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The effect of deep-frying and pan-frying methods on the organoleptic properties, protein, and calcium content of presto milkfish floss (*Chanos chanos*)

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Abstract

This study investigates the impact of deep-frying and pan-frying processing methods on the sensory characteristics, protein content, and calcium levels of presto milkfish floss (*Chanos chanos*). A pre-experimental study design was employed using a randomized block design, with data analyzed through unpaired *t*-tests and the Mann-Whitney test at a 95% confidence interval. Significant differences were observed in the acceptability of the floss regarding color, taste, and texture ($p<0.05$). In contrast, no significant difference was found in aroma ($p>0.823$) between the deep-fried (A1) and pan-fried (A2) samples. The *post-hoc* analysis revealed that deep-fried presto milkfish floss (A1) achieved the highest overall acceptability regarding color, taste, aroma, and texture. The deep-fried variant (A1) was preferred by the panelist and met the fish floss quality standards set by SNI 7690-1-2013. This variant was characterized by a yellowish-brown color, enhanced taste due to higher oil content, which determines the number of double bonds that will accelerate the oxidation rate, and a crunchier texture resulting from reduced moisture content, which also slowed microbial growth. The aroma was deemed pleasant and consistent with the ingredients used. Chemical analysis showed that the deep-fried presto milkfish floss (A1) contained 20.6 g of protein and 115.7 mg of calcium per 100 g. This composition contributes approximately 103% of the daily protein requirement and 17.8% of the daily calcium requirement for children aged two years.

Introduction

Milkfish is a prominent aquaculture commodity in Southeast Sulawesi, yet its smaller-sized variants are often less desirable due to numerous bones. Diversifying its processing methods is a promising strategy to enhance milkfish consumption within the community. This includes transforming the fish into more shelf-stable life products such as fish floss, presto milkfish, milkfish otak-otak, milkfish siomay, and others (Dewi *et al.*, 2019). However, processed milkfish products often face challenges related to their fishy and earthy odors and the presence of bones, which can adversely impact their organoleptic properties. Previous research suggests that natural ingredients like lime are effective in mitigating fishy and earthy smells in milkfish, while the use of presto cooking methods can soften the bones, improving the product's texture (Thalib *et al.*, 2019).

The deep-frying and pan-frying methods used in preparing fish floss significantly affect the oil and fat content of the final product, which is a concern for health-conscious consumers (Erickson, 2007). The quantity of oil used in these methods influences the number of double bonds in the oil, affecting the oxidation rate (Dewi *et al.*, 2011). Unlike popular fish such as salmon, which is rich in omega-3 and frequently consumed by pregnant women as a complementary food for breastfeeding (Middleton *et al.*, 2018), milkfish contains a higher level of omega-3 and calcium and is more cost-effective (Balai Pengembangan dan Penelitian Mutu Perikanan, 1996). Calcium in milkfish is essential for children's growth, as it supports bone and muscle development (Maulu *et al.*, 2021), while its protein content is essential for brain development, thereby enhancing cognitive function, especially during the critical period from conception to age two.

Previous studies have demonstrated that the organoleptic properties of fish floss can vary depending on the frying method. For example, Arkani (2017) reported significant differences in aroma, taste, and texture, but not in color, between deep-fried and pan-fried Nike fish floss. Additionally, variations in chemical quality, such as moisture, fat, and protein content, were observed, although ash content remained unaffected (Arkani, 2017). Tombo (2017) also found that deep-fried catfish floss was preferred by panelists in terms of color, taste, aroma, and texture. In contrast, pan-fried catfish floss exhibited better storage stability, avoiding rancidity over 29 days (Tombo, 2017). The research gap relates to the processing of shredded meat (abon) using the deep-frying method, which results in abon with lower water content, causing thermal destruction of microorganisms and enzymes, thus improving its shelf life. The large amount of cooking oil used during deep frying at high temperatures leads to faster heat distribution, causing evaporation of water in the food material, which is replaced by oil. This evaporation causes minerals to remain in the abon, resulting in higher ash and fat content compared to abon processed using the pan-frying method. However, the heat transfer through conduction in deep-fried abon causes protein damage.

This study aims to assess the acceptability, protein, and calcium content of presto milkfish floss (*Chanos chanos*) prepared using deep-frying and pan-frying methods, with the goal of developing a processed fish product that is more appealing to the community.

Materials and Methods

Research design

This study was a pre-experimental study with a completely randomized design in a 2×3 factorial arrangement. The first factor involved two frying methods: deep frying (A) and pan frying (B), while the second factor focused on the organoleptic properties, protein content, and calcium content of the samples. Each treatment was replicated three times.

Materials

The primary raw material used for producing the fish floss was fresh milkfish (*Chanos chanos*), sourced directly from local fishing areas. The milkfish samples were obtained from milkfish ponds in Bombana Regency, Southeast Sulawesi, approximately 147 km from Kendari City. The selected fish had an average length of 15 to 17 cm and a weight between 300 and 360 grams per fish. The processing location for the production of pressurized milkfish (*Chanos chanos*) floss was established in the Food Technology Laboratory of the Department of Nutrition at the Health Polytechnic of the Ministry of Health in Kendari. The spices incorporated in the preparation of the fish floss are detailed in Table 1.

Researchers aimed to investigate the benefits of milkfish, which contains significantly higher levels of omega-3 and calcium compared to salmon. Despite its nutritional advantages, milkfish is less popular among consumers and less suitable for children’s consumption due to its numerous bones. However, through food processing diversification, milkfish can attain high economic value. The calcium content in milkfish is a primary nutrient for children’s physical growth, as it is essential for bone and muscle development. Additionally, the protein in milkfish is crucial for brain function development, potentially enhancing children's cognitive abilities.

Processing of fish floss

The production of presto milkfish floss followed the method described by Suryani (2005). Initially, the milkfish were cleaned, gutted, and thoroughly washed. The fish were then pressure-cooked for 20 minutes to soften the bones. After cooking, the meat was manually shredded to achieve a fine texture. All spices except galangal and lemongrass were blended and sautéed with 10 mL of oil while continuously stirring. Galangal and lemongrass were added afterwards until a fragrant aroma developed. The shredded fish meat was gradually added to the sautéed spices, with continuous stirring to ensure even distribution until the mixture was nearly dry. For floss processed using the deep-frying method, the nearly dried mixture of shredded meat and spices was fried in hot oil at approximately 178°C until it reached a golden-brown color. The ratio of sliced meat to oil was 1:2, or until all the shredded meat was fully submerged in the oil. For floss processing with the pan-frying method, 10 mL of cooking oil (about two tablespoons) was added to the nearly dried mixture of shredded fish meat and spices, which was then fried over medium heat until it was completely dry and formed into floss. This process took about 45 minutes at around 122°C. Once the fish floss was prepared using both methods, it was pressed using a household manual press to remove excess oil. The floss was then dried in an oven, preheated by a gas stove for 15 minutes, and left to cool until all water vapor had evaporated. Finally, the dried fish floss was packed in polyethylene plastic bags and analyzed for sensory acceptability, protein, and calcium.

Organoleptic testing

Organoleptic testing refers to the evaluation of products based on human sensory perception. This study employed a preference or hedonic test to assess consumers' degree of liking or disliking of the product. The hedonic test measured acceptability using a scale ranging from "very much like" (score 4), "like" (score 3), "dislike slightly" (score 2), to "dislike" (score 1). The panelists who participated in this evaluation were 40 untrained students from the Department of Nutrition's DIV Program at the Health Polytechnic of Kendari. Data were collected using a hedonic test form with a 1-4 rating scale, assessing sensory attributes such as color, aroma, taste, and texture. The panelists participating in this evaluation consisted of 40 untrained students from the DIV Program in the Department of Nutrition at the Kendari Health Polytechnic. The sensory attributes tested in this study were texture, taste, aroma, and color. Descriptions of each sensory attribute were explained to the panelists before they conducted the organoleptic test.

Chemical analysis of presto fish floss prepared by deep frying and pan frying methods

The chemical analysis of presto fish floss prepared by deep-frying and pan-frying methods involved measuring macronutrient (protein) and micronutrient (calcium) content. Protein content was determined using the Kjeldahl method, while calcium levels were assessed using atomic absorption spectrophotometry. To ensure reliability, each measurement of protein and calcium for the fish floss processed by the two methods was conducted in triplicate. The samples to be analyzed are those selected based on the panelists' preference level.

Data analysis

The analysis of product acceptability was conducted using both quantitative and descriptive methods. The data were further analyzed using the Statistical Package for Social Science (SPSS) software. To evaluate differences between the treatments in terms of sensory attributes, color, aroma, taste, and texture, a paired *t*-test was performed with a significance threshold of 0.05. Additionally, a Mann-Whitney test was applied to identify differences among the four sensory attributes, also at a 0.05 significance level.

Results

The organoleptic evaluation focused on assessing panelists' preferences for the color, aroma, taste, and texture of the presto milkfish floss (*Chanos chanos*) processed using two different frying methods, deep frying, and pan frying. The final versions of presto milkfish floss processed by both deep frying and pan frying are presented in Figure 1.

Organoleptic evaluation of presto milkfish floss prepared by deep-frying and pan-frying methods

As shown in Table 2 and Figure 2, deep-fried milkfish floss (A1) received the highest acceptance scores from panelists across all organoleptic evaluation criteria: color, aroma, taste, and texture. The deep-fried product (A1) was deemed acceptable from a sensory standpoint, being preferred by panellists and conforming to the quality standards for fish floss outlined in the Indonesian National Standard (SNI) 7690-1-2013. It was characterized by a brownish-yellow color, a richer taste due to higher oil content (which influences the number of double bonds and the rate of oxidation), a crunchier texture resulting from lower moisture content that inhibits microbial growth, and a pleasant aroma consistent with the spices used. Moreover, the deep-fried milkfish floss (A1) exhibited a higher oil absorption rate, which affects the number of double bonds and consequently accelerates the oxidation process. Its lower moisture content also contributes to a slower rate of microbial growth. Statistical analysis revealed a significant difference between the two products ($p<0.05$). Consequently, it is recommended that the deep-fried milkfish floss (A1) be promoted as a processed fish product with potential acceptance by consumers.

Protein and calcium content analysis of presto milkfish floss processed by deep frying
According to the Indonesian Industry Standard (SII) for fish floss No. 0368-800368-85 (Junianto *et al.*, 2024), the protein content required for fish floss is 20%, but no standard for calcium content is specified. Meanwhile, the quality standard for fish floss as per SNI 7690-1-2013 requires a minimum protein content of 30%, without calcium requirements. As presented in Table 3, the protein and calcium content of deep-fried milkfish floss (A1) suggests that it is a suitable product for providing high-quality fish-based nutrition, particularly for children aged 2 years. The product delivers 103% of the recommended dietary allowances (RDA) for protein and 17.8% of the RDA for calcium. For reference, an average portion of animal-based food (50 g) contains at least 7 g of protein. Therefore, the deep-fried milkfish floss (A1) aligns with the protein and calcium standards set by both SII and SNI for fish floss. For future product enhancement, it is suggested to explore the incorporation of additional calcium-rich ingredients such as eggshells, shellfish, or shrimp shells to increase the calcium content of the deep-fried milkfish floss (A1).

Discussion

Color is a critical attribute influencing consumer acceptance or rejection of a product, as it is often the first characteristic evaluated both subjectively and visually. In the organoleptic assessment of milkfish floss (*Chanos chanos*) processed using deep frying (A1) and pan frying (A2) methods, the highest panelist preference was recorded for the A1 product. This product was more favored than the A2 product, primarily due to its appealing brownish-yellow color, compared to the less desirable pale yellow of A2. The brownish-yellow hue of the A1 milkfish floss is a result of the Maillard reaction between amino acids and reducing sugars during frying, which contributes to the browning effect (Mustar, 2013). The statistical analysis revealed a significant difference in the color attributes between the two products ($p=0.006$).
This study aligns with the findings of Tombo (2017), which indicated that catfish floss prepared by deep frying was preferred by panelists in terms of color, aroma, taste, and texture compared to catfish floss made using the pan-frying method. Similarly, deep-fried milkfish floss received higher preference from panelists than roasted milkfish floss (Fahmi and Purnamayati, 2020). The deep-frying technique involves the use of cooking oil as a medium for heat transfer, which gets absorbed into the fish, filling its pores, and leading to notable changes in the texture, color, and flavor of the milkfish floss (Susanty *et al.*, 2019).
Aroma, another important attribute, is strongly influenced by the volatile compounds formed during cooking processes like deep frying and pan frying, which create distinctive profiles that appeal to consumers. The organoleptic assessment of the aroma of milkfish floss prepared by both deep-frying (A1) and pan-frying (A2) methods showed that panelists equally liked both products due to their pleasant aroma. The fragrant aroma of milkfish floss is believed to originate from the spices added to the floss. The spices used as seasonings are primarily chosen for their sufficient content of oleoresins and essential oils, as these two components create the desired distinctive flavor and aroma. Therefore, the spices used for seasoning must be sufficiently mature to ensure optimal levels of oleoresins and essential oils. This similarity is attributed to the changes in specific oil compounds and the caramelization of sugars during both frying processes, which produce a distinctive aroma (Mustar, 2013). The lack of difference in aroma between the two methods is likely due to the identical spice formulations used for both types of floss, with the pleasant aroma mainly resulting from the added spices. Statistical analysis supports this finding, as there was no significant difference in aroma attributes between the deep-fried and pan-fried products

(p=0.823). This observation is consistent with the results of (Fahmi and Purnamayati, 2020), who found that the aroma of deep-fried and roasted milkfish floss was equally preferred by the panelists.

The panelists rated the taste of the presto milkfish floss prepared by deep frying (A1) higher than that of the pan-frying version (A2), with the A1 product having a more savory flavor. This enhanced taste is attributed to the absorption of oil during deep frying, which increases the fat content and contributes to the savory quality of the floss. The statistical analysis revealed a significant difference in taste between the two products (p=0.025). The deep-frying process also induces the Maillard reaction, which alters the sensory characteristics of the milkfish floss by enhancing flavor and aroma. However, in some food products, the Maillard reaction can have negative effects, such as reducing the solubility of proteins (Renol *et al.*, 2020).

Texture plays a crucial aspect of food quality, often considered more influential than aroma, taste, or color. It plays a significant role in the overall flavor perception of a product. Changes in the texture can alter the taste and aroma, affecting the rate at which these stimuli are perceived by the salivary glands. In this study, the panelists rated the texture of the milkfish floss prepared by deep frying (A1) higher than that of the pan-fried version (A2), with the A1 product having a crunchier texture. The statistical analysis showed a significant difference in texture between the two products (p=0.013). The crunchiness of the A1 floss is attributed to the deep-frying process, which causes the fish product to undergo complete dehydration, forming internal pores that result in a drier texture. The use of cooking oil as a heat transfer medium during deep frying, which is absorbed into the fish, contributes to changes in texture, color, and flavor (Susanty *et al*., 2019).

While sensory acceptance is an essential factor in determining the preference of panelists, the nutritional profile, particularly the protein and calcium content, offers benefits that make this product valuable as a dietary option. The protein content of the deep-fried milkfish floss (A1) in this study was found to be 20.6%, meeting the minimum protein content standard of 20% as specified by the SII. High protein foods like fish-based products provide a substantial source of essential amino acids, which are necessary for human health, particularly in children during their developmental stages (Jensen *et al.*, 2023). Studies indicated that fish-based foods positively affect child growth and nutritional status over time (La Banudi *et al.*, 2024).

Calcium is another vital nutrient that is crucial for bone health, muscle function, and overall metabolic processes. The calcium content of the deep-fried milkfish floss (A1) was recorded at 115.7 mg per 100 g, contributing significantly to the recommended dietary intake, particularly in young children. The importance of calcium intake during early childhood cannot be overstated, as it supports bone mineralization and reduces the risk of developing osteoporosis later in life (Weaver *et al*., 2016). Fish-based foods are an excellent source of bioavailable calcium, especially when bones are included in the preparation. Additionally, calcium absorption from fish is often more efficient than from plant-based foods due to the presence of fewer inhibitors such as oxalates and phytates (Bourassa *et al*., 2022; Shkembi and Huppertz, 2022).

This study has several limitations that should be acknowledged. Firstly, we focused on a single fish species, namely milkfish (*Chanos chanos*), which may limit the generalizability of our findings to other fish species. Future research should consider including a diverse range of fish species to provide a more comprehensive understanding of mineral content across different aquatic organisms. Secondly, our analysis was limited to the examination of calcium levels, which, while crucial for bone density, represents only one aspect of the complex mineral profile that contributes to skeletal health. Additionally, expanding the scope of the research to include other nutritional components, such as vitamin D and protein content, could offer valuable insights into the overall contribution of fish consumption to skeletal health. This multi-faceted approach would provide a more holistic view of the nutritional benefits of fish and its potential impact on bone density and strength.

Conclusions

The presto milkfish floss (A1) produced using the deep-frying method was preferred by the panelists due to its appealing brownish-yellow color, savory flavor, and crunchy texture. However, its aroma was similar to that of the milkfish floss prepared by the pan-fried method (A2), likely due to the identical spice formulation used for both products. The chemical analysis of the A1 fish floss revealed a protein content of 20.6 g and a calcium content of 115.7 mg per 100 g. This product is recommended as a fish-based food rich in protein and calcium, particularly suitable as an alternative source of animal protein for young children (aged 2 years), providing 103% of the RDA for protein and 17.8% of the RDA for calcium per 100 g. According to the quality standards established by the SNI and SII, the deep-fried presto milkfish floss (A1) meets the required protein and calcium levels for fish floss products. For future development, it is suggested to incorporate ingredients that are high in calcium, such as eggshells, seashells, or shrimp shells, to further enhance the calcium content of the deep-fried presto milkfish floss.

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 A1 (Milkfish floss with deep frying method)	 A2 (Milkfish floss with pan frying)

Figure 1. Final products of milkfish floss processed by deep-frying (A1) and pan-frying (A2) methods.

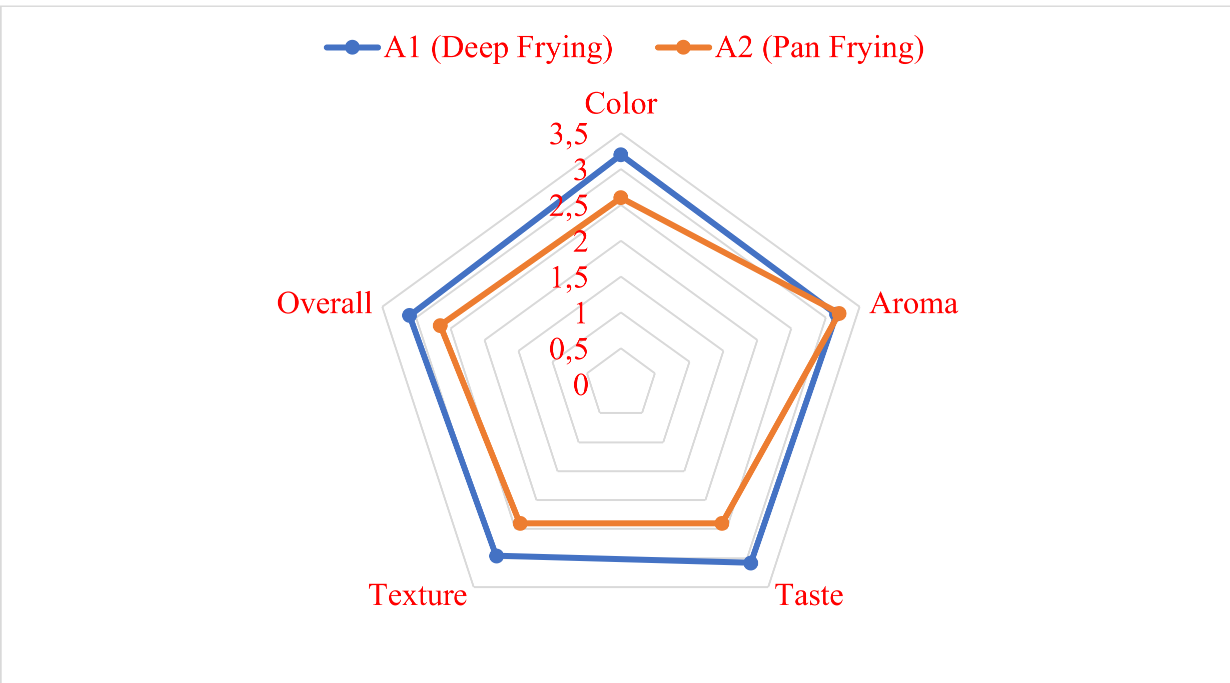

Figure 2. Organoleptic evaluation based on all aspects of presto milkfish floss prepared by deep-frying and pan-frying methods.

Table 1. Composition of spices used in the processing of presto milkfish floss per kilogram of shredded fish meat.

Spices	Percentage (weight of spices per weight of shredded fish meat)	Weight (g)
Shallots	0.250	2.5
Garlic	0.830	8.3
Candlenut	0.410	4.1
Coriander	0.230	2.3
Salt	1.420	14.2
Sugar	4.167	41.67
Galangal	0.333	3.33
Ginger	0.250	2.5
Tamarind	0.080	0.8
Turmeric	0.167	1.67
Bay leaves	0.025	0.25
Lemongrass	0.167	1.67

Table 2. Organoleptic evaluation based on all aspects of presto milkfish floss prepared by deep-frying and pan-frying methods.

Milkfish floss product	Color	Aroma	Taste	Texture	Mean±SD
A1 (deep-frying)	3.20 ± 0.71^{a}	3.16 ± 0.69^{a}	3.08 ± 0.86^{a}	2.96 ± 0.79^{a}	3.10 ± 0.76^{a}
A2 (pan-frying)	2.60 ± 0.82^{b}	3.20 ± 0.71^{a}	2.40 ± 1.08^{b}	2.40 ± 0.71^{b}	2.65 ± 0.89^{b}

Similar letters (a, b) indicate no significant difference at the 5% significance level (Mann-Whitney test). SD, standard deviation.

Table 3. Protein and calcium content analysis of presto milkfish floss per 100 g prepared by deep frying (A1).

Parameter	Milkfish floss (A1)	RDA	Percentage of RDA
Protein	20.6%	20 g	103
Calcium	115.7 mg	650 mg	17.8

RDA, recommended dietary allowances.