

ORIGINAL ARTICLE

Sensory Characteristics of Chicken Nuggets with Addition of Chicken Liver and Moringa Leaves for Anemia Prevention

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ABSTRACT

Introduction: The increasing trend of anemia in female adolescents over the last decade has caused a major concern that must be addressed immediately. Chicken livers and moringa leaves are food products known for their high iron content. This study aimed to determine the characteristics and nutritional content, especially iron, of chicken nuggets fortified with these two food ingredients. **Methods:** This study used an experimental design with 30 semi-trained panelists. Three product namely, P1 (88% chicken meat, 10% chicken liver, and 2% moringa leaves), P2 (75% chicken meat, 20% chicken liver, and 5% moringa leaves), and P3 (60% chicken meat, 30% chicken liver, and 10% moringa leaves). Sensory evaluation included taste, aroma, color, and texture. Nutritional content assessment using proximate analysis. Analyses used ANOVA for each characteristic. **Results:** Significant differences were found between the three products in terms of color ($p = 0.00$), taste ($p = 0.44$), and overall assessment ($p = 0.00$). There was a significant difference in terms of liking for the products ($p = 0.010$), with the majority of panelists preferring formula P2. The results of the nutritional content analysis showed that there was a significant difference in iron content among the three products ($p = 0.001$). **Conclusion:** There were significant differences in terms of color, taste, overall assessment, and iron content, with the most preferred formula being formula P2. Clinical trials on young women with anemia are needed to see the effectiveness of P2 formula chicken nuggets in increasing their hemoglobin levels.

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INTRODUCTION

Anemia remains a significant global public health issue, particularly affecting female adolescents. Globally, the prevalence of anemia is notably high among women: 32.5% in non-pregnant women, 40.1% in pregnant women, and 32.8% in women of reproductive age (1). A substantial portion of anemia cases, roughly 50%, is directly linked to insufficient intake of animal products. To combat this widespread problem, common interventions such as supplementation and food fortification are required (2). In recognition of the criticality of this issue, the Indonesian government is currently actively working to reduce the anemia incidence, especially in female adolescents, as part of a broader national effort to develop human resources by

ensuring that adolescents receive balanced nutrition (3). Animal-derived products are considered primary sources of iron that is essential to anemia prevention. For example, chicken liver is highly valued for its rich iron content, providing 15.8 mg of iron per 100 g of chicken liver (4). Consuming animal-derived iron, such as that found in chicken liver, is an effective strategy to prevent iron-deficiency anemia. Beyond direct consumption, chicken liver can also be used as a raw material for industrial applications, allowing for the creation of iron-fortified products specifically designed for individuals with iron-deficiency anemia (5). In addition to animal sources, vegetable-based options are also frequently utilized to improve anemia due to their nutritional benefits. One notable example is the application of moringa leaves as a biscuit ingredient, which has been shown to increase hemoglobin levels in pregnant women (6). Khoja found that moringa leaves provide higher bio-accessibility and bio-availability of iron compared to other plant sources, making them a highly potential source of iron.

There is a growing interest in the exploration of innovative food products as a means of preventing anemia. Of these, processed foods like nuggets are frequently used to boost protein and iron levels. Listiani et al. (2022) developed a nugget product enriched with kidney beans and chicken liver and concluded that it could effectively contribute to iron intake and help prevent anemia (7). The optimized nugget formula significantly increased iron content, contributing 35% of the daily iron requirement. Despite its benefits, incorporating chicken liver into meat formulations can impact various quality characteristics, including emulsion stability, water-holding capacity, cooking shrinkage, texture, and color (7). This means determining the optimal replacement ratio of ingredients poses a crucial challenge when developing new iron-rich formulas. Based on these considerations, we took an interest in developing a novel chicken nugget product incorporating both chicken liver and moringa leaves specifically to prevent anemia in female adolescents.

MATERIALS AND METHODS

This study was conducted at the Sensory Laboratory of the Faculty of Agriculture, Universitas Lampung, on January 14, 2025, with an ethical permit issued by the Faculty of Medicine, Universitas Lampung, Number 41/UN26.18/PP. 05.02.00/2024, dated December 2, 2024. The number of panelists participating in the sensory evaluation in this study was determined according to Indonesian National Standard (SNI) No. 01-2346-2006 concerning Guidelines for Organoleptic and/or Sensory Testing (8). According to this standard, such testing must involve a minimum of 30 semi-trained panelists. The semi-trained panelists in this study consisted of students of the Undergraduate Study Program of Agricultural Product Technology at Universitas Lampung who had taken courses or participated in trainings on sensory testing.

The tools used in making the nugget products were a scale, a cutting board, a basin, a Mitochiba CH 250 Star chopper, plates, spoons, baking sheets, a knife, a steamer pot, a freezer/refrigerator, a spatula, a pan, a drainer, and a stove. The ingredients used were chicken meat, chicken liver, moringa leaves, and additional ingredients such as breadcrumbs, eggs, wheat flour, garlic, sugar, ground nutmeg, ground coriander, salt, pepper, and oil (9).

The working procedure started with preparing and cleaning the chicken meat, chicken liver, and moringa leaves. The chicken meat and chicken liver were then weighed according to the different formulae used in this study and mashed using a chopper. Moringa leaves that had been blanched according to the different formulae were then added, along with other ingredients, namely, 60 g of eggs, 1 cm of ginger, breadcrumbs, two cloves of garlic, half a teaspoon of salt, half a teaspoon of pepper, and other spices. The well-mixed dough was

then poured on a baking sheet for molding (3 cm thickness) and steaming. Before steaming, the steamer pot was preheated for 10 minutes. The steaming itself was performed for 30 minutes at 100°C. After steaming, the dough was left to cool down at room temperature for 10 minutes and then cut down into small pieces. Further details are presented in Figure 1.

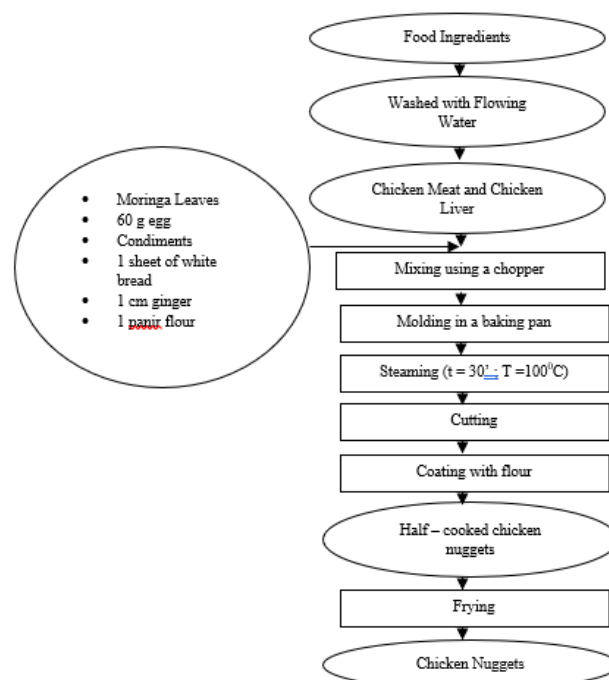


Figure 1: Process of making combination chicken liver nuggets

The chicken nugget products were formulated based on previous research by Wibisono (2023), which used 9% (FNA1), 18% (FNA 2), and 27% (FNA 3) meat replacement with chicken liver (10). The addition of moringa leaves followed (11). The ratios of chicken meat, chicken liver, and moringa leaves used in this study are presented in Table I.

Sensory evaluation, including the aroma, taste, color,

Table I Preparation of chicken nuggets with the addition of chicken liver and moringa leaves

Ingredients	P1 g (%)	P 2 g (%)	P 3 g (%)
Chicken Meat	220 (44,9)	187.5 (38,26)	150 (30,6)
Chicken Liver	25 (5,1)	50 (10,20)	75 (15,3)
Moringa Leaves	5 (1)	12.5 (2,55)	25 (5,1)
Flour	100 (20,4)	100 (20,4)	100 (20,4)
Egg	60 (12,2)	60 (12,2)	60 (12,2)
Fresh bread	50 (10,2)	50 (10,2)	50 (10,2)
Seasoning	30 (6,12)	30 (6,12)	30 (6,12)

Source : (10)

P 1 : Chicken liver and moringa nugget formula 1 (Ratio = Chicken Meat (88%) : Chicken Liver (10%) : Moringa Leaves (2%))

P 2 : Chicken liver and moringa nugget formula 2 (Ratio = Chicken Meat (75%) : Chicken Liver (20%) : Moringa Leaves (5%))

P 3 : Chicken liver and moringa nugget formula 3 (Ratio = Chicken Meat (60%) : Chicken Liver (30%) : Moringa Leaves (10%))

texture, and overall acceptability of each formula, was conducted using a nine-point hedonic scale (1 = extremely dislike, 2 = strongly dislike, 3 = moderately dislike, 4 = somewhat dislike, 5 = neither like nor dislike, 6 = slightly like, 7 = moderately like, 8 = strongly like, and 9 = extremely like) (12).

Nutritional content assessment was conducted using established methodologies. Water content was determined using the thermogravimetry method, ash content was determined using the dry ashing method, and fat content was determined using the Soxhlet method, all of which were in accordance with Indonesian National Standard (SNI) No. 01-2891-1992 (SNI 1992). Protein content was measured using the Micro Kjeldahl method in accordance with Association of Official Analytical Collaboration (AOAC) Official Method No. 960.52-1961 (13). Carbohydrate content was calculated by difference, and the *Aw* (water activity) value was calculated using the isothermal sorption method.

Analysis was conducted using One-Way ANOVA and the Friedman test to evaluate product preference, with values previously adjusted using the Fisher and Yates tables, aided with SPSS version 22.

RESULTS

Different formula compositions produce different nutritional content; the higher the chicken liver content, the higher the iron content in chicken nuggets. As for sensory attributes, it was found that the products had a pleasant aroma, a greenish yellow color, and a chewy texture, similar to chicken nuggets in general (Figure 2). Based on the sensory evaluation with 30 semi-trained panelists, the most preferred attribute of the first and second formulae was the aroma, and the most preferred attribute of the third formula was the texture. On the other hand, the least preferred attribute of the first and second formulae was the texture, and the least preferred quality of the third formula was the color. Overall, P2 was the most preferred formula. The results of the preference analysis are presented in Figure 3.

Based on the One-way ANOVA results, as shown in Table II, the panelists perceived significant differences



Figure 2: Chicken nugget products with the addition of chicken liver and moringa leaves

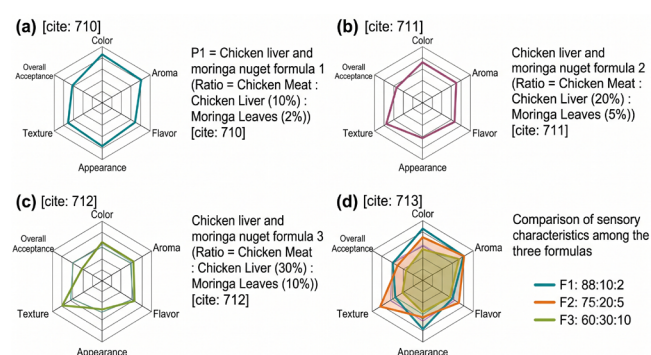


Figure 3: Spider Web Analysis of Product Sensory Characteristics : (a) P 1 = Chicken liver and moringa nugget formula 1 (Ratio = Chicken Meat (88%) : Chicken Liver (10%) : Moringa Leaves (2%)); (b) Chicken liver and moringa nugget formula 2 (Ratio = Chicken Meat (75%) : Chicken Liver (20%) : Moringa Leaves (5%)); (c) Chicken liver and moringa nugget formula 3 (Ratio = Chicken Meat (60%) : Chicken Liver (30%) : Moringa Leaves (10%)); (d) Comparison of sensory characteristics among the three formulas

Table II: Sensory Test Analysis

Variable	Color ^a	Aroma ^{ns}	Taste ^a	Texture ^{ns}	Overall ^b
P1	7.00 ± 1.86 ^b	7.10 ± 1.27	6.70 ± 1.06 ^{ab}	6.50 ± 1.59	6.82 ± 1.00 ^b
P2	7.23 ± 1.22 ^b	7.37 ± 1.3	7.07 ± 1.74 ^b	6.7 ± 1.73	7.09 ± 1.12 ^b
P3	4.9 ± 1.52 ^a	6.67 ± 1.77	6.00 ± 2.00 ^a	5.77 ± 1.90	5.83 ± 1.47 ^a

P 1 : Chicken liver and moringa nugget formula 1 (Ratio = Chicken Meat (88%) : Chicken Liver (10%) : Moringa Leaves (2%))

P 2 : Chicken liver and moringa nugget formula 2 (Ratio = Chicken Meat (75%) : Chicken Liver (20%) : Moringa Leaves (5%))

P 3 : Chicken liver and moringa nugget formula 3 (Ratio = Chicken Meat (60%) : Chicken Liver (30%) : Moringa Leaves (10%))

Notes : The value is shown as the mean standard deviation, values in the same column with different p-values differ significantly (p 0.05) with code ^a, ^{ns} means that there is no significant difference. ^a included in subsets a; ^b included in subsets b; ^{ab} included in subsets a and b.

in color, taste, and overall assessment among the three formulae. P3 consistently received the lowest scores across these attributes, indicating that it was less preferred in terms of color, taste, and overall appeal compared to P1 and P2. Conversely, P2 achieved the highest scores in all sensory aspects, including color, aroma, taste, texture, and overall assessment.

The Friedman test was conducted to determine the differences in product preference and the characteristics of each chicken nugget product. The results showed significant differences. Based on post-hoc test results, the largest value was observed in P2. The results of the favorability ranking test for the products are shown in Table III.

The proximate analysis results, as presented in Table IV, revealed no significant differences in carbohydrate, protein, water, fat, and ash content among the products. However, a statistically significant difference was observed in iron content, directly correlating with the amount of chicken liver present in the product; the higher the chicken liver proportion, the greater the iron content.

Table III: Product favorability ranking test

Variable	Mean $\pm$ SD	p value
P1	1.87 $\pm$ 0.73	0.10
P2	1.7 $\pm$ 0.79	
P3	2.43 $\pm$ 0.77	

P 1 : Chicken liver and moringa nugget formula 1 (Ratio = Chicken Meat (88%) : Chicken Liver (10%) : Moringa Leaves (2%))

P 2 : Chicken liver and moringa nugget formula 2 (Ratio = Chicken Meat (75%) : Chicken Liver (20%) : Moringa Leaves (5%))

P 3 : Chicken liver and moringa nugget formula 3 (Ratio = Chicken Meat (60%) : Chicken Liver (30%) : Moringa Leaves (10%))

DISCUSSION

Color

Results of this study revealed a significant difference in color perception regarding the three chicken nugget products, with most panelists disliking the color of the third product (P3) with a score of 4,9 and preferring that of the second product (P2) with a score of 7,23. This was because the third formula used a reduced chicken meat proportion in the composition in favor of the chicken liver and moringa leaf elements. Moringa leaves greatly affected the color of the nuggets, giving the nuggets a more greenish color than their typical yellow color. The green color came from the chlorophyll content of moringa leaves (14). A previous study reported that the addition of vegetables, such as spinach, to nuggets caused the nuggets much less favored in terms of color than those that did not contain vegetables (15). Chicken liver was added to the products manually, causing its color to also affect the chicken nugget products' color (16). Some panelists disliked the third product (P3) because of the greater proportions of chicken liver and moringa leaves in its composition than in the other two products.

Aroma

As with color, panelists also preferred the second product (P2) to the third (P3) in terms of aroma with a score of 6,67, but there was no significant difference among the three products. In other words, the addition of chicken liver and moringa leaves did not significantly affect the aroma of the three products. The addition of chicken liver to the chicken nugget compositions imparted a fishy aroma to the chicken nugget products (17), to the extent that the aroma of moringa leaves in all products became overpowered by the distinctive fishy aroma of the chicken liver. A previous study has also shown that the addition of vegetables, such as spinach, did not produce a strong aroma because it was overcome by

the distinctive aroma of the chicken liver content in the food product (18). Food ingredients can produce certain aroma because they contain certain volatile compounds (14).

Taste

Panelists gave different assessments with regard to the taste of the three chicken nugget products, with the second product being most liked. The One-way ANOVA results showed a significant difference among the products. As with the two previous indicators, the third product (P3) was the least preferred in terms of taste with a score of 6,00, as the addition of chicken liver and moringa leaves affected its taste. Taste is one of the attractions of a food product to consumers. Most consumers judge the quality of a food product based on its taste; the tastier the food product, the more favored it is. The taste of a food product comes from the ingredients used in its manufacturing, in this case chicken meat and added chicken livers and moringa leaves (14). Chicken nuggets enriched with chicken liver and moringa leaves produce a distinctive taste, with the taste of chicken liver being dominant (17). Chicken liver has good nutritional content, but its fishy taste and aroma reduce its likability compared to other food ingredients.

Texture

Texture is important to the acceptability of a food product. In terms of texture, P3 received the worst assessment from panelists, with a score of 5.77, as panelists only slightly liked its texture. This is in line with the finding by Choe et al. (2019) that the addition of leaves, such as lotus leaves and green tea leaves, affected the texture and elasticity of sausage products (19). The difference test results showed that there was no significant difference between the three products. This is in line with previous research which found no significant difference between treatment nuggets (supplemented with chicken liver) and control nuggets. Although liver is recognized as a rich source of nutrients, its stability difficulties indicate the need to include it as a functional ingredient in more innovative cuisines or food products (16).

Preference Test

The preference test results showed that P2 was the most preferred by panelists, with a significant value, as it had a balanced composition of the main ingredients used. The formula had high acceptability in terms of aroma, taste, texture, and color. These results are in accordance with previous research on processed animal products

Table IV: Proximate Test Results on Chicken Liver Nuggets Products with The Addition of Chicken Liver and Moringa Leaves. (per 100 g)

Variable	% Carbohydrate ^{ns}	% Protein ^{ns}	% Water Content ^{ns}	% Fat ^{ns}	% Ash Content ^{ns}	Iron (mg)
P1	21.99 $\pm$ 7.05	13.72 $\pm$ 0.96	57.99 $\pm$ 7.34	5.05 $\pm$ 0.99	1.25 $\pm$ 0.19	2.78 $\pm$ 0.01 ^a
P2	21.42 $\pm$ 5.24	12.95 $\pm$ 0.48	59.66 $\pm$ 7.80	4.62 $\pm$ 1.89	1.29 $\pm$ 0.19	3.37 $\pm$ 0.01 ^b
P3	21.21 $\pm$ 5.42	13.54 $\pm$ 0.07	63.36 $\pm$ 0.09	3.48 $\pm$ 0.07	1.54 $\pm$ 0.10	4.17 $\pm$ 0.01 ^c

P 1 : Chicken liver and moringa nugget formula 1 (Ratio = Chicken Meat (88%) : Chicken Liver (10%) : Moringa Leaves (2%))

P 2 : Chicken liver and moringa nugget formula 2 (Ratio = Chicken Meat (75%) : Chicken Liver (20%) : Moringa Leaves (5%))

P 3 : Chicken liver and moringa nugget formula 3 (Ratio = Chicken Meat (60%) : Chicken Liver (30%) : Moringa Leaves (10%))

Notes : The value is shown as the mean standart deviation, Values in the same column with different p- values differ significantly (p 0.05). ^{ns} means that there is no significant difference.

in terms of sensory evaluation and overall acceptability (20). It is also consistent with a study showing positive sensory evaluation results of nugget products added with chicken liver and beef liver, indicating acceptability according to panelists and suitability for consumption (16).

Nutritional Content

The results of proximate analysis showed that the carbohydrate content in all the three products was relatively consistent, averaging at around 21%, with no significant differences observed. The protein content was also comparable, ranging between 12% and 13%, while the fat content was approximately 4%. These nutritional values comply with Indonesian National Standard No. 7758-2013. The presence of chicken liver in all formulae contributed to relatively high moisture content, which could enhance the products' appeal to consumers and influence the products' sensory characteristics. This finding is consistent with Fauziah et al. (2020), according to whom chicken liver contains sufficient moisture to improve the palatability of chicken-liver-based processed food products. Additionally, the ash content in the food products serves as a marker for the presence of minerals (9).

Among the three formula, P3 had the highest iron concentration, which was attributable to its greater inclusion of chicken liver and moringa leaves. These ingredients are recognized for their substantial iron contribution, supporting daily nutritional requirements. Based on the iron content of the three products, it was found that all three products included in iron source category, as they exceed 15% (>2.25 mg) of the daily iron requirement for adolescent girls (15 mg/day). Therefore, these products can be an alternative for preventing anemia, especially in adolescent girls. Fauziah et al. (2020) reported that nuggets made with chicken liver and tempeh had iron levels of around 5.8 mg per 100 grams (9). Similarly, Ramadhani (2024) found that chicken nuggets enriched with chicken liver and moringa leaf flour contained 5.87 mg of iron and 12.57% protein per 100 grams (21). It can be concluded that integrating chicken liver and moringa leaves into processed foods like nuggets not only boosts their protein and iron content but also enhances their functional nutritional value. A well-designed nugget formula presents a promising innovation to improve the intake of vital nutrients, particularly iron, in the effort to combat anemia.

CONCLUSION

Adding chicken liver and moringa leaves into chicken nuggets increases the iron content of the chicken nuggets, whose consumption helps fulfil the iron requirements of an individual in order to prevent anemia. There were significant differences in terms of taste, color, and overall assessment among the three chicken nugget

products under study, with P2 being the most likable. P3 had the highest iron content as it used the largest proportion of chicken liver and moringa leaves of all formulae. More in-depth investigations into the effect of nugget product development with the addition of chicken liver and moringa leaves on hemoglobin levels in female adolescents and the most optimal temperature and length of time to fry nuggets are recommended.

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