

# The addition of Moringa leaf flour (*Moringa oleifera*) to anchovy nuggets (*Stolephorus* sp.) as an alternative nutritious snack, its effect on chemical and sensory characteristics

Sulistyo Prabowo<sup>1\*</sup>, Intan Purnamasari Surya<sup>1</sup>, Yulian Andriyani<sup>1</sup>, Yuliani<sup>1</sup>, Adhian Dini Khoirina<sup>1</sup>

<sup>1</sup>Agricultural Products Technology Study Program, Faculty of Agriculture, Mulawarman University, Samarinda, East Kalimantan, Indonesia 75119

**Abstract.** Nuggets are a popular snack food typically made from meat or fish and are quite popular due to their practicality and easy acceptance by consumers. Unfortunately, the nutritional content of nuggets on the market is still unbalanced, necessitating innovation. Anchovies are a readily available source of protein, iron, and calcium at an affordable price. Moringa leaves have long been recognized as a healthy food ingredient. This study aimed to determine the effect of adding moringa leaf flour on the chemical and sensory characteristics of anchovy nuggets. This study used a completely randomized design with three replications. The data obtained were analyzed using analysis of variance and further tested using the Tukey test at the 5% level. The chemical characteristics observed included moisture, ash, protein, iron, and calcium content. Meanwhile, sensory characteristics were assessed using a consumer acceptance test. The results showed that the addition of moringa leaf flour significantly affected moisture, ash, protein, iron, and calcium content, as well as consumer acceptance (color, aroma, texture, and taste). The results showed that the addition of moringa leaf flour generally increased the nutritional value of the nugget product, particularly in terms of protein, minerals, and calcium. However, consumer preference decreased with increasing amounts of moringa leaf flour. In this study, the preference for anchovy nuggets also fell below the median. The addition of moringa leaf flour affected the chemical and sensory characteristics of anchovy nuggets.

**Keywords:** anchovy fish, moringa leaf, nugget, snack

## 1. Introduction

Adolescence is a transitional stage from childhood to adulthood. During this period, individuals experience growth and development to achieve mental, emotional, social, and physical maturity. The condition of adolescents is largely determined by their nutrition and health during adolescence. Therefore, nutrition and health are major factors in determining the quality of adolescence. During adolescence, nutritional problems that can occur include malnutrition, overnutrition, and obesity [1]. One of the major contributing factors to the rising prevalence of malnutrition, overnutrition, and obesity among adolescents is the frequent consumption of fast food, which is typically low in essential nutrients but high in saturated fats, calories, and various additives such as preservatives and synthetic colorants. Such dietary habits can gradually deteriorate the quality of daily nutrient intake and exert adverse long-term effects on health, including an increased risk of degenerative diseases and metabolic disorders. Therefore, it is essential to promote the development of alternative processed food products that are healthier, nutritionally balanced, and remain acceptable and appealing to consumers [2].

Nuggets are a very popular snack food and are liked by many people, from children to adults. Most nuggets currently available on the market are primarily made from chicken or beef, processed with the addition of fillers, binders, and synthetic flavor enhancers. This formulation often results in an unbalanced nutritional profile high in fat, salt, and cholesterol, yet relatively low in high-quality protein and essential micronutrients. Furthermore, the fluctuating prices of main raw materials such as chicken and beef contribute to increased production costs and, consequently, higher market prices of the final product.

Anchovies (*Stolephorus* sp) are a highly valuable fishery commodity containing protein, minerals, and other nutrients that are very beneficial to health, especially variety of essential amino acids [3]. Anchovies

\* Corresponding author: [sprabowo@faperta.unmul.ac.id](mailto:sprabowo@faperta.unmul.ac.id)

have the advantage of being edible in their entirety, including their bones, making them a source of protein, calcium, and iron. In addition to anchovies, moringa leaves are also highly nutritious. Moringa leaves (*Moringa oleifera*) have quite complex nutritional content. The organic compounds contained in moringa leaf flour are 6.8 g of protein, 6.78 mg of  $\beta$ -carotene, 7 g of minerals, mainly iron, 70 mg of phosphorus, and 220 mg of vitamin C [4].

Nuggets are a popular food product among consumers because they are easy to prepare. Nuggets are processed products made using restructuring technology, which involves using small, irregular pieces of meat. These pieces are then bound together into larger pieces using binding agents. Nuggets are generally made from chicken meat, although there are also some fish nugget processing industries, although they are not as numerous as chicken nugget industries [5]. Given the nutritional limitations of commercial nuggets, it is necessary to develop innovative products that are more nutritious, affordable, and based on locally available food resources. One promising alternative ingredient is anchovy (*Stolephorus sp.*). Anchovies are an abundant source of animal protein in Indonesia, easy to obtain, and contain high levels of protein, calcium, phosphorus, and omega-3 fatty acids, which are beneficial for growth and bone health. Moreover, the utilization of anchovies as raw material for processed food products can support the diversification of fishery-based products while increasing the added value of local fish catches and improving the economic welfare of small-scale fishermen [6].

To further enhance the nutritional and functional quality of the nuggets, anchovies can be combined with moringa leaves. Moringa leaves are widely recognized as a “superfood” due to their richness in vitamins A, C, and E, iron, calcium, and natural antioxidants, which play vital roles in maintaining immune function and protecting the body against oxidative stress [7]. The incorporation of moringa leaf powder into anchovy-based nugget formulations is expected to improve the product’s color, aroma, and nutritional profile without compromising its sensory acceptability among consumers.

## 2. Materials and methods

### 2.1. Material

The ingredients used in this study were anchovies, moringa leaf flour, wheat flour, tapioca flour, bread flour, garlic, eggs, salt, chicken bouillon powder, granulated sugar, white pepper powder, and cooking oil. The materials used in the chemical analysis were  $H_2SO_4$ , distilled water, Kjeldahl apparatus, 50% NaOH,  $H_3BO_3$ , methyl red, methyl blue,  $K_2S_2O_8$  (potassium persulfate), KSCN (potassium thiocyanate),  $HNO_3$  (nitric acid),  $(NH_4)_2C_2O_4$  (ammonium oxalate), and  $NH_4OH$  (sodium hydroxide). The tools used in this study were spoons, bowls, pots, basins, choppers, digital scales, and plastic gloves. The tools used in chemical analysis were a furnace, oven, spectrophotometer, hot plate, analytical balance, clamps, desiccator, Bunsen burner, Kjeldhal flask, 10 mL measuring flask, 250 mL Erlenmeyer flask, 100 mL Erlenmeyer flask, Soxhlet, condenser, distillation apparatus, measuring cups, burettes, filter paper.

### 2.2. Research method

This study used a completely randomized design (CRD) with one factor, namely, a comparison of moringa leaf flour additions with five treatments of 0 g, 3 g, 6 g, 9 g, and 12 g. Each treatment was repeated three times. The parameters observed were consumer acceptance tests and chemical analysis consisting of moisture, ash, protein, iron, and calcium content. The data obtained was analyzed using the *Analysis of Variance* (ANOVA) program. If the calculated F was greater than the table F, the analysis was continued with a Tukey post hoc test at a 5% level. Meanwhile, the data obtained from the acceptance test with 40 untrained panelists was analyzed using the Dunt test. All statistical data obtained were processed using MS. Excel and analyzed using the SigmaPlot Ver 15 data processing software application.

### 2.2.1. Consumer acceptance test

Consumer acceptance test in this study was conducted by 40 untrained panelists. The samples were presented in plastic containers that had been coded with three random numbers. Before conducting the assessment, the panelists were given an explanation of the testing procedure that would be carried out on the nugget products. Next, the panelists were given an assessment form using a 9-point rating scale with (9) = really like it, (8) Like it a lot, (7) Like it, (6) Somewhat like it, (5) Neutral, (4) Somewhat dislike it, (3) Dislike it, (2) Really dislike it, and (1) Really dislike it. In this study, panelists were asked to evaluate attributes including color, aroma, texture, and taste. After completing the taste test on each sample, panelists were asked to neutralize the taste using drink plain water and pause for about 10 seconds before continuing to the next sample [8].

### 2.2.2. Moisture content analysis

Moisture content testing was carried out using the “gravimetry” principle. The research procedure began by heating the porcelain dish in an oven at 105°C for 30 minutes, then cooling it in a desiccator. After that, the porcelain dish was weighed and recorded as the empty dish weight. The nugget sample was weighed at 2 g in a porcelain dish that had been weighed empty. The porcelain dish containing the sample was placed in an oven at 105°C for 5 hours. The sample was cooled in a desiccator for 15 minutes, then weighed [9]. Weighing was carried out until a constant weight was obtained. The content was calculated using the following formula:

$$\% \text{ moisture content} = \frac{B - C}{B - A} \times 100 \%$$

Description:

A: Weight of empty dish (g)

B: Weight of dish + sample before drying (g)

C: Weight of dish + sample after drying (g)

### 2.2.3. Ash content analysis

A total of 2 g of sample was weighed. It was then placed in a furnace at 650°C until completely incinerated. The sample was then cooled using a desiccator for approximately 30 minutes and weighed until a constant weight was obtained [10]. The ash content was calculated using:

$$\% \text{ ash content} = \frac{\text{ash weight (g)}}{\text{sample weight (g)}} \times 100 \%$$

### 2.2.4. Protein content analysis

Weigh 0.1 g of sample, add 2.5 ml of concentrated H<sub>2</sub>SO<sub>4</sub> and 1 g of catalyst to a Kjeldahl flask. Then destroy the sample in an acid cabinet until the solution becomes clear green. After cooling, add 50 ml of distilled water, 10 ml of 50% NaOH solution and 5 boiling chips. Distill the solution and collect the distillate in a 100 ml Erlenmeyer flask containing 10 ml of 0.1 N HCl solution, then add a few drops of PP indicator. Collect 40 ml of distillate. Titrate the solution obtained with 0.1 N NaOH until it turns pink [11]. Titration was also performed on the blank.

$$N (\%) = \frac{(\text{ml HCL material} - \text{ml blank}) \times 14,007 \times 100}{\text{mg sample}}$$

$$\text{Protein content (\%)} = \%N \times \text{conversion factor (6,25)}$$

### 2.2.5. Iron content analysis

Weigh 5 g of the sample that has been ground in a porcelain crucible, then ash it in a muffle furnace until it turns to ash. Dissolve the ash using 25 ml of 1:3 HNO<sub>3</sub> while grinding it in a porcelain mortar, then filter it using filter paper. Collect the filtrate using filter paper into a 100 ml Erlenmeyer flask. Add 1 ml of clear filtrate to 2 ml of 1.5 M ammonium thiocyanate. If the sample contains iron (Fe), the color of the solution will turn red. Then the absorbance is read using a spectrophotometer with a wavelength of 510 nm [12]. The data obtained is recorded and calculated using an iron standard curve.

$$Fe = \frac{\text{Absorbance (ppm sample)} \times 10 \times 100}{\text{sample weight (g)} \times 1000}$$

### 2.2.6. Calcium content analysis

Calcium content analysis using the permanganometric titration method. A total of 1 g of dry sample was incinerated at a temperature of 550°C ± 5 hours. After that, the sample is placed in a 250 mL Erlenmeyer flask, then 50 mL of distilled water, 10 mL of ammonium oxalate solution, and 2 drops of methyl red indicator are added. The solution was made slightly alkaline by adding dilute ammonia, then made slightly acidic by adding a few drops of acetic acid until the solution turns pink (pH 5). The mixture was heated to boiling point and then left at room temperature overnight. The mixture then filtered using Whatman No. 42 filter paper and washed several times with distilled water until the filtrate free of oxalate. Next, the precipitate was transferred to another Erlenmeyer flask by piercing the tip of the filter paper with a glass stirrer, then washed and dissolved with hot sulfuric acid. The solution was titrated while still warm (70-80°C) with a 0.01 N standard KMnO<sub>4</sub> solution for 15 seconds until a pink color first appears in the solution. A piece of filter paper was inserted and the titration continued until the pink color first appears and lasts for 15 seconds [13]. The calcium content calculated based on the volume of KMnO<sub>4</sub> standard solution used for titration using the following formula:

$$\text{calcium (\%)} = \frac{V_{KMnO4} \times N_{KMnO4} \times 20 \times 100\%}{\text{mg sample}}$$

## 2.3. Results and discussion

The results of observations on anchovy nuggets with added moringa leaf powder were conducted on two main variables, namely sensory characteristics and chemical content. The anchovy nuggets produced in this study are presented in Figure 1.

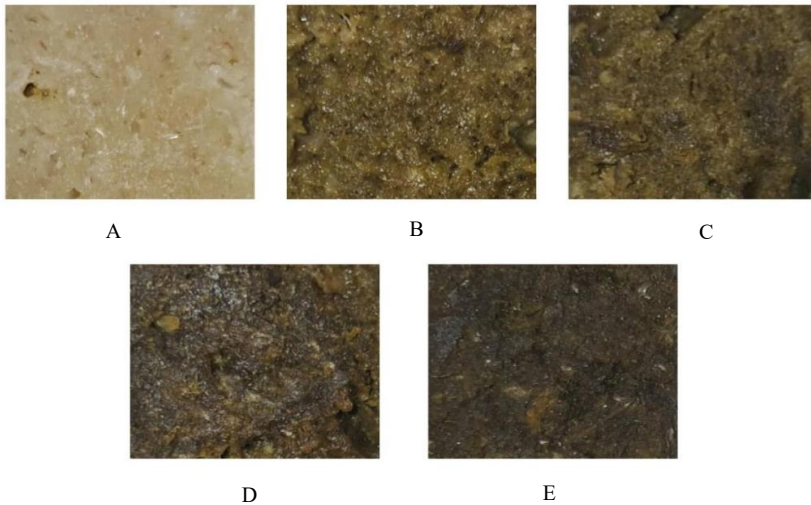


Figure 1. Samples of Anchovy Nuggets, A=F0 (0 g moringa leaves), B=F1 (3 g moringa leaves), C=F2 (6 g moringa leaves), D=F3 (9 g moringa leaves), E=F4 (12 g moringa leaves)

### 2.3.1. Sensory characteristics

In this study, the parameters used were the panelist’s level of preference (hedonic scale) for the color, aroma, texture, and taste of anchovy nuggets with added moringa leaf powder. The panelists used in this study consisted of 40 semi-trained panelists. They tested the hedonic level of several formulations with different sensory profiles. These differences can be seen in the parameters of color, aroma, taste, and texture. The results of the hedonic level test can be seen in Table 1.

Table 1. The hedonic test score of formulated nugget

Formula	Color	Aroma	Texture	Flavor
F0 (0 g)	5.04±0.14 <sup>b</sup>	5.34±0.15 <sup>a</sup>	5.67±0.05	5.54±0.14 <sup>a</sup>
F1 (3 g)	5.15±0.09 <sup>a</sup>	5.45±0.20 <sup>a</sup>	5.77±0.19	5.44±0.42 <sup>a</sup>
F2 (6 g)	5.03±0.05 <sup>b</sup>	5.35±0.09 <sup>ab</sup>	5.76±0.13	5.39±0.07 <sup>b</sup>
F3 (9 g)	4.92±0.14 <sup>c</sup>	5.21±0.23 <sup>c</sup>	5.65±0.14	5.38±0.35 <sup>b</sup>
F4 (12 g)	4.27±0.64 <sup>c</sup>	4.74±0.21 <sup>c</sup>	5.44±0.04	4.44±0.14 <sup>c</sup>

Note: Data (mean±SD) is data obtained from sensory test questionnaires that has been converted into interval data.

#### 2.3.1.1. Color

In this study, the color of anchovy-based nuggets showed noticeable variation among treatments with different levels of moringa leaf powder addition (0 g, 3 g, 6 g, 9 g, and 12 g). The sensory evaluation revealed that all formulations received an average score around “Somewhat dislike it” (4), indicating that increasing moringa leaf powder concentration did not significantly affect the overall color preference of panelists. The addition of moringa leaf powder imparted a greenish hue to the interior of the nuggets, and this coloration intensified with higher fortification levels [14]. This phenomenon is attributed to the high chlorophyll content naturally present in moringa leaves, which acts as a dominant green pigment. At high concentrations, chlorophyll accumulation can cause the nugget color to shift from light green to dark green or even blackish tones [15]. Syahfitri & Susanti [16], reported that dried moringa leaves contain approximately 162 mg of chlorophyll per 8 g, which explains the pronounced pigmentation effect observed at higher inclusion levels.

From a consumer perspective, color preferences are generally associated with familiar visual cues of product quality. Nuggets with a yellowish-white or light-green color are typically considered more appealing, while those exhibiting darker or blackish tones are perceived as less appetizing and may reduce visual acceptance [16]. These findings suggest that, although moringa leaf powder contributes valuable nutrients and bioactive compounds, its concentration in nugget formulations should be optimized to maintain consumer-preferred color characteristics. Balancing nutritional enhancement with sensory acceptability remains a crucial consideration in developing moringa-fortified anchovy nuggets.

### 2.3.1.2. Aroma

The aroma of anchovy-based nuggets with varying levels of moringa leaf powder addition showed significant differences among treatments. Nuggets formulated with 0 g, 3 g, 6 g, and 9 g of moringa leaf powder received an average sensory score of “Somewhat dislike it” (4), whereas the addition of 12 g resulted in a “neutral” score (5). This finding indicates that the incorporation of moringa leaf powder influenced the aroma characteristics of anchovy nuggets. The addition of moringa leaf powder was found to reduce the typical fishy odor of anchovy without diminishing its characteristic taste, thereby improving consumer acceptance of the product’s aroma. However, as the concentration of moringa leaf powder increased, a distinct beany or grassy odor began to develop. Conversely, higher anchovy content enhanced the savory aroma, making the product more appealing to consumers [17].

According to Stalterfoht, *et.al* [18], the beany odor associated with moringa leaves is primarily caused by the enzyme lipoxxygenase, which catalyzes the oxidation of polyunsaturated fatty acids into volatile compounds responsible for undesirable odors. A study by Habsari, *et.al*. [19] reported that nuggets containing a blend of 75% anchovy and 25% moringa leaf received the highest aroma scores from panelists, suggesting that moderate inclusion levels optimize sensory balance. In contrast, Prasasti, *et.al*. [20] found that mackerel nuggets containing 10–20% moringa leaf powder did not exhibit significant differences in aroma intensity. Therefore, selecting an appropriate proportion of moringa leaf powder is essential to maintaining a pleasant and acceptable aroma profile for consumers.

### 2.3.1.3. Texture

The texture of anchovy-based nuggets with varying concentrations of moringa leaf powder showed significant differences among treatments. Nuggets formulated with 0 g, 3 g, 6 g, and 9 g of moringa leaf powder received an average sensory score of “neutral” (5), whereas the addition of 12 g resulted in a “Somewhat dislike it” score (4). In this study, moringa leaf powder functioned as a binding agent and a dietary fiber source that influenced the structural and physical properties of the nuggets. A small amount of moringa leaf powder improved the texture of the product; however, higher concentrations tended to decrease texture scores. This may be attributed to the high fiber content in moringa leaves, which binds water within the dough matrix and affects the elasticity of the nuggets [15].

According to Aristika, *et.al*. [21], increasing the concentration of moringa leaf powder leads to a greater interaction between water and flour components, facilitating gel formation. Moringa leaves contain approximately five times more fiber than most common vegetables. The presence of non-polysaccharide compounds in moringa leaf powder also supports the development of a more compact structural network, influencing the firmness and cohesiveness of the nugget texture. This finding aligns with Puyanda, *et.al*. [22], who observed that increasing the proportion of moringa leaf powder in *tempeh* formulations resulted in more visible green specks and a denser texture. Texture is one of the key sensory attributes that can be evaluated through tactile perception, encompassing parameters such as softness, chewiness, and firmness, which directly contribute to consumer acceptability.

### 2.3.1.4. Flavor

The sensory evaluation of taste in anchovy-based nuggets fortified with moringa leaf powder showed significant differences among treatments. Panelists rated the samples containing 0 g, 3 g, 6 g, and 9 g of moringa leaf powder with an average score of “Somewhat dislike it” (4), while the 12 g treatment received a “dislike it” score (3). The addition of moringa leaf powder had a significant impact on the flavor profile of the nuggets, potentially contributing to bitter or astringent notes that were less preferred by consumers. As the concentration of moringa leaf powder increased, the overall taste acceptability tended to decrease. This

effect may be attributed to the presence of tannins in moringa leaves, which are known to impart bitterness. Tannins interact with proteins or glycoproteins in the mouth, forming complexes that trigger sensations of astringency, dryness, and puckering on the tongue and oral cavity [23]. Furthermore, certain strong-flavored compounds in moringa leaves may alter the natural taste characteristics of the product, thereby reducing consumer acceptance of anchovy nuggets.

Low to moderate levels of moringa leaf powder are generally acceptable to consumers; however, higher concentrations tend to reduce taste scores due to increasing bitterness. Solichah, *et.al.* [24] reported that catfish nuggets formulated with 5–15% fresh moringa leaves did not show significant differences in taste among treatments, although panelists expressed a preference for the control sample (without moringa). Similarly, Elbarbary, *et.al.* [25] found that in fish burgers, a concentration of 2% moringa leaf powder already led to a decrease in sensory ratings compared to 1%, indicating a sensory acceptance threshold. This suggests that flavor tolerance depends on both the type of fish used and the form of moringa material incorporated (fresh, powdered, or extract).

The hedonic test results showed that there was a significant difference in the panelists level of preference for the treatments tested. On the treatment assessment scale, the addition of 3 g of moringa leaf powder received the highest score for color, aroma, and texture. This shows that this treatment was most preferred by the panelists. Formulation F0 (0 g moringa leaf powder) had the highest score for the taste parameter. The significant differences between these formulations indicate that the composition of the raw materials and the process have a major influence on the sensory profile.

Formulation F1 (3 g moringa leaf flour) had the most similar sensory profile to the control, especially in terms of color, aroma, and texture. This was because the composition of moringa leaf flour added was less than in the other formulations. According to the study Negara *et.al.* [17], the higher the addition of moringa leaf powder, the lower the panelists' preference for color, aroma, and texture.

### 2.3.2. Chemical characteristics

The addition of moringa leaf flour has a significant effect on moisture content, ash, protein, iron, and calcium as depicted in Table 2 below.

Table 2. The effect of moringa leaf flour formula on chemical properties of nugget

Formula	Moisture content (%)	Ash content (%)	Protein content (%)	Iron content (%)	Calcium content (%)
F0 (0 g)	43.89±0.76 <sup>a</sup>	2.31±0.09 <sup>a</sup>	9.91±0.09 <sup>a</sup>	0.76±0.20 <sup>a</sup>	0.02±0.00 <sup>ab</sup>
F1 (3 g)	43.28±1.70 <sup>a</sup>	2.16±0.05 <sup>b</sup>	10.27±0.13 <sup>a</sup>	1.09±0.10 <sup>a</sup>	0.02±0.00 <sup>b</sup>
F2 (6 g)	40.24±1.10 <sup>b</sup>	2.32±0.08 <sup>a</sup>	11.98±0.11 <sup>b</sup>	1.19±0.02 <sup>b</sup>	0.02±0.00 <sup>b</sup>
F3 (9 g)	40.39±0.68 <sup>b</sup>	2.28±0.08 <sup>b</sup>	12.62±0.25 <sup>c</sup>	1.22±0.01 <sup>b</sup>	0.03±0.00 <sup>a</sup>
F4 (12 g)	39.72±0.99 <sup>b</sup>	2.16±0.00 <sup>c</sup>	13.34±0.05 <sup>d</sup>	1.23±0.00 <sup>c</sup>	0.04±0.01 <sup>a</sup>

Note: Data (mean±SD) were obtained from 3 replicates. Data were analyzed using ANOVA. Data in the same column followed by different letters indicate significant differences ( $p < 0.05$ , Tukey's test).

#### 2.3.2.1. Moisture content

Water plays an important role in foodstuffs. The level of water content in a foodstuff can affect the quality and shelf life of the product. Water content is one of the important characteristics of foodstuffs, because water can affect the appearance, taste, and texture of foodstuffs [26]. Based on Table 2, the moisture content of anchovy nuggets ranges from 39.72 to 43.89%. Differences in moisture content may be due to differences in the formulation of moringa leaf flour added during the production of fish nuggets. According to Rahmawanti *et al.* [27], moringa leaf flour has a moisture content of 4.09%, while wheat flour has a moisture content of 13.5%. The high fiber content in moringa leaf powder (approximately 19.2 g/100 g) exhibits hydrophilic properties, enabling it to bind water effectively [28]. This characteristic allows the water in the dough to become trapped and less likely to evaporate during the cooking process. The water molecules bound to the hydrophilic groups of moringa leaf fiber are more difficult to remove during drying or cooking, thereby contributing to improved water retention in the final product [29]. Thus, adding less wheat flour will reduce the moisture content of the fish nuggets. In this study, the highest moisture content in treatment P0 was 43.89%, which is in line with previous studies which shows that fish nuggets without the addition of moringa

leaf puree had the highest moisture content of around 40.8%. This value still meets the water content requirements according to SNI of a maximum of 60.0% [30].

#### **2.3.2.2. Ash content**

Ash content is an indicator of mineral content in a food ingredient. Moringa leaves are rich in minerals, such as calcium, potassium, magnesium, and iron [31]. The ash content test results in Table 2 show that the average ash content in the treatment ranged from 2.16% to 2.32%. This indicates that the more moringa leaf powder added to all treatments, the higher the ash content of the resulting fish nuggets due to the mineral content. This is in line with the research by Rahmawanti et al. [27], which shows that the formulation of moringa leaf powder in all treatments indicates that the more moringa leaf powder added, the higher the ash content in the resulting fish nuggets. This is also due to the supporting ingredients used in the study, such as eggs, onions, salt, and pepper, which affect the ash content of fish nuggets because each of these supporting ingredients has different mineral content [32].

#### **2.3.2.3. Protein content**

Protein is an important macronutrient that serves as the main source of nitrogen and essential amino acids. Essential amino acids cannot be synthesized by the body and must be obtained from food [33]. The protein content in Table 2 shows that sample P4 has a high protein content compared to sample P0. In this study, the protein content increased due to the high protein content in moringa leaves. Moringa leaves contain 25-30% protein, with complete and easily digestible essential amino acids [31]. In addition, the increase in protein content can also be influenced by the functional properties of proteins in moringa leaves, which can play a role in forming product structure and increasing nutrient retention during the processing [34]. This is in line with Fahlia [35] research, which shows that the addition of moringa leaf flour to snack bars has a significant effect on protein content, even though the increase is relatively small.

#### **2.3.2.4. Iron content**

The results of the iron content test in Table 2 show that sample P4 is the nugget with the highest iron content compared to the other samples. The addition of moringa leaf powder can increase the iron content sequentially. These results show that the more moringa leaf powder is added, the higher the iron content in the nuggets. The addition of moringa leaf powder can increase the iron content in nuggets, due to the high natural iron content in moringa leaves. This is in line with research Gopalakrishnan *et al.* [31] which states that moringa leaves are rich in minerals, especially iron, which plays an important role in the formation of hemoglobin and the prevention of anemia.

#### **2.3.2.5. Calcium content**

The calcium content in Table 2 shows that P4 has the highest calcium content among the other samples. This indicates that the higher the substitution of moringa leaf flour, the higher the calcium content in the fish nuggets. This is because moringa leaves are a plant source with a very high calcium content. Dried moringa leaves contain approximately 2003 mg/100 g of calcium [31]. In this study, the addition of moringa leaf powder to fish nuggets resulted in improvements in several treatments. The more moringa leaf powder added, the higher the calcium content in the nugget product. This is in line with the study by Angelina *et al.* [36] which states that the addition of moringa leaf powder causes a significant increase in protein, calcium, fiber, and minerals in several food products.

### **2.4. Conclusion**

The addition of moringa leaf flour to anchovy nuggets significantly impacted the product's chemical (nutritional) and sensory (consumer acceptability) characteristics. The addition of moringa leaf flour generally increased the nutritional value of the nuggets, particularly the protein, iron, and calcium content. The formula containing 12 g of moringa leaf flour (F4) showed the highest protein (13.34±0.05%), iron (1.23±0.00%), and calcium (0.04±0.01%). This increase was

due to the high nutritional content of moringa leaves, such as protein (25-30%), iron, and calcium (approximately 2003 mg/100 g of dry leaves).

The addition of moringa leaf flour also significantly affected moisture and ash content. Despite the increase in nutritional value, consumer preference tended to decrease with increasing amounts of moringa leaf flour added. The addition of moringa leaf flour affected consumer acceptance of color, aroma, texture, and taste. The color tended to become greenish and its intensity increased with the addition of moringa leaf flour, which was less desirable. The flavor tended to decrease, likely due to the presence of tannins in moringa leaves, which can produce a bitter or astringent taste.

The formulation with 3 g of moringa leaf flour (F1) produced anchovy nuggets with the best overall response from panelists for color, aroma, and texture, and had a sensory profile most similar to the control (F0, 0 g). The formulation without the addition of moringa leaf flour (0 g, F0) scored the highest for taste parameters. Overall, this study indicates that anchovy nuggets fortified with moringa leaf flour have potential as an alternative nutritious snack, with the optimal formulation based on consumer acceptance being the addition of 3 g of moringa leaf flour.

## References

- [1] W. Irdiana and T. S. Nindya, "The Relationship Between Breakfast Habits and Nutrient Intake with the Nutritional Status of Female Students at SMAN 3 Surabaya," *Amerta Nutrition*, vol. 1, no. 3, p. 227, 2017, doi: 10.20473/amnt.v1i3.2017.227-235.
- [2] H. Masthalina, M. Purba, and L. Pangaribuan, "Fast Food Consumption Patterns Nutritional Status and Anemia Among Female, *Journal of Science Education Research*, vol. 10, no. 7, pp. 3656–3663, Jul. 2024, doi: 10.29303/jppipa.v10i7.8030.
- [3] A.M. Iqbal, A. Asfar, A. Rifai, M. I. Nurdin, J.D. Damayanti, A. M. I. T. Asfar. Processing Dried Anchovies into Gammi Salted Shredded Meat. *Dinamisia : Journal of Community Service*, vol. 5, no. 1, Nov. 2020, doi: 10.31849/dinamisia.v5i1.4488.
- [4] G. H. Augustyn, H. C. D. Tuhumury, and M. Dahoklory, "THE EFFECT OF ADDING MORINGA OLEIFERA LEAF FLOUR ON THE ORGANOLEPTIC AND CHEMICAL CHARACTERISTICS OF MOCAF (*Modified Cassava Flour*) BISCUITS," *AGRITEKNO, Journal of Agricultural Technology*, vol. 6, no. 2, pp. 52–58, Oct. 2017, doi: 10.30598/jagritekno.2017.6.2.52.
- [5] L. Anggraini and A. Andriani, "Chemical and organoleptic quality of snakehead fish nuggets through the addition of red bean flour," *Jurnal SAGO Gizi dan Kesehatan*, vol. 2, no. 1, p. 11, Apr. 2021, doi: 10.30867/gikes.v2i1.429.
- [6] D. Rexi, S. Pintauli, A. Dalimunthe, and N. Nasri, "IDENTIFICATION AND CHARACTERIZATION OF ANCHOVY (*Stolephorus commersonii*) PRODUCED IN TANJUNG TIRAM VILLAGE BATU BARA REGENCY," *Indonesian Journal of Pharmaceutical and Clinical Research*, vol. 8, no. 01, pp. 01–06, Jun. 2025, doi: 10.32734/idjpcr.v8i01.20636.
- [7] B. Arianto, B. Handayani, and T. Moedjiherti, "Training on Making Local Rural Foods Based on Moringa Leaves in Koroncong Village, Pandeglang Regency," *Suluh Abdi*, vol. 6, no. 2, Dec. 2024, doi: 10.32502/sa.v6i2.9049.
- [8] A. V. A. Resurreccion, *Consumer Sensory Testing for Product Development*. Gaithersburg, Maryland: An Aspen Publication, 1998.
- [9] H. P., Hutapea, Quality testing of bulk cooking oil sold in Surakarta traditional markets by determining water content, acid value, and peroxide value. *QUIMICA: Journal of Science and Applied Chemistry*. 2021.
- [10] E. Ciptawati, I. B. Rachman, H. O. Rusdi, and M. Alvionita, "Comparative Analysis of Catfish Processing Methods on Nutrient Content," *Ind. J. Chem. Anal.*, vol. 04, no. 01, pp. 40–46, 2021, doi: 10.20885/ijca.vol4.iss1.art5.
- [11] M. P. Anindyajati, B. Dwiloka, and A. N. Al-Baarri. Springiness, Fat Content, Protein Content, and Hedonic Quality of Turkey Meatball (*Meleagris gallopavo*) Based on Commercial Carcass Cuts. *Journal Food Technology*, 6(2)42-48. 2022

- [12] A. Novitaroh, R. P. Sulistiani, J. Teguh Isworo, and Y. K. Syadi. Sensory Properties, Protein Content, and Iron Content in Moringa Leaf Cookies. *Journal Nutrition*, 11(1),32-43. 2022.
- [13] Primawestri, M., Sumardianto, S., & Kurniasih, R. A., Characteristics of catfish sticks (*Clarias gariepinus*) with different meat-to-bone ratios. *Journal of Fisheries Science and Technology*, 5(1), 44-51. 2023.
- [14] A. M. & Yustina Wuri Wulandari, Novita Sari Aryani, “Characteristics Of Plain Bread Substituting Potato Flour (*Solanum tuberosum* L.) With The Addition Of Moringa Leaf Flour (*Moringa oleifera* Lamk.),” *Journal Of Food Technology And Industry*, vol. 4, no. 2, Sep. 2019, doi: 10.33061/jitipari.v4i2.3148.
- [15] M. S. Putri, Y. Syafitri, and Z. A. Talitha, “The Effect of Adding Moringa Oleifera Leaf Flour on the Sensory and Chemical Characteristics of Tilapia (*Oreochromis niloticus*) Nuggets,” *METANA*, vol. 21, no. 1, pp. 9–20, Jun. 2025, doi: 10.14710/metana.v21i1.65225.
- [16] S. Syahfitri and D. Susanti, “The Effectiveness of Adding Moringa Leaves to Squid Nuggets for the Prevention of Stunting in Padang Village, Manggeng District,” *Journal of Social Technology*, vol. 2, no. 2, pp. 174–181, Feb. 2022, doi: 10.36418/jurnalsostech.v2i2.296
- [17] Negara, J. K., Sio, A. K., Rifkhan, R., Arifin, M., Oktaviana, A. Y., Wihansah, R. R. S., & Yusuf, M., Microbiological and sensory aspects (taste, color, texture, aroma) in two different forms of cheese presentation. *Journal of Animal Production and Technology*, 4(2), 286-290. 2016.
- [18] H. Stolterfoht, C. Rinnofner, M. Winkler, and H. Pichler, “Recombinant Lipoygenases and Hydroperoxide Lyases for the Synthesis of Green Leaf Volatiles,” *J Agric Food Chem*, vol. 67, no. 49, pp. 13367–13392, Dec. 2019, doi: 10.1021/acs.jafc.9b02690.
- [19] W. Habsari, D. A. Lestari, and W. T. Hartanto, “Physical and Chemical Analysis of Anchovy Nuggets with Additional Moringa and Cassava Leaves to Prevent Stunting,” *Journal of Agricultural Engineering*, vol. 14, no. 3, p. 879, May 2025, doi: 10.23960/jtep-l.v14i3.879-886.
- [20] T. D. Prasasti, P. Pusparini, D. Rosmana, and A. Sulaeman, “Mackerel Nuggets and Moringa Leaves as High-Protein Snacks for Elementary School Children,” *Journal of Nutrition and Dietetics*, vol. 3, no. 2, pp. 82–90, 2024, doi: <https://doi.org/10.34011/jgd.v3i2.2774>.
- [21] G. I. Aristika, A. R. Riwu, and S. Sulmiyati, “The Effect of Adding Moringa Leaf Powder in Chicken Nugget Production on Organoleptic Quality,” *Journal of Dryland Animal Husbandry*, vol. 4, no. 4, Dec. 2022, doi: 10.57089/jplk.v4i4.1198.
- [22] I. R. Puyanda, N. Suhartatik, V. Nuraini, and I. Setyorini, “Addition Of *Moringa oleifera* Leaf Flour With Variations In Drying Temperature And Concentration To Improve The Nutritional Value Of Tempeh,” *Journal of Food Processing*, vol. 8, no. 2, pp. 125–132, Dec. 2023, doi: 10.31970/pangan.v8i2.117.
- [23] D. Y. Ardianti, R. Anggriani, and S. Sukardi, “Making Cookies Substituting Taro Flour (*Colocasia esculenta* (L) Schot) and Moringa Leaf Flour (*Moringa oleifera* Lamk.),” *Journal of Food Technology and Halal Science*, vol. 2, no. 1, p. 167, 2019, doi: 10.22219/fths.v2i1.12973.
- [24] E. Solichah, “Evaluation of physicochemical, nutritional, and organoleptic properties of nuggets based on moringa (*Moringa oleifera*) leaves and giant catfish (*Arius thalassinus*),” *Food Science and Technology*, vol. 42, 2022, doi: 10.1590/fst.72020.
- [25] N. Kh. Elbarbary et al., “Evaluation of the Quality of Fish Burger Formulated with Moringa oleifera Leaves During Frozen Storage,” *Egypt J Aquat Biol Fish*, vol. 28, no. 3, pp. 473–490, May 2024, doi: 10.21608/ejabf.2024.357416.
- [26] D.S., Untari, Production of tuna nuggets (*Euthynnus affinis*) with the addition of moringa flour (*Moringa oleifera*) as an effort to increase nutritional value. *Journal of Tropical Fisheries Processing*, 2(1), 133-142. 2024.

- [27] M. D. Rahmawanti, A. Mustofa, and M. Karyantina., Chemical and Organoleptic Characteristics of Layur Fish (*Trichiurus lepturus*) and Layang Benggol Fish (*Decapterus russelli*) Nuggets Fortified with Moringa Leaf Powder (*Moringa oleifera*). AGRITEKNO: Journal of Agricultural Technology, vol. 13, no. 2, pp. 202–209, Oct. 2024, doi: 10.30598/jagritekno.2024.13.1.202.
- [28] Y. Rahmi, Y. A. Wani, T. S. Kusuma, S. C. Yuliani, G. Rafidah, and T. A. Azizah, “Nutritional, Physical, and Organoleptic Profile of Wet Noodles Made with Moringa Oleifera Leaf Flour,” Indonesian Journal of Human Nutrition, vol. 6, no. 1, pp. 10–21, Jun. 2019, doi: 10.21776/ub.ijhn.2019.006.01.2.
- [29] M. I. Trisnawati, F. C. Nisa. “The Effect of Adding Moringa Leaf Protein Concentrate and Carrageenan on the Quality of MOCAF-Substituted Dry Noodles.” Journal of Food and Agroindustry, 3(1), 237-247. 2015.
- [30] BSN, *Naget Ikan*. Indonesia, 2013. [Online]. Available: <https://pesta.bsn.go.id/produk/detail/8847-sni77582013>
- [31] L. Gopalakrishnan, K. Doriya, and D. S. Kumar, “Moringa oleifera: A review on nutritive importance and its medicinal application,” *Food Science and Human Wellness*, vol. 5, no. 2, pp. 49–56, Jun. 2016, doi: 10.1016/j.fshw.2016.04.001.
- [32] A. I. Ismail, D. Yuniati, and N. Aryanti, “Formulation of Nuggets Made from Flying Fish (*Parexocoetus brachypterus*), Millet Flour (*Setaria italica* (L.) Beauv.) and Moringa Leaves (*Moringa oleifera*) as a PMT Menu to Prevent Stunting,” *Jurnal Galung Tropika*, vol. 12, no. 3, pp. 295–305, 2023, doi: 10.31850/jgt.v12i3.1152.
- [33] S. Adhikari, M. Schop, I. J. M. de Boer, and T. Huppertz, “Protein Quality in Perspective: A Review of Protein Quality Metrics and Their Applications,” *Nutrients*, vol. 14, no. 5, p. 947, Feb. 2022, doi: 10.3390/nu14050947.
- [34] A. Leone, A. Spada, A. Battezzati, A. Schiraldi, J. Aristil, and S. Bertoli, “Moringa oleifera Seeds and Oil: Characteristics and Uses for Human Health,” *Int J Mol Sci*, vol. 17, no. 12, p. 2141, Dec. 2016, doi: 10.3390/ijms17122141.
- [35] N. Fahlia, The Effect of Moringa Oleifera Lam. Leaf Flour Substitution on the Organoleptic Properties and Calcium Content of Snack Bar. *Journal of Nutrition and Food*, 4(2), 216-228. 2020.
- [36] Angelina, C., Swasti, Y. R., & Pranata, F. S., Increasing the nutritional value of food products by adding Moringa oleifera leaf powder. *Journal of Agrotechnology*, 15(01), 79-93. 2021.