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Nutrient Content and Acceptability of Milkfish Meatballs Substituted with Red Bean Purée for Stunting Prevention

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ABSTRACT/ ABSTRAK

ABSTRACT*. Stunting remains a chronic nutritional problem and continues to pose a major public health challenge in Indonesia. Inadequate intake of protein and iron is recognized as one of the principal risk factors. The development of local food products rich in protein and iron is therefore required as an innovative strategy to support sustainable stunting prevention efforts. This study aimed to determine the protein and iron content as well as the acceptability of milkfish meatballs substituted with red bean purée as an alternative for stunting prevention. A pre-experimental design was employed using four meatball formulations based on different levels of red bean purée substitution (0%, 35%, 45%, and 55%). Sensory evaluation was conducted by 30 semi-trained panelists, while protein and iron analyses were performed on the selected formulation using the Kjeldahl method and Atomic Absorption Spectrophotometry. The F1 formulation (35% red bean purée) demonstrated the highest acceptability, particularly in terms of taste and texture. Nutritional analysis showed that the F1 formulation contained 11.46 g of protein and 4.50 mg of iron per 100 g of product; the protein content exceeded the minimum requirement of the Indonesian National Standard (SNI 7266:2014), and the iron content surpassed the estimated value based on the Indonesian Food Composition Table (TKPI). Milkfish meatballs substituted with red bean purée (F1 formulation) exhibited good acceptability and relatively high nutritional value, indicating their potential as a protein- and iron-rich local food-based product for stunting prevention.*

Kata kunci:

Bakso Ikan Bandeng, Kacang merah, Protein, Stunting, Zat Besi

ABSTRAK. Stunting merupakan masalah gizi kronis yang masih menjadi tantangan di Indonesia. Kekurangan protein dan zat besi merupakan salah satu faktor risiko utama. Pembuatan produk pangan lokal yang kaya protein dan zat besi diperlukan sebagai strategi inovatif dalam mendukung upaya pencegahan *stunting* secara berkelanjutan. Penelitian ini bertujuan untuk mengetahui kadar protein dan zat besi serta daya terima bakso ikan bandeng yang disubstitusi dengan puree kacang merah sebagai alternatif pencegahan *stunting*. Penelitian menggunakan desain pre-eksperimen dengan empat formulasi bakso berdasarkan persentase substitusi puree kacang merah (0%, 35%, 45%, 55%). Uji organoleptik dilakukan oleh 30 panelis agak-terlatih, dan analisis kandungan protein serta zat besi dilakukan pada formulasi terbaik menggunakan metode Kjeldahl dan Spektrofotometri Serapan Atom. Formula F1 (35% puree kacang merah) menunjukkan tingkat penerimaan terbaik dari aspek rasa dan tekstur. Kandungan gizi formula F1 mencapai 11,46 g protein dan 4,50 mg zat besi per 100 g produk, protein melebihi minimal Standar Nasional Indonesia (SNI 7266:2014) dan zat besi melebihi estimasi Tabel Komposisi Pangan Indonesia (TKPI). Bakso ikan bandeng substitusi puree kacang merah formula F1 memiliki daya terima yang baik dan kandungan gizi yang cukup tinggi, serta berpotensi menjadi produk tinggi protein dan zat besi sebagai upaya pencegahan *stunting* berbasis pangan lokal.

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INTRODUCTION

Stunting remains a nutritional issue affecting children in Indonesia and is characterized by long-term inadequate nutrient intake, resulting in a height-for-age z-score below −2 SD. Data from the Indonesian Nutrition Status Survey (SSGI) in 2024 reported a stunting prevalence of 19.8%, representing a decrease of 4.6% compared to 2021. Nevertheless, stunting among children continues to require serious attention from the government and other health-related sectors, as the 2024 prevalence has not yet met the target set in the 2020–2024 National Medium-Term Development Plan (RPJM), which established a benchmark of 19% (Presidential Regulation, 2021). Similarly, stunting prevalence in South Sulawesi has not reached the RPJM target, with SSGI (2024) reporting a prevalence of 23.3% in the province (Kementerian Kesehatan Republik Indonesia, 2024).

Long-term stunting may lead to adverse consequences during adolescence and adulthood, including reduced productivity and cognitive capacity, as well as an increased risk of obesity and other chronic diseases. Insufficient intake of essential nutrients, particularly those supporting growth and development such as protein and iron, constitutes one of the primary risk factors for stunting in children. The risk of stunting is reported to increase up to 7.65-fold in children with protein deficiency, while children with low iron intake may have a 3.08-fold higher risk. Therefore, the development of innovative food products with high protein and iron content is necessary to support stunting prevention efforts (Nugraheni et al., 2020).

Milkfish (Chanos chanos) is a popular fish species in Southeast Asian countries and is highly favored by communities, particularly in South Sulawesi. In addition to its popularity, milkfish offers several advantages over other fish species, including its savory flavor, firm flesh that does not easily disintegrate during cooking, and affordability (Fitri et al., 2016). Its nutritional value further enhances its potential; according to the Indonesian Food Composition Table (TKPI) (2017), 100 g of milkfish contains 123 kcal of energy, 20 g of protein, 4.8 g of fat, 45 mg of vitamin A, 0.05 mg of vitamin B1, 0.1 mg of vitamin B2, 2 mg of iron, 0.9 mg of zinc, 150 mg of phosphorus, and 20 mg of calcium. Fresh milkfish can be processed into various nutritious and palatable products, such as shredded milkfish and milkfish meatballs (Abriana et al., 2021).

Fish meatballs are commonly prepared using tapioca or cassava flour as a filler. However, when milkfish meatballs rely solely on tapioca flour, their nutritional value tends to remain relatively low, as tapioca flour contains limited amounts of protein and iron (Debora et al., 2023). Red beans possess favorable nutritional properties and may serve as an enriching ingredient in milkfish meatball formulations. Based on TKPI 2017, 100 g of red beans contains 171 kcal of energy, 11 g of protein, 2.2 g of fat, 28 g of carbohydrates, 2.1 mg of fiber, 0.15 mg of vitamin B1, 0.15 mg of vitamin B2, 3.7 mg of iron, 1.4 mg of zinc, 134 mg of phosphorus, and 293 mg of calcium (Kementerian Kesehatan Republik Indonesia, 2018).

Processing milkfish and red beans into ready-to-eat meatballs may enhance acceptability, particularly among children. However, scientific studies addressing formulation, nutritional value analysis, and acceptability testing of milkfish meatballs substituted with red bean purée remain limited. Therefore, this study aimed to evaluate acceptability and to analyze the protein and iron content of milkfish meatballs substituted with red bean purée as an innovative local food-based approach for stunting prevention.

RESEARCH METHOD

This study employed a pre-experimental study by developing formulations of milkfish meatballs substituted with red bean purée. The research design used was a post-test only group design. Acceptability testing of the four formulations of milkfish meatballs substituted with red bean purée was conducted at the Food Technology Science Laboratory, Department of Nutrition, Poltekkes Kemenkes Makassar. The formulation that demonstrated the best acceptability was subsequently analyzed for protein and iron content at the Center for Public Health Laboratory (Balai Besar Laboratorium Kesehatan, BBLK) Makassar. The study was carried out from 25 June to 11 July 2025.

The equipment used in the preparation of milkfish meatballs substituted with red bean purée included a chopper, kitchen knife, spoon, bowl, plate, weighing scale, pot, stove, frying pan, spatula, cutting board, and basin. The ingredients consisted of milkfish, red beans, tapioca flour, egg white, garlic, shallot, fried shallot, pepper, salt, and ice cubes. Four formulations of milkfish meatballs substituted with red bean purée were prepared, with different ratios of red bean purée to tapioca flour, namely control/F0 (0:100), F1 (35:65), F2 (45:55), and F3 (55:45).

Table 1. Composition of Milkfish Meatball Formulations for Each Treatment

Ingredient	Formulation			
	F0 (Control)	F1 (35%)	F2 (45%)	F3 (55%)
Milkfish	100 g	100 g	100 g	100 g
Tapioca flour	45 g	30 g	25 g	20 g
Red bean purée	0 g	15 g	20 g	25 g
Egg white	20 g	20 g	20 g	20 g
Garlic	10 g	10 g	10 g	10 g
Shallot	5 g	5 g	5 g	5 g
Ice cubes	17 g	17 g	17 g	17 g
Fried shallot	2 g	2 g	2 g	2 g
Pepper	3 g	3 g	3 g	3 g
Salt	2 g	2 g	2 g	2 g

Notes: *F0 = 0% red bean purée (control); F1 = 35% red bean purée; F2 = 45% red bean purée; F3 = 55% red bean purée.*

Data collection was conducted using two approaches, namely laboratory analysis and sensory (organoleptic) evaluation. Protein content was determined using the Kjeldahl method, while iron content was analyzed using Atomic Absorption Spectrophotometry (AAS). The laboratory results were compared with values calculated based on the Indonesian Food Composition Table (TKPI) and the Indonesian National Standard for fish meatballs (SNI 7266:2014). Panelists' acceptability scores for taste, aroma, color, and texture were assessed using a four-point hedonic scale (1 = dislike, 4 = like very much). The panelists involved were semi-trained panelists. Data analysis was performed using ANOVA, and the Kruskal–Wallis test was applied when the data were not normally distributed. Significant results were further analyzed using the Mann–Whitney test. The data are presented in the form of tables and narrative descriptions. This study received ethical approval No. 1494/M/KEPK-PTKMS/VII/2025 from the Ethics Committee of Poltekkes Makassar.

RESULTS

Characteristics of Milkfish Meatballs Substituted with Red Bean Purée

Milkfish meatballs substituted with red bean purée were spherical in shape with a diameter of approximately ±5 cm. Each batch of meatball dough yielded around 10 meatballs, with an average weight of ±15 g per meatball. The milkfish meatballs substituted with red bean purée exhibited a grayish-white color with slight red speckles derived from the red bean purée, giving them a distinct appearance compared with conventional fish meatballs. The aroma reflected a characteristic combination of milkfish and red bean aromas, resulting in a relatively neutral final aroma that was not overly fishy. The taste profile was savory with a subtle hint of red bean flavor, providing a more complex sensory profile while remaining acceptable to consumers. The texture was generally soft, slightly tender, and not overly chewy. The moist nature of red bean purée influenced product moisture, producing a slightly soft texture while maintaining good structural integrity in meatball form.

Acceptability of Milkfish Meatballs Substituted with Red Bean Purée

Sensory (organoleptic) evaluation was conducted to assess panelists' acceptability of milkfish meatballs substituted with red bean purée. The evaluation involved four formulations with substitution levels of 0%, 35%, 45%, and 55%. The assessed parameters included taste, aroma, color, and texture. Acceptability testing was performed by semi-trained panelists using a four-point hedonic scale (1 = dislike, 2 = slightly dislike, 3 = like, 4 = like very much).

Table 2. Mean Acceptability Scores of Milkfish Meatballs Substituted with Red Bean Purée

Parameter	Mean Values for Each Treatment				p-value
	F0	F1	F2	F3	
Taste	3.03 ± 0.718	3.30 ± 0.466	3.13 ± 0.730	2.70 ± 0.877	0.033
Aroma	3.00 ± 0.587	3.17 ± 0.461	3.07 ± 0.583	3.00 ± 0.643	0.0689
Color	3.10 ± 0.481	3.20 ± 0.551	3.07 ± 0.640	2.87 ± 0.730	0.241
Texture	2.90 ± 0.885	3.10 ± 0.481	2.87 ± 0.730	2.47 ± 0.819	0.022

Source: *Processed Primary Data, 2025.*

The results indicate that the taste parameter showed a statistically significant difference ($p < 0.05$), followed by Mann–Whitney post hoc analysis, with the F1 formulation (35%) obtaining the highest score and F3 (55%) the lowest. Aroma and color parameters did not show significant differences ($p > 0.05$), with all formulations remaining within the "like" category. The texture parameter also demonstrated a significant difference ($p < 0.05$), with the F1 formulation (35%) again achieving the highest score and F3 (55%) the lowest. Based on these findings, the F1 formulation (35%) was selected for further nutritional content analysis.

Table 3. Mann–Whitney Test Results for Taste and Texture

Formulation Pair	Taste		Texture	
	Taste (p-value)	Interpretation	Texture (p-value)	Interpretation
F0 vs F1	0.147	Not significant	0.346	Not significant
F0 vs F2	0.636	Not significant	0.838	Not significant
F0 vs F3	0.120	Not significant	0.077	Not significant
F1 vs F2	0.418	Not significant	0.142	Not significant
F1 vs F3	0.003	Significant	0.001	Significant
F2 vs F3	0.059	Not significant	0.085	Not significant

Source: *Processed Primary Data, 2025.*

Table 3 shows that for the taste parameter, only the F1 vs F3 comparison demonstrated a significant difference ($p = 0.003$), while other formulation pairs did not differ significantly ($p > 0.05$). A similar pattern was observed for texture, where only the F1 and F3 formulations showed a significant difference ($p = 0.001$), whereas the remaining pairs showed no meaningful differences.

Protein and Iron Content of Milkfish Meatballs Substituted with Red Bean Purée

Nutritional analysis was conducted on the selected formulation, F1 (35%). Laboratory testing included protein analysis using the Kjeldahl method and iron analysis using Atomic Absorption Spectrophotometry (AAS). The analytical results are presented in Table 4.

Table 4. Protein and Iron Content of Milkfish Meatballs Substituted with Red Bean Purée

Method	Protein	Iron
Laboratory analysis	11.46 g/100 g	4.50 mg/100 g
TKPI-based calculation	16.07 g/100 g	1.93 mg/100 g
Fish meatball standard (SNI 7266:2014)	Min. 7.0%	–

Source: *BBLK Makassar, 2025; TKPI, 2017; SNI 7266:2014.*

Laboratory results showed that per 100 g of milkfish meatballs substituted with red bean purée from the selected formulation (F1), the product contained 11.46 g of protein and 4.50 mg of iron. The protein content met the minimum requirement of the Indonesian National Standard for fish meatballs (7.0%). Compared with TKPI-based calculations, the protein content was lower than the estimated value (16.07 g), whereas the iron content was higher than the estimated value (1.93 mg).

DISCUSSION

Sensory Acceptability of Milkfish Meatballs Substituted with Red Bean Puree

Sensory perception of products combining milkfish and red beans reflects good consumer adaptation to animal–plant-based food compositions. The results of the organoleptic test demonstrated that the acceptability of milkfish meatballs substituted with red bean puree differed significantly in terms of taste and texture ($p < 0.05$), with formulation F1 (35% red bean puree) obtaining the highest scores compared with other formulations. On average, panelists rated this formulation from “like” to “very like” across all sensory attributes, including taste, aroma, color, and texture. These findings indicate that the incorporation of red bean puree up to a level of 35% remains sensorially acceptable to consumers.

This result is consistent with the study by Munawaroh et al. (2024), which reported that the substitution of legume-based protein ingredients up to 30% in milkfish meatballs was able to maintain panelists’ preference for taste and texture. Similarly, Kumalasari et al. (2025) reported that red bean substitution in milkfish sausage production positively affected nutritional value and was well accepted sensorially, although excessive use resulted in a decline in texture scores.

A similar trend was observed in the present study, where increasing the proportion of red bean puree to 55% led to a significant decrease in taste and texture scores. This decline is presumably associated with the soft texture and high moisture content of red bean puree, which adversely affect meatball elasticity. Higher moisture levels reduce protein concentration, weakening protein–protein interactions and consequently diminishing mechanical properties such as firmness and elasticity of the product (Oyinloye & Yoon, 2024).

Color and aroma parameters did not differ significantly between formulation F1 and the control without substitution ($p > 0.05$). Panelists reported that the meatballs retained an appealing appearance, were neither excessively dark nor slimy, and that the characteristic aroma of milkfish remained dominant while blending harmoniously with the mild aroma of red beans. These findings are supported by Kumalasari et al. (2025), who reported that red bean substitution in milkfish sausage did not reduce color and aroma acceptability. Additionally, Ssepuuya et al. (2025), in a study on composite fish–legume flours (70:30 to 90:10) for instant products, found a balanced fish–bean aroma and a naturally yellowish-brown color, indicating no dominant legume odor or undesirable color changes that could reduce consumer purchase intention.

Protein Content of Milkfish Meatballs Substituted with Red Bean Puree

Protein is an essential macronutrient that plays a critical role in growth, tissue repair, and stunting prevention. In functional food development, the combination of animal and plant proteins has been widely adopted as a strategic approach to improving the nutritional balance of food products. Animal protein from milkfish has high biological value due to its complete and balanced essential amino acid profile. Meanwhile, plant protein from legumes such as red beans contributes to total protein content and provides additional benefits, including dietary fiber, iron, and natural antioxidants. Foods that combine animal and plant protein sources not only enhance nutritional profiles but also improve overall amino acid quality (Hidayati et al., 2025).

The protein content of milkfish meatballs substituted with red bean puree exceeded the minimum standard specified in SNI 7266:2014 for fish meatballs (≥7%). Although the measured protein level was lower than the estimated value based on the Indonesian Food Composition Table (TKPI), it can still be categorized as relatively high. This finding is in line with Agung et al. (2024), who reported a protein content of 12.65% in milkfish taro crispy products with a 30% substitution of red bean puree.

The reduction in protein content compared with raw ingredients may be attributed to thermal processing, which can induce protein denaturation. Ciptawati et al. (2021) reported decreased protein levels in catfish processed by steaming and frying compared with fresh fish. Protein denaturation or structural damage can occur during processing at temperatures above 50°C, resulting in reduced measurable protein content in processed fish products (Sunarma et al., 2025). In addition, the incorporation of red bean puree with high moisture content may produce a dilution effect, lowering protein concentration per unit weight of the final product. Although red beans contain plant protein, the presence of substantial water reduces protein density per 100 g of product. This phenomenon aligns with the concept that adding more water to a protein matrix maintains total protein content but disperses it over a larger volume, thereby decreasing concentration (Oyinloye & Yoon, 2024).

According to the Indonesian Recommended Dietary Allowance (AKG), protein requirements for children range from 20–40 g/day. If 15% of daily intake is allocated to snacks, the required protein intake from snacks is approximately 6.0 g/day (Kementerian Kesehatan Republik Indonesia, 2019). Milkfish meatballs substituted with red bean puree contain approximately 1.71 g of protein per piece (±15 g); therefore, the consumption of four meatballs can meet children's protein requirements from a snack portion.

Iron Content of Milkfish Meatballs Substituted with Red Bean Puree

Iron is an essential micronutrient that plays a vital role in hemoglobin synthesis, oxygen transport throughout the body, and immune system function. Iron deficiency, particularly in children, can lead to iron-deficiency anemia, which is associated with impaired growth and an increased risk of stunting (WHO, 2016). Red beans are a rich plant-based source of iron and, when combined with animal-based sources such as milkfish, can enhance the iron content of food products (Mannan et al., 2023).

The iron content of milkfish meatballs substituted with red bean puree in formulation F1 reached 4.50 mg/100 g, which is considerably higher than the TKPI-estimated value of 1.93 mg. This level also exceeds that of several comparable processed fish products, such as fish sausages and nuggets, which typically contain less than 3 mg/100 g of iron (Kumalasari & Melati, 2025). The relatively high iron content can be attributed to the combined contribution of red beans and milkfish, both of which are notable dietary iron sources. A similar outcome was reported by Adam et al. (2022), who found a high iron content (10.59 mg/100 g) in steamed buns formulated with a combination of animal protein from local shellfish flour and plant protein from red bean paste.

Based on AKG, the daily iron requirement for children ranges from 7–10 mg. If 15% of daily intake is allocated to snacks, the required iron intake from snacks is approximately 1.5 mg (Kementerian Kesehatan Republik Indonesia, 2019). Milkfish meatballs substituted with red bean puree contain approximately 0.67 mg of iron per piece (±15 g); therefore, the consumption of three meatballs is sufficient to meet children's iron requirements from a snack portion.

CONCLUSION

The selected formulation of milkfish meatballs substituted with red bean puree was formulation F1 (35% red bean puree). Formulation F1 achieved the highest acceptability scores for taste and texture attributes. The protein and iron contents of milkfish meatballs substituted with red bean puree were relatively high, amounting to 11.46 g of protein and 4.50 mg of iron per 100 g of product. To meet children's protein requirements from a snack portion, the consumption of four meatballs is required, while three meatballs are sufficient to fulfill iron requirements. This milkfish meatball product demonstrates potential as an alternative food product for local food–based stunting prevention.

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