall sensory evaluation, the 25% meat:75% bone formulation was selected as the reference formulation. Two additional formulations (15% meat:85% bone and 35% meat:65% bone) were subsequently included to evaluate the effect of different meat-to-bone ratios on the hedonic quality and calcium content of Nile tilapia fish sticks.

The experiment used a completely randomized design with one factor, namely the meat-to-bone ratio of Nile tilapia. Three formulations were evaluated: P1 (15% meat:85% bone), P2 (25% meat:75% bone), and P3 (35% meat:65% bone). Each treatment was prepared in two independent replications. The six experimental units were randomly assigned to the treatments using a completely randomized design to minimize experimental bias. The formulation of each treatment is presented in Table 1.

**Table 1.** Formulation of Fish Sticks Based on Different Meat-to-Bone Ratios of Nile Tilapia

| Ingredient | P1 | P2 | P3 |
|---|---|---|---|
| Wheat flour (g) | 300 | 300 | 300 |
| Tapioca starch (g) | 200 | 200 | 200 |
| Margarine (g) | 47 | 47 | 47 |
| Salt (g) | 14 | 14 | 14 |
| Nile tilapia meat (g) | 75 | 125 | 175 |
| Nile tilapia bone (g) | 425 | 375 | 325 |

P1 = 15% meat:85% bone; P2 = 25% meat:75% bone; P3 = 35% meat:65% bone

Fish-stick preparation consisted of raw material preparation, fish processing, formulation, dough preparation, shaping, frying, and sensory and calcium analyses. Nile tilapia were cleaned, washed, and soaked in lemon juice for 10–15 min to reduce fishy odor. The fish were then boiled until cooked, after which the meat was separated from the bones. The bones were boiled again for approximately 1 h until softened, cleaned of adhering tissue, and homogenized using a blender. Meat and bone were weighed according to each treatment formulation and mixed with wheat flour, tapioca starch, margarine, salt, and seasonings until a homogeneous dough was obtained. The dough was rolled to approximately 2 mm thickness, cut into 8–10 cm strips, and fried at approximately 110 °C for 4–6 min until golden brown. The products were drained and cooled to room temperature before analysis.

### 2.3 Hedonic Quality and Calcium Analysis

Hedonic quality was evaluated by 25 trained panelists (18 males and 7 females), aged 20–23 years, who were undergraduate students in the Fisheries Product Technology Study Program, Universitas Negeri Gorontalo. The panelists had prior experience in sensory evaluation of fishery products and were selected based on good health, normal sensory function, willingness to participate, and the absence of fish allergies. Before evaluation, they attended a 20-min orientation on the sensory attributes, scoring criteria, and evaluation procedures. Hedonic quality was assessed using a five-point scale adapted from Harmain et al. (2015), with slight modifications for Nile tilapia fish sticks. Samples were labeled with random three-digit codes and presented in randomized order to minimize evaluation bias.

Calcium content was determined using the titrimetric method of Apriyantono et al. (1989). Samples were ashed at 540 °C for 8 h, dissolved in distilled water, and reacted with saturated ammonium oxalate and methyl red indicator. The solution was adjusted to approximately pH 5, heated, and allowed to stand before filtration. The resulting precipitate was filtered using Whatman No. 42 filter paper and titrated with 0.01 N $KMnO_4$ until a stable pink endpoint was obtained. Calcium content was expressed as a percentage.

### 2.4 Data Analysis

Hedonic quality data for appearance, aroma, taste, and texture were analyzed using the Kruskal–Wallis test at a 5% significance level ($p < 0.05$). When significant differences were detected, pairwise comparisons were performed using the Mann–Whitney test. Calcium content was analyzed using one-way analysis of variance (ANOVA) at a 5% significance level ($\alpha = 0.05$), followed by Duncan's multiple range test when significant differences were detected. The results were expressed as mean ± standard deviation.

## 3. RESULTS AND DISCUSSION

### 3.1 Appearance Hedonic Quality

The appearance scores of Nile tilapia fish sticks increased progressively from 2.32 ± 0.48 in P1 to 3.00 ± 0.76 in P2 and 3.72 ± 1.21 in P3 (Figure 1). The Kruskal–Wallis test followed by Mann–Whitney pairwise comparisons indicated significant differences among treatments ($p < 0.05$), as shown by different superscript letters.

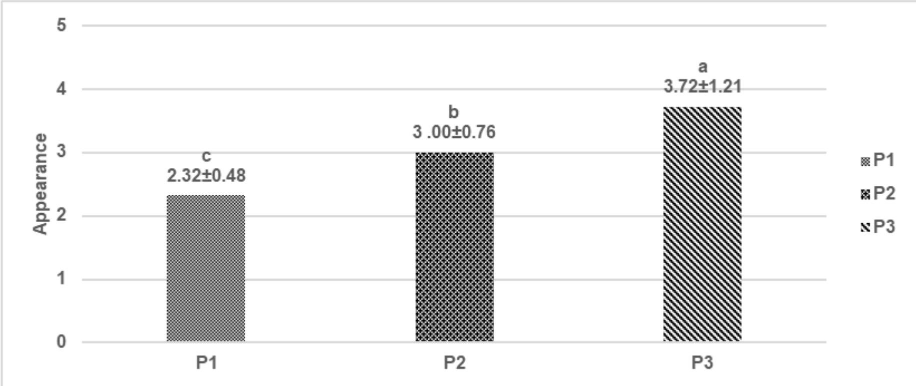


**Figure 1**. Appearance Quality of Fish Sticks formulated with Different Ratios of Tilapia Meat and Bone
P1 = 15% meat:85% bone; P2 = 25% meat:75% bone; P3 = 35% meat:65% bone. Different superscript letters indicate significant differences among treatments based on the Mann–Whitney test ($p < 0.05$)

The higher appearance score obtained by P3 (35% meat:65% bone) indicates that increasing the proportion of fish meat produced fish sticks with a more desirable visual appearance. Fish meat provides a smoother and more cohesive matrix than bone particles, resulting in a more uniform surface, brighter colour, and fewer visible coarse particles after frying. In contrast, the higher proportion of bone in P1 (15% meat:85% bone) likely produced a rougher product surface because finely blended bone particles remained visible within the dough and affected the overall product appearance.

During frying, fish meat proteins also contribute to the formation of a compact structure and promote a more uniform golden-brown colour through protein denaturation and Maillard reactions. Conversely, excessive bone incorporation may interrupt the continuity of the dough matrix, leading to less homogeneous colour development and a rougher surface texture. These physical differences are readily perceived by panelists because appearance is the first sensory attribute evaluated before aroma, taste, and texture.

The present findings are consistent with Setiyanti et al. (2023), who reported that increasing the proportion of Nile tilapia meat significantly improved the organoleptic quality of fish sticks, including appearance. Likewise, Kusumaningrum and Sulistyawati (2024) demonstrated that different fish components produce distinct visual characteristics in fish-stick products because muscle tissue and bone differ in composition and processing behaviour. Similar observations were reported by Aktaruzzaman et al. (2022), who identified appearance as one of the major determinants of consumer acceptance of processed Nile tilapia fish products.

Overall, these findings indicate that the meat-to-bone ratio directly influences the visual quality of Nile tilapia fish sticks, and a higher meat proportion (35% meat:65% bone) provides the most acceptable appearance among the formulations evaluated.

### 3.2 Aroma Hedonic Quality

The mean aroma scores were $2.64 \pm 0.91$, $3.64 \pm 0.95$, and $3.16 \pm 0.69$ for P1, P2, and P3, respectively (Figure 2). The Kruskal–Wallis test showed significant differences among treatments ($p = 0.02$). Mann–Whitney pairwise comparisons indicated significant differences between P1 and P2 and between P1 and P3 ($p < 0.05$), whereas P2 and P3 did not differ significantly ($p > 0.05$).

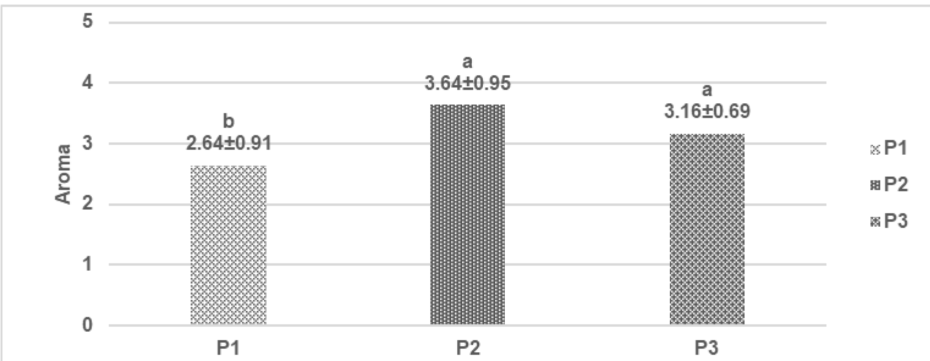


**Figure 2**. Aroma Quality of Fish Sticks Formulated with Different Ratios of Tilapia Meat and Bone
P1 = 15% meat:85% bone; P2 = 25% meat:75% bone; P3 = 35% meat:65% bone. Different superscript letters indicate significant differences among treatments based on the Mann–Whitney test ($p < 0.05$)

P2 exhibited the highest aroma score (3.64 ± 0.95), indicating that the 25% meat:75% bone formulation produced the most acceptable aroma among the tested formulations. This result suggests that aroma development was influenced not only by the amount of fish meat but also by the balance between meat and bone. Fish meat contains proteins, amino acids, and lipids that generate desirable volatile compounds during frying, whereas fish bones still retain collagen, residual proteins, and lipids that also contribute to characteristic fish aroma after thermal processing. Therefore, an appropriate combination of meat and bone may produce a more balanced aroma profile than formulations containing either excessive bone or excessive meat.

The lower aroma score of P1 may be attributed to the high proportion of bone, which can intensify the characteristic odour of fish-processing by-products and reduce aroma acceptability. Conversely, increasing the meat proportion to 35% (P3) did not further improve aroma significantly compared with P2, indicating that aroma intensity reached an acceptable level at the 25:75 meat-to-bone ratio. This finding suggests that increasing meat content beyond this proportion does not necessarily enhance aroma quality because aroma perception depends on the interaction among raw material composition, thermal processing, and volatile compound formation.

These findings agree with Setiyanti et al. (2023), who reported that the proportion of Nile tilapia meat significantly influenced the aroma characteristics of fish sticks. Similarly, Fitri et al. (2016) and Siswanti et al. (2017) demonstrated that differences in fish-part composition affected the sensory characteristics of fish-based snack products, including aroma. Overall, the present study indicates that a balanced meat-to-bone ratio is essential for producing fish sticks with acceptable aroma quality.

### 3.3 Taste Hedonic Quality

The mean taste scores were 2.16 ± 0.85 in P1, 2.84 ± 0.75 in P2, and 2.76 ± 0.52 in P3 (Figure 3). According to the sensory quality criteria, a score of 3 represents a moderately strong meat-and-bone fish taste, whereas a score of 4 indicates a strong fish taste.

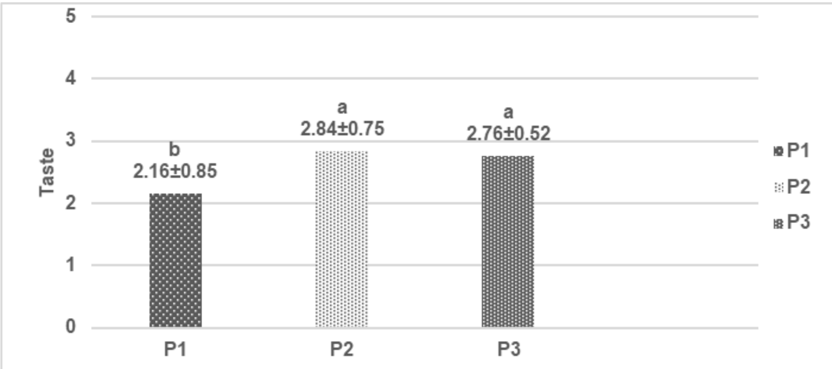


**Figure 3**. Taste Quality of Fish Sticks Formulated with Different Ratios of Tilapia Meat and Bone
P1 = 15% meat:85% bone; P2 = 25% meat:75% bone; P3 = 35% meat:65% bone. Different superscript letters indicate significant differences among treatments based on the Mann–Whitney test ($p < 0.05$)

The Kruskal–Wallis test revealed significant differences among treatments ($p = 0.03$). Mann–Whitney pairwise comparisons showed significant differences between P1 and P2 and between P1 and P3 ($p < 0.05$), whereas P2 and P3 did not differ significantly ($p > 0.05$).

The highest taste score obtained by P2 indicates that the 25% meat:75% bone ratio provided the most acceptable flavour among the tested formulations. Taste perception in fish products is strongly influenced by the balance of soluble proteins, free amino acids, peptides, and lipids released from fish tissues during cooking. A moderate proportion of meat combined with softened fish bone may have produced a more balanced savoury flavour, whereas the excessive bone proportion in P1 likely reduced taste acceptability because bone components contribute less to desirable flavour than muscle tissue.

Interestingly, increasing the meat proportion from 25% to 35% (P3) did not significantly improve taste quality. This finding suggests that consumer perception of taste does not necessarily increase with higher meat content, but rather depends on achieving an appropriate balance between flavour-generating compounds derived from meat and the overall product formulation, including seasonings and processing conditions.

The present findings are consistent with Setiyanti et al. (2023), who reported that the proportion of Nile tilapia meat significantly affected the taste characteristics of fish sticks. Similar observations were reported by Fitri et al. (2016), Fera et al. (2019), and Sari et al. (2019), who demonstrated that variation in fish-part composition influenced the sensory acceptance of fish-based snack products. Therefore, under the formulation conditions evaluated in this study, the 25% meat:75% bone ratio provided the optimum taste quality.

### 3.4 Texture Hedonic Quality

The mean texture scores were 3.56 ± 0.71 in P1, 3.88 ± 0.88 in P2, and 2.40 ± 0.50 in P3 (Figure 4). According to the sensory quality criteria, a score of 3 represents a moderately dry and crispy texture, whereas a score of 4 indicates a dry and crispy texture. Thus, P2 exhibited the highest texture score, followed by P1 and P3.

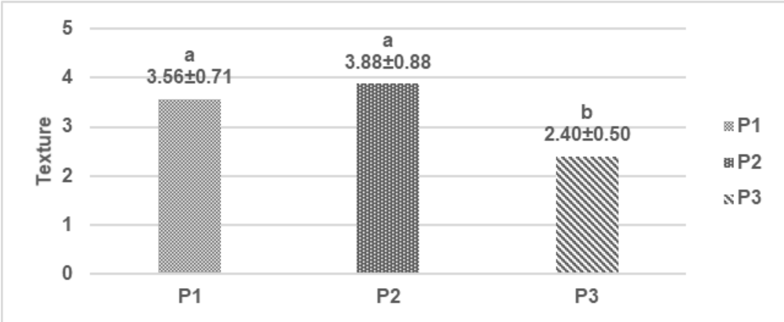


**Figure 4**. Texture Quality of Fish Sticks Formulated with Different Ratios of Tilapia Meat and Bone
P1 = 15% meat:85% bone; P2 = 25% meat:75% bone; P3 = 35% meat:65% bone. Different superscript letters indicate significant differences among treatments based on the Mann–Whitney test ($p < 0.05$)

The Kruskal–Wallis test indicated significant differences among treatments ($p < 0.05$). Mann–Whitney comparisons showed that P1 and P2 did not differ significantly ($p > 0.05$), whereas both treatments differed significantly from P3 ($p < 0.05$).

The superior texture observed in P2 suggests that the 25% meat:75% bone ratio provided a more desirable balance between crispness and structural integrity. Texture development in fried fish sticks is strongly influenced by the interaction between muscle proteins, bone particles, starch, and moisture loss during frying. An appropriate proportion of meat contributes to protein network formation, whereas softened bone particles may reinforce the product structure without excessively disrupting the dough matrix. Consequently, P2 produced a dry and crispy texture that was most consistent with the expected sensory characteristics.

Although P1 contained a higher proportion of bone, its texture remained comparable to that of P2, indicating that the softened bone particles did not adversely affect crispness. In contrast, increasing the meat proportion to 35% (P3) resulted in significantly lower texture scores. This may be attributed to the greater moisture retention associated with higher meat content, which can reduce crispness after frying and produce a softer product.

This interpretation is consistent with Sari et al. (2017), who described dry and crispy texture as an important quality attribute of fish-stick products evaluated using hedonic quality assessment. These findings are consistent with Sari et al. (2019), who reported that variations in meat and bone proportions influenced the textural characteristics of fish sticks. Similarly, Kusumaningrum and Sulistyawati (2024) demonstrated that differences in fish parts significantly affected the physical characteristics of fried fish-stick products. Overall, the present results indicate that the 25% meat:75% bone formulation produced the most desirable texture, although it was not significantly different from P1.

### 3.5 Calcium Content

Calcium content decreased progressively with increasing meat proportion, from 0.92 ± 0.07% in P1 to 0.88 ± 0.07% in P2 and 0.61 ± 0.14% in P3 (Figure 5). Different superscript letters indicate significant differences among treatments based on one-way ANOVA followed by Duncan's Multiple Range Test ($p < 0.05$).

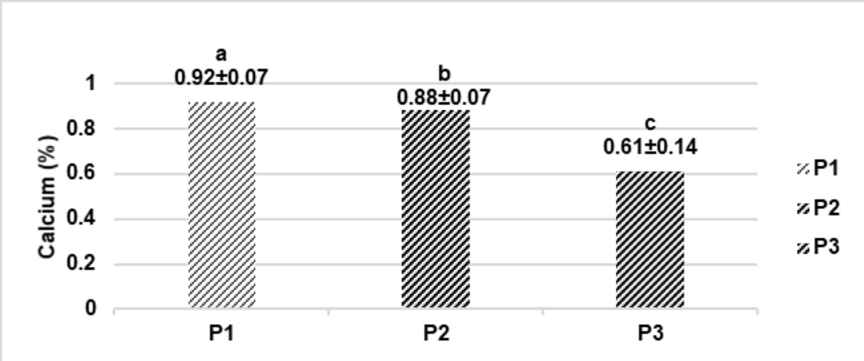


**Figure 5**. Calcium Content of Fish Sticks Formulated with Different Ratios of Tilapia Meat and Bone
P1 = 15% meat:85% bone; P2 = 25% meat:75% bone; P3 = 35% meat:65% bone. Different superscript letters indicate significant differences among treatments based on Duncan's multiple range test ($p < 0.05$).

The progressive decrease in calcium content from P1 to P3 clearly demonstrates that bone proportion was the principal factor determining calcium enrichment in the fish sticks. Fish bones are naturally rich in calcium phosphate and other mineral compounds; therefore, increasing the proportion of bone directly increased the mineral contribution to the final product. Conversely, replacing bone with meat reduced the amount of calcium incorporated into the formulation because fish muscle contains considerably lower mineral concentrations than bone.

This finding agrees with Petenuci et al. (2008), who reported that Nile tilapia bone flour contains high concentrations of calcium and phosphorus, highlighting its potential as a natural mineral source. Similar observations were reported by Fitri et al. (2016) and Sari et al. (2019), who demonstrated that increasing the proportion of fish bone enhanced the nutritional quality of fish-stick products, particularly their calcium content. More recently, Trisnawati et al. (2024) also showed that incorporating fish-bone-derived biocalcium significantly increased calcium levels while maintaining acceptable product quality.

From a sustainable food-processing perspective, these findings demonstrate that Nile tilapia bones, which are commonly discarded as processing by-products, can be effectively utilized as functional food ingredients to improve the nutritional value of fish sticks. This supports current efforts to increase the value of fish-processing by-products through their incorporation into value-added food products (Darko et al., 2024).

However, calcium enrichment should be considered together with sensory acceptance. Although P1 contained the highest calcium level because of its highest bone proportion, it did not consistently achieve the highest sensory scores. In contrast, P2 provided the best overall balance between sensory quality and nutritional enhancement. Therefore, the present findings demonstrate a practical trade-off between maximizing calcium content and maintaining consumer acceptability, suggesting that the 25% meat:75% bone formulation represents the most balanced formulation among those evaluated.

## 4. CONCLUSION

This study demonstrated that varying the meat-to-bone ratio is an effective approach to modify both the sensory quality and calcium content of Nile tilapia (Oreochromis niloticus) fish sticks, confirming that formulation plays a critical role in balancing product acceptability and nutritional enhancement. Among the tested formulations, the 25:75 meat-to-bone ratio achieved the best overall hedonic quality, whereas increasing the proportion of fish bone enhanced calcium enrichment, with the highest calcium content obtained from the 15:85 formulation. These findings highlight the potential of fish-bone incorporation as a sustainable strategy for developing calcium-enriched fish products while promoting the valorization of fish-processing by-products. Further studies should evaluate the shelf life, calcium bioavailability, and consumer acceptance of fish sticks formulated with different meat-to-bone ratios under commercial processing and storage conditions. Economic feasibility and large-scale production should also be investigated to support industrial application.

## REFERENCES

Aktaruzzaman, M., Hani, U., Sayeed, M. A., Chowdhury, M. A., Hussain, M. A., Ahmed, K. T., & Hasan, M. M. (2022). Quality assessment and shelf-life of processed tilapia (*Oreochromis niloticus*) fish sticks:

Laboratory based study. Archives of Agriculture and Environmental Science, 7(4), 514–520. https://doi.org/10.26832/24566632.2022.070405

Apriyantono, A., Fardiaz, D., Puspitasari, N. L., Sedarnawati, & Budiyanto, S. (1989). Analisis pangan. IPB Press.

Darko, H. S. O., Ismaiel, L., Fanesi, B., Pacetti, D., & Lucci, P. (2024). Current trends in food processing by-products as sources of high value-added compounds in food fortification. Foods, 13(17), 2658. https://doi.org/10.3390/foods13172658

Fera, F., Asnani, & Asyik, N. (2019). Karakteristik kimia dan organoleptik produk stik dengan substitusi daging ikan gabus (*Channa striata*). Jurnal Fish Protech, 2(2), 148–156. https://doi.org/10.33772/jfp.v2i2.9226

Fitri, A., Anandito, R. B. K., & Siswanti. (2016). Penggunaan daging dan tulang ikan bandeng (*Chanos chanos*) pada stik ikan sebagai makanan ringan berkalsium dan berprotein tinggi. Jurnal Teknologi Hasil Pertanian, 9(2).

Gawborisut, S., Ketkaew, C., & Buasook, T. (2024). Production of biocalcium from fermented fish bone residue for fish emulsion sausage fortification. Foods, 13(6), 882. https://doi.org/10.3390/foods13060882

Harmain, R. M., Dali, F. A., & Abdullah, W. (2015). Organoleptic hedonic quality and chemical analysis on sticks seaweed Kappaphycus alvarezii with fortification flour rebon shrimp (*Mysis* sp.). International Seminar Fishery and Marine Sciences in Accordance with Sail Tomini and Festival of Boalemo, 1, 119–130.

Jimenez-Champi, D., Romero-Orejon, F. L., Muñoz, A. M., & Ramos-Escudero, F. (2024). The revalorization of fishery by-products: Types, bioactive compounds, and food applications. International Journal of Food Science, 2024, Article 6624083. https://doi.org/10.1155/2024/6624083

Kusumaningrum, I., & Sulistyawati, S. (2024). Chemical characteristics of fish sticks from different parts of catfish (*Clarias* sp.). Jurnal Pengolahan Hasil Perikanan Indonesia, 27(7). https://doi.org/10.17844/jphpi.v27i7.52274

Petenuci, M. E., Stevanato, F. B., Visentainer, J. E. L., Matsushita, M., Garcia, E. E., de Souza, N. E., & Visentainer, J. V. (2008). Fatty acid concentration, proximate composition, and mineral composition in fishbone flour of Nile tilapia. Archivos Latinoamericanos de Nutrición, 58(1), 87–90.

Puspitasari, R. L., Khavidhar, F., Gustiananda, K. A., Alwan, M., Widyanto, P. C. A., Anisah, S., & Haq, A. (2021). Bone flour from suckermouth fish (*Pterygoplichthys pardalis*) and tilapia fish (*Oreochromis mossambicus*). International Journal of Biosciences and Biotechnology, 9(1), 42–48. https://doi.org/10.24843/IJBB.2021.v09.i01.p05

Sari, D. K., Rahmawati, H., & Susilawati, S. (2019). Snakeskin gourami (*Trichogaster pectoralis*) stick high in protein and calcium as of fish product diversification. Jurnal Pengolahan Hasil Perikanan Indonesia, 22(2), 311–317. https://doi.org/10.17844/jphpi.v22i2.27770

Sari, S. D., Dali, F. A., & Harmain, R. M. (2017). Karakteristik organoleptik stik alga laut *Kappaphycus alvarezii* fortifikasi tepung udang rebon (Mysis sp.) selama penyimpanan dalam kemasan polipropilen. Jurnal Entropi, 12(1), 33–38.

Setiyanti, A., Laswati, D. T., Saputro, A. E., Rukmini, A., & Darmawan, E. (2023). Pengaruh penambahan daging ikan nila (*Oreochromis niloticus*) terhadap sifat kimia dan organoleptik pada camilan stik. AGROTECH: Jurnal Ilmiah Teknologi Pertanian, 5(2), 23–34. https://doi.org/10.37631/agrotech.v5i2.1519

Siswanti, S., Agnesia, P. Y., & Anandito, R. B. K. (2017). Pemanfaatan daging dan tulang ikan kembung (*Rastrelliger kanagurta*) dalam pembuatan camilan stik. Jurnal Teknologi Hasil Pertanian, 10(1), 41–49. https://doi.org/10.20961/jthp.v10i1.17492

Tarigan, N., & Sihotang, U. (2024). The potential of tilapia bone (*Oreochromis niloticus*) to meet calcium sufficiency. Amerta Nutrition, 8(3SP), 372–379. https://doi.org/10.20473/amnt.v8i3SP.2024.372-379

Trisnawati, M. R., Wijayanti, I., & Riyadi, P. H. (2024). Characteristics of Nile tilapia (*Oreochromis niloticus*) fish balls with the addition of Asian sea bass (Lates calcarifer) bones bio-calcium. Journal of Zoology and Systematics, 2(2), 11–22. https://doi.org/10.56946/jzs.v2i2.427