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Development Nutritional Evaluation and Acceptability of Moringa Moringa oleifera and Eel Monopterus albus Meatballs as a Functional Food for Stunted Toddlers

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ABSTRACT

Stunting remains a major nutritional problem in Indonesia with a relatively high prevalence, particularly in South Sulawesi. One cause is low nutritional intake in toddlers. Moringa leaves (Moringa oleifera) and eel (Monopterus albus) are local foods rich in protein, iron, and vitamins, but their utilization remains low. This study aims to determine the nutritional content and acceptability of a combination of moringa leaf and eel meatballs as a functional food for stunted toddlers. The study used an experimental design with two formulations: F1 (300 g eel: 30 g moringa leaves) and F2 (150 g eel: 15 g moringa leaves). Nutritional analysis was conducted in the laboratory, while acceptability testing was conducted on 6 mothers and 6 toddlers using a 5-point hedonic test. Laboratory test results showed that F1 had a higher protein content (5.68%) than F2 (4.02%), while F2 had higher carbohydrate (26.35%) and energy (125.17 kcal) than F1 (97.48 kcal). Organoleptic tests (n=12) showed high acceptance for color (mean: 4.09) and texture (mean: 4.06), while aroma (mean: 3.46) and flavor (mean: 3.42) were rated moderately acceptable on a 5-point hedonic scale. Thus, the combination of moringa leaf and eel meatballs has the potential to be a locally based functional food alternative to support toddler nutrition and can be used as an innovative strategy to reduce stunting rates in Indonesia.

Keywords: *stunting, toddlers, moringa leaf meatballs, eel, functional food*

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INTRODUCTION

In Indonesia, stunting remains a serious threat to future generations [1][2]. Stunting has the highest prevalence rate compared to other nutritional problems [3]. The prevalence of stunting among Indonesian toddlers is 36.4% [4]. South Sulawesi is one of the three provinces with the highest prevalence of stunting, reaching 35.7% [5]. One of the main factors contributing to stunting in toddlers is unbalanced food intake [6][7]. Stunting occurs due to nutritional problems during pregnancy and early childhood [8].

Interventions to prevent stunting include providing nutritional supplements to pregnant women and toddlers [9][10]. Food serves as a vital source of energy, protein, vitamins, and minerals [11]. The types of food ingredients used in nutritional supplementation are often selected from local sources [12][13]. The development of local ingredients is essential because they have the potential to become functional foods and contribute to sustainable food security [14].

One local food ingredient with excellent nutritional value is Moringa leaves (Moringa oleifera) [15]. Moringa leaves are easy to find in the community and are rich in nutrients such as protein, vitamin A, and iron [16][17][18]. They have been shown to improve the nutritional status of malnourished children [19]. Another local ingredient with high nutritional potential is eel (Monopterus albus), a freshwater fish known for its delicious taste [20][21] and rich content of protein and essential amino acids [22].

The combination of Moringa leaves and eel offers complementary nutritional benefits — Moringa contributes plant-based micronutrients such as iron, calcium, and vitamins, while eel provides high-quality animal protein and essential amino acids. This nutritional synergy makes their combination particularly effective for addressing protein-energy malnutrition and micronutrient deficiencies associated with stunting.

However, despite their high nutrient content, public awareness of Moringa's nutritional value remains limited. Similarly, eel consumption is relatively low because of its snake-like appearance, leading to underutilization of both ingredients in daily diets. In this context, diversifying functional food products can increase community acceptance and consumption of local nutrient-rich foods [23].

One innovative approach is the development of Moringa–eel meatballs, combining both ingredients in a familiar and widely accepted food product [24]. Meatballs are a popular and well-liked food among Indonesians [25][26]. This innovation aligns with national priority programs, including the free nutritious food program and initiatives to strengthen food security and human resource development, as outlined in the 2025–2029 RPJMN (Priority 4: Science, Technology, Education, and Health).

To address the stunting problem, several studies have explored similar interventions. For example, supplementation with Moringa oleifera extract during pregnancy has shown potential to prevent stunting in children aged 36–42 months [15]. Another study developed high-calcium instant porridge made from Moringa leaves [27], using the Borg and Gall research and development method, identifying the best formulation (F3) with 196 kcal per serving. Organoleptic test results from other research also revealed that fish meatballs made with 9.5 g of mackerel and 5 g of Moringa leaf flour achieved the best acceptability [28].

Subsequent research using organoleptic testing methods found that meatballs made with 40% sago flour and 5% moringa flour (P1) had better aroma, chewiness, texture, and taste [29]. Subsequent research found that nutrition education can be used to prevent stunting [30]. Observing the 5 studies above, in general, they have several limitations, including the use of an average research approach and method of only one method, such as organoleptic testing or experimental RCT-DB. In addition, on average, only one type of food is used as the main ingredient without considering other food ingredients that can

complement the nutritional profile of the product. Therefore, researchers offer significant innovations in the context of approaches, methods, and innovations in functional food formulations for stunted toddlers, including: A multicomponent approach: This research does not focus solely on a single food ingredient, but rather combines two nutrient-rich foods, namely moringa leaves and eel. Practical product innovation: By selecting meatballs as the product, this research provides a practical and easily accepted solution. The objectives of this research include: To determine the nutritional content of the meatball formulation (Energy, Protein, Fat, and Carbohydrates), To determine the level of acceptance of the meatball formulation containing a combination of moringa leaves and eel among mothers and toddlers.

METHODS

The research was conducted with an experimental design using a Completely Randomized Design (CRD), with two treatments comparing eel and moringa leaf composition: F1 (300g:30g) and F2 (150g:15g). Preliminary research, including the formulation and production of meatballs combining moringa leaves and eel, was carried out at the Culinary Laboratory of Muhammadiyah University of Parepare. Nutrient content testing—including protein, fat, and carbohydrate analysis—was conducted at the Center for Public Health Laboratory, Makassar. The analysis methods used were:Kjeldahl method for protein determination, Gravimetric method (e.g., Soxhlet extraction) for fat analysis, and Titrimetric method for carbohydrate analysis. Organoleptic testing using the hedonic test method to assess panelists' acceptance of the color, taste, aroma, and texture of moringa leaf–eel meatballs was conducted in Parepare City from July to August 2025.

The process began with the formulation of the moringa leaf–eel meatball combination at the Nutrition Laboratory of Muhammadiyah University of Parepare (during a 1-month period). Tools used included a blender/food processor, knife, cutting board, large

bowl, spoon, large pot, sieve, and stove. Ingredients used were eel, moringa leaves, tapioca flour, wheat flour, eggs, garlic, salt, and water. Data collection was carried out in two stages. A total of 12 panelists participated in the hedonic test, consisting of six mothers and six toddlers. The sampling technique used was convenience sampling, involving individuals who were easily accessible and willing to participate from a specific community area. Inclusion criteria: Mothers aged 20–45 years, oddlers aged 2–5 years who were willing to participate, participants in good health during data collection. Exclusion criteria : Toddlers with food allergies (seafood, eggs, or flour) and participants unable to complete the tasting session. A structured questionnaire was developed to measure panelists' acceptance or preference for moringa leaf–eel meatballs. Assessment included color, taste, aroma, and texture. Acceptability levels were analyzed using an organoleptic test with a hedonic scale ranging from: 5 = very like, 4 = like, 3 = quite like, 2 = less like, 1 = dislike.

RESULTS

Subject characteristics

Subject characteristics according to the criteria of age, occupation, last education and age of the child are described in Table 1 .

Table 1. Subject characteristics based on age, last education, mother's occupation and toddler age

Characteristics	Frequency (f)	Percentage (%)
Mother's Age (Years)		
< 30	2	33.33
31- 40	3	50.0
41- 50	1	16.67
Total	6	100.00
Mother's Last Education		
SENIOR HIGH SCHOOL	4	66.67
Bachelor's Degree (S1)	2	33.33
Total	6	100.00

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Mother's Job		
housewife	3	50.0
Self-employed	3	50.0
Total	6	100.00
Child's Age (Months)		
37 – 48	2	33.33
49 – 60	4	66.67
Total	6	100.0

Table 1 displays the age distribution data of the subjects, with the highest percentage in the 31-40 age group, namely 50%, and the lowest in the 41-50 age group, namely 16.67%. Meanwhile, the highest percentage of the subjects' last education level was high school, namely 66.67%, and the lowest was bachelor's degree (S1), namely 33.33%. In terms of employment, the subjects only had two types of jobs: domestic workers and self-employed, with the same percentage, namely 50%. For children's ages, the highest percentage was in the 49-60 month age group, namely 66.67%, while the lowest was in the 37-48 month age group, namely 33.33%.

Composition and Nutritional Content of Moringa and Eel Meatball Combination

Moringa leaf combination meatballs are made in 2 formulations with the composition as shown in table 2.

Table 2. Composition of meatballs made from a combination of moringa leaves and eel

No	Ingredients Formula	Heavy	
		Formulation 1 (gr)	Formulation 2 (gr)
1	Eel Flour (gr)	300	150
2	Moringa Leaf Flour (gr)	30	15
3	Tapioca (gr)	100	100
4	Wheat flour (gr)	100	100
5	Egg (piece)	1	1
6	Garlic (gr)	2	2

7	Salt (gr)	0.5	0.5

The results of laboratory tests show that the nutritional content (protein, fat, carbohydrates and energy) of meatballs made from a combination of moringa leaves and eel is as shown in table 3.

Table 3. Nutritional content of the meatball formulation combining moringa leaves and eel (per 100 grams)

No.	Contents	Formulation 1	Formulation 2
1	Fat	0.32%	0.41%
2	Protein	5.68%	4.02%
3	Carbohydrate	17.97%	26.35%
4	Energy	97.48 kcal	125.17 kcal

Protein content analysis

Formula 1 showed a higher protein content (5.68%) compared to Formula 2 (4.02%). This is very logical because Formula 1 uses 300 grams of eel flour, more than double the 150 grams used in Formula 2. Eels are an excellent source of animal protein. Therefore, increasing the amount of eel flour in Formula 1 directly increases the protein content of the final product. This indicates that the protein content of the product is significantly influenced by the proportion of eel flour in the formula.

Fat content analysis

Interestingly, although Formula 1 contains more eel flour, its fat content is actually lower (0.32%) than Formula 2 (0.41%). However, the difference in fat content between the formulas is relatively small, and both are considered low-fat products, making them suitable for consumption by the general public, including those with dyslipidemia.

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Carbohydrate and Energy Analysis

Formula 2 contains higher carbohydrates (26.35%) than Formula 1 (17.97%). This increase in carbohydrates is due to the addition of fillers such as tapioca starch and wheat flour, which are present in higher percentages in Formula 2 to compensate for the lower eel flour content. This increase in carbohydrates directly impacts the energy value. Formula 2 produces 125.17 kcal of energy, higher than Formula 1's 97.48 kcal. This indicates that the energy in this product is primarily contributed by carbohydrates, rather than fat or protein.

Based on the above description, it can be concluded that Formula 1 is higher in protein and lower in energy, making it suitable as a high-protein, low-calorie product, ideal for healthy diet programs or those with special nutritional needs (e.g., the elderly or those with metabolic diseases). Meanwhile, Formula 2 is higher in carbohydrates and energy, suitable for groups requiring higher energy intake , such as school-age children or workers with heavy physical activity. Both have very low fat content, making them safe for general consumption.

Acceptability of Meatball Combination of Moringa Leaves and Eel

The analysis of the average subject acceptance of the moringa leaf formulation showed significant results in four indicators, namely color, aroma, texture, and taste, which are presented in Table 4.

Table 4. Average subject response to Meatball formulation containing moringa leaves and eel in terms of color, aroma, texture, and taste

Indicator	Moringa Leaf and Eel Meatball Combination (F1 and F2)	
	Average	Criteria
Color	4.09	Like
Aroma	3.46	Just Like
Texture	4.06	Like
Flavor	3.42	Just Like

The data in Table 4 shows that the average assessment of the subjects for meatballs containing moringa leaves and eel, especially in terms of color and texture indicators, reached the criteria of liking, while the aroma and taste obtained the criteria of liking quite a lot. Acceptability is a method used to assess the extent to which a food product can be accepted by consumers through the involvement of the five senses. This assessment reflects individual preferences for the product, which are measured through organoleptic tests to determine the level of liking or disliking [31]. [32] One approach commonly used is the hedonic test, which is a subjective assessment method for sensory aspects such as color, aroma, texture, and taste, in order to obtain an overview of consumer acceptance of food products [33].

DISCUSISION

Color is one of the visual quality attributes that plays an important role in creating consumers' first impressions of food products, so it is considered a significant organoleptic factor [34] . In the context of food products, bright and attractive colors can increase consumption interest and stimulate people's appetite. The findings of this study indicate that the majority of respondents prefer the color of meatballs made from a combination of moringa and eel, which are considered to have a natural appearance without the addition of synthetic dyes, so they are considered safer for consumption. Several respondents stated that the natural color of the raw materials provides a special attraction. However, there was input that the use of fresher moringa leaves could produce a brighter and more visually appealing meatball color. These results are in line with the findings of Hikmawati Mas'ud (2021) which showed that color is one of the most preferred aspects by consumers in choosing food [35]. In general, various studies confirm that color has a crucial role in forming initial perceptions and increasing consumer acceptance of food products [36].

Aroma is an important indicator in assessing the taste of a food product, because it can provide an impression of deliciousness that influences consumer preferences. Food with a distinctive and attractive aroma is generally more popular with the public [33] . The results of this study indicate that most respondents gave a fairly favorable rating to the aroma of meatballs made from a combination of moringa and eel. This indicates that although the aroma is acceptable, the level of respondents' preference has not yet reached the very favorable category, possibly due to the distinctive aroma of eel which is quite strong. The addition of eel provides a certain aroma characteristic that not all consumers find attractive. Meanwhile, previous research by Khasanah Via (2019) showed that the addition of moringa leaf extract to meatball products with mocaf flour substitution can provide significant differences in sensory characteristics, including color, aroma, and taste [37].

Texture is one of the visual and sensory characteristics that can be directly observed by consumers and contributes greatly in forming initial perceptions of the quality of food products [38] in the context of consumer acceptance, texture has an important role because it can influence the level of liking for a food product [36] based on the results of the study, the majority of respondents stated that they liked the texture of meatballs made from a combination of moringa and eel. The texture of the meatballs was considered soft but still able to maintain its shape well, thus providing a more interesting and satisfying consumption experience for consumers.

Taste is the result of the interaction of various food components that can be assessed through the human sense of taste. [39] The results of this study indicate that most respondents gave a fairly favorable assessment of the taste of meatballs made from a combination of moringa and eel. The bitter taste derived from moringa leaves, caused by the tannin compound content, can still be minimized by adding other appropriate ingredients. However, the presence of eel in the product formulation was considered to

have less positive contribution to taste, possibly because most people are not accustomed to consuming eel. This finding is in line with the research of Katmawanti et al. (2021), which stated that in baby porridge products with moringa leaf substitution, taste attributes have a significant influence on the results of organoleptic evaluation.

The findings in this study support the results of previous studies which stated that the use of moringa leaves as a substitute ingredient in food products can produce a good level of acceptability, especially in terms of color, aroma, texture, and taste [39] . This study also strengthens the evidence that the addition of moringa leaf flour in the formulation of new cake products has the potential to be well received by consumers based on these sensory attributes [31] . Based on the test results, the formulation of meatballs made from moringa and eel has the potential to be developed as a food that is suitable for daily consumption. Moringa leaves themselves have prospects as a functional food ingredient or natural additive. In addition, one of the advantages of meatballs using eel is the high protein content compared to conventional meatballs on the market [40].

CONCLUSION

This study demonstrates that the meatball formulations combining moringa leaves and eel have potential as functional foods for stunting prevention. Formula 1, which contains a higher proportion of eel, yields a greater protein content, while Formula 2 provides higher carbohydrate and energy levels. Both formulations also contain low fat. The organoleptic assessment showed that the color and texture were highly preferred by the panelists, while the aroma and taste received moderately favorable ratings. These findings indicate that local food innovations based on moringa leaves and eel are acceptable to the community. Therefore, the developed formulations have the potential to serve as locally based functional food options to support child nutrition and contribute to stunting reduction efforts in Indonesia.

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