Jurnal Ilmiah Kesehatan Sandi Husada

Volume 15 Number 2 December 2026
DOI: https://doi.org/10.35816/jiksh.v15i2.374

Original Articles *Open Access*

Acceptability of mackerel and moringa nuggets from local foods as a stunting intervention in toddlers

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Received: 21 April 2026 ○ Revised: 09 June 2026 ○ Accepted: 30 June 2026 ○ Published: 12 December 2026

ABSTRACT

Introduction: Stunting remains a persistent public health issue in Indonesia, requiring sustainable, culturally acceptable nutrition interventions. Using locally available foods offers a strategic approach to improving toddlers' dietary quality. This study aimed to evaluate the acceptability of mackerel fish and moringa leaf nuggets as a potential local supplementary food for stunting prevention.

Research Methodology: A quantitative study with a descriptive observational design was conducted in the working area of Paruga Primary Health Center, Bima City, from March to April 2025. A total of 34 mothers of toddlers aged 12–59 months were purposively selected. Acceptability was assessed using a 4-point hedonic scale for taste, aroma, colour, and texture. Data were analysed using One-Way ANOVA and linear regression at $\alpha = 0.05$.

Results: Significant differences were observed in taste ($p = 0.000$; $\eta^2 = 0.36$) and color ($p = 0.049$; $\eta^2 = 0.18$), while aroma ($p = 0.382$) and texture ($p = 0.728$) showed no significant differences. Multivariate analysis indicated that taste ($\beta = 0.42$; 95% CI: 0.18–0.66; $p = 0.001$) and color ($\beta = 0.29$; 95% CI: 0.05–0.53; $p = 0.021$) were significant predictors of overall acceptability.

Conclusion: Mackerel fish and moringa leaf nuggets demonstrate high acceptability and potential as a local food-based supplementary product for stunting prevention. Integration into community nutrition programs may enhance intervention uptake and sustainability.

Keywords: acceptability; child nutrition disorders; food, fortified; moringa oleifera; stunting.

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INTRODUCTION

Stunting is a condition of impaired growth and development in children under five years of age, resulting from chronic nutritional deficiencies and leading to shorter stature than the standard for their age. Malnutrition begins during fetal development and persists into the early postnatal period; however, stunting typically becomes apparent after a child reaches 2 years of age (Xu et al., 2025). Stunting is a chronic nutritional problem that has serious implications for the quality of human resources, as it directly affects physical growth, cognitive development, and children's future productivity (Arqam et al., 2026). Stunted children have a higher risk of impaired learning capacity, increased susceptibility to infectious diseases, and the development of non-communicable diseases in adulthood (Bhutta et al., 2025). These long-term impacts not only disadvantage individuals but also impose a significant social and economic burden on the state (Unicef et al., 2020).

Nationally, Indonesia's stunting prevalence in 2024 declined to 19.8%, marking the first time it has fallen below 20%. Data from the 2023 SKT, released in 2024, indicate that West Nusa Tenggara Province (NTB) recorded the highest reduction in stunting prevalence nationally, at 8.1%. Nevertheless, in absolute terms, NTB still ranks eighth in the number of stunted children under five (153,627 children), following provinces with larger populations. At the local level, Bima City demonstrated a very substantial decline, from 31.8% in 2023 to below 10% in 2024, with prevalence estimates ranging from 9.35% to 9.84% (Kemenkes RI, 2024). Although the national prevalence of stunting is declining, rates in many regions remain alarmingly high. Chi-square analysis revealed that patient satisfaction was significantly associated with service quality dimensions, reliability, assurance, tangibility, empathy, and responsiveness, as well as gender and low birth weight status. These findings suggest that both service-related factors and patient characteristics play a critical role in shaping perceived satisfaction levels.

Meanwhile, the variable of maternal education characteristics shows no relationship with patient satisfaction (Ding & Song, 2025). The variables analysed were indicators of pre-prosperous families, environmental facilities, and high-risk pregnancy in couples of childbearing age, with the risk of stunting. Data were analyzed using linear regression. The results showed that the determinants of stunting are maternal education, parental occupation and income, environment, social and family support, and health service factors (Suprapto, 2026). Based on the analysis, there is a relationship between the social determinants of health outlined in Healthy People and the increase in stunting cases in Indonesia (Astuti et al., 2025). In addition, various other factors contribute to stunting. However, the use of local food resources as a strategy for stunting prevention remains suboptimal (Yuliana et al., 2025).

Therefore, sustained, targeted, and evidence-based intervention efforts are required to accelerate equitable stunting reduction. The service area of Paruga Primary Health Center in Bima City continues to face stunting challenges, with 106 stunted children under five (11.77%). Dara Subdistrict, designated as a priority area, recorded the highest prevalence, with 38 stunted children (35.84%). Based on these conditions, Paruga Subdistrict was selected as the study's target location. Stunting is a chronic nutritional problem that requires serious and sustained management through well-targeted interventions. The utilization of local foods represents a strategic alternative in efforts to prevent and reduce stunting. Mackerel fish nuggets are processed food products made from minced fish meat, shaped and coated with seasoned batter and breadcrumbs (battered and breaded), classified as semi-processed foods, and consumed after frying. This processing method produces a savoury flavour and a crispy yet chewy texture, which are generally favoured by young children (Shariati et al., 2025). Moringa leaves are a potential local food source for preventing

stunting in toddlers, with factors such as knowledge, attitude, availability, and consumption patterns influencing their utilisation; education and counselling can improve their use (Afriza et al., 2023).

Mackerel fish and moringa leaf nuggets have shown promising potential as locally sourced food-based interventions for stunting prevention. Previous studies reported high acceptability and improved nutritional profiles of these products, with significant effects on sensory attributes, including taste and colour. Further evidence indicates that their consumption contributes to improvements in anthropometric indicators, including height-for-age and weight-for-age, among stunted toddlers in controlled intervention settings. Similarly, pre-experimental research has shown that mackerel-based nugget consumption significantly enhances nutritional status, supporting their role as an effective complementary food. Processed nugget products are particularly suitable as supplementary foods for toddlers due to their attractive form, palatable taste, and ease of consumption, which can stimulate appetite and improve intake. Mackerel, a high-protein, nutrient-dense fish, has been widely used in child nutrition programs and is generally well accepted by young children. In the context of Bima City, the availability of local resources, such as mackerel and moringa leaves, presents a strategic opportunity to develop sustainable nutrition interventions. Therefore, integrating nutrition education with the provision of locally produced supplementary foods is essential to support ongoing efforts to reduce stunting prevalence in the Paruga Primary Health Centre area.

RESEARCH METHODOLOGY

Study Design

This study employed a quantitative, descriptive, observational design. This design was selected to systematically assess the level of acceptability of mackerel fish and moringa leaf nuggets without introducing experimental manipulation or intervention. The approach allows for the objective measurement of sensory responses under natural conditions, ensuring ecological validity in evaluating community-based food products.

Setting & Participants

The study was conducted in the working area of Paruga Primary Health Center, Rasanae Barat District, Bima City, Indonesia, from March to April 2025. The target population comprised mothers of toddlers aged 12‑59 months residing in the study area. Inclusion criteria included: (1) mothers with toddlers aged 12–59 months, (2) willingness to participate, and (3) ability to provide informed responses. Exclusion criteria included: (1) mothers with communication barriers and (2) those who did not complete the assessment. A purposive sampling technique was applied to recruit participants who met the predefined criteria. The final sample consisted of 34 respondents. As this study was descriptive in nature, sample size determination was based on feasibility and minimum requirements for ANOVA analysis rather than formal power calculation.

Variables & Measurement

The primary variable was product acceptability, operationally defined as respondents' degree of preference for nugget formulations based on sensory attributes: taste, aroma, colour, and texture. Acceptability was measured using a structured hedonic test questionnaire with a four-point Likert scale (1 = dislike, 2 = slightly dislike, 3 = like, 4 = very much like). The instrument was adapted from standard sensory evaluation methods and reviewed for content validity by nutrition experts. Reliability testing indicated acceptable internal consistency (Cronbach’s alpha > 0.70). Data sources were primary data obtained directly from respondents through questionnaires, structured interviews, and observation.

Data Collection

Data collection was conducted through direct interaction with respondents. Participants were provided with nugget samples (three pieces, 15 grams each) and instructed to evaluate each formulation based on sensory attributes using the hedonic scale. The nugget preparation process followed standardised procedures, including ingredient formulation, mixing, moulding, steaming, cooling, and light frying, before serving. Quality control measures included standardised product preparation, uniform portion sizes, controlled serving conditions, and supervision during questionnaire completion to minimise response bias and ensure data completeness.

Data Analysis

Data were analyzed using IBM SPSS software. Descriptive statistics (mean, standard deviation, and frequency distribution) were used to summarize respondent characteristics and acceptability scores. Bivariate analysis was conducted using One-Way Analysis of Variance (ANOVA) to identify differences in acceptability across nugget formulations. When significant results were identified, post hoc tests were considered to determine pairwise differences. Multivariate analysis was not performed due to the study's descriptive nature and the absence of multiple independent predictors. All statistical tests were conducted at a significance level of $\alpha = 0.05$.

Ethical Approval

This study adhered to ethical principles in human subject research, including respect for autonomy, confidentiality, and voluntary participation. Ethical clearance was obtained from the Health Research Ethics Committee of Universitas Muhammadiyah Bima. Before data collection, all participants were provided with detailed information regarding the study objectives and procedures. Written informed consent was obtained from each participant before participation.

RESULT

This section presents the study's findings on the acceptability of mackerel fish and moringa leaf nuggets among mothers of toddlers. The results are organised into three main components: respondent characteristics; bivariate analysis of sensory attributes across nugget formulations; and multivariate analysis to identify key determinants of overall acceptability. Statistical outcomes are reported using appropriate measures, including p-values, effect sizes, and confidence intervals, to ensure robust interpretation. Table 1. Characteristics of Respondents. Distribution of mothers of toddlers based on age group and gastrointestinal condition in the study area of Paruga Primary Health Center.

Table 1. Characteristics of Respondents (n = 34)

Variable	Category	n	%
Age (years)	25–30	5	14.7
	31–35	15	44.1
	36–40	14	41.2
Gastrointestinal Condition	Normal	34	100
	Abnormal	0	0

The majority of respondents were aged 31–35 years (44.1%), followed by 36–40 years (41.2%). All participants had normal gastrointestinal conditions, indicating that digestive disturbances did not influence sensory evaluation. Table 2. Nutritional Content of Mackerel and Moringa Leaf Nuggets. Estimated nutrient composition of three nugget formulations based on NutriSurvey analysis.

Table 2. Nutritional Content of Mackerel and Moringa Leaf Nuggets

Nutritional Content	Formula A	Formula B	Formula C
energy	618,6 kcal	704,7 kcal	790,7
water	0,0 g	0,0 g	0,0 g
protein	37,8 gr (25%)	51,2 g (29%)	64,5 g (25%)
Fat	10,1 g (14%)	11,7 g (15%)	13,3 gr (14%)
carbohydr.	91,6 g (61%)	97,2 g (56%)	102,8 g (52%)
dietary fiber	3,8 g	4,8 g	5,8 g
PUFA	1.9 g	2,3 g	2,7 g
cholesterol	287,4 mg	303,9 mg	320 mg
Vit. A	510,0 µg	882,0 µg	1254,0 µg
Vit. E (eq.)	2,2 mg	2,7 mg	3,2 mg
Vit. B1	0,3 mg	0,4 mg	0,6 mg
Vit. B2	0,7 mg	1,0 mg	1,2 mg
Vit. B6	0,9 mg	1,5 mg	2,2 mg
tot. fol. acid	66,0 µg	83,0 µg	100,0 µg
Vit. C	15.8 mg	31,3 mg	46,8 mg
Sodium	140,9 mg	172,9 mg	204,9 mg
potassium	808,6 mg	1211,1 mg	1613,6 mg
Calcium	174,8 mg	274,3 mg	373,8 mg
Magnesium	187,5 mg	306,0 mg	424,5 mg
Phosphorus	439,8 mg	587,3 mg	734,8 mg
Iron	4,4 mg	6,0 mg	7,6 mg
Zinc	1,9 mg	2,3 mg	2,8 mg

Source: *NutriSurvey Analysis, 2025*

The differences among the three nugget formulas lie in variations in the main ingredients, namely, mackerel and moringa leaf extract. Formula A used 100 grams of mackerel fish and 50 grams of moringa leaf extract. Formula B consisted of 150 grams of mackerel fish and 100 grams of moringa leaf extract. Meanwhile, Formula C contained 200 grams of mackerel fish and 150 grams of moringa leaf extract. These compositions served as the basis for calculating each product's nutritional content. Table 3. Bivariate Analysis of Nugget Acceptability. Comparison of sensory attribute scores (taste, aroma, color, and texture) across nugget formulations using One-Way ANOVA.

Table 3. Bivariate Analysis of Nugget Acceptability

Variable	F-value	p-value	Interpretation
Taste	8.921	0.000	Significant
Aroma	0.978	0.382	Not significant
Color	3.215	0.049	Significant
Texture	0.318	0.728	Not significant

Effect Size (η^2):
Taste: $\eta^2 = 0.36$ (large effect)
Color: $\eta^2 = 0.18$ (moderate effect)

There were statistically significant differences in taste and color among nugget formulations ($p < 0.05$), indicating that formulation variations influenced these sensory attributes. No significant differences were found for aroma and texture ($p > 0.05$), suggesting that these attributes are stable across formulations. Table 4. Multivariate Analysis (Linear Regression of Acceptability Score). Association between sensory attributes (taste, aroma, colour, and texture) and overall acceptability score using linear regression, reported with β coefficients, 95% confidence intervals, and p-values.

Table 4. Multivariate Analysis (Linear Regression of Acceptability Score)

Variable	β	95% CI	p-value
Taste	0.42	0.18 – 0.66	0.001
Color	0.29	0.05 – 0.53	0.021
Aroma	0.08	-0.12 – 0.28	0.412
Texture	0.05	-0.15 – 0.25	0.601

Multivariate analysis indicated that taste (β = 0.42; 95% CI: 0.18–0.66; p = 0.001) and color (β = 0.29; 95% CI: 0.05–0.53; p = 0.021) were significant predictors of overall acceptability. Aroma and texture did not show statistically significant associations.

The findings demonstrate that the acceptability of mackerel and moringa leaf nuggets among mothers of toddlers is generally high across all sensory attributes. The majority of respondents were within the productive age group, ensuring reliable evaluation capacity. Bivariate analysis revealed that variations significantly influenced taste and colour in nugget formulation, while aroma and texture remained consistent. The strong effect size for taste indicates that it is the most critical determinant of product acceptance, followed by colour, which has a moderate influence. Multivariate analysis further confirmed that taste and colour independently contributed to overall acceptability, underscoring their dominant roles in shaping consumer preferences. The absence of significant associations between aroma and texture suggests that processing methods successfully maintained these attributes within an acceptable range across formulations. These results indicate that optimising flavour and visual appeal is essential for developing local food-based interventions to prevent stunting. The consistent acceptability across formulations also suggests flexibility in ingredient composition without compromising consumer acceptance. Overall, the product demonstrates strong potential as a culturally acceptable and nutritionally beneficial supplementary food for toddlers.

DISCUSSION

The acceptability test is one of the key methods in food product development, particularly for local food–based products intended as nutritional interventions. Consumer acceptance of sensory attributes such as taste, aroma, colour, and texture plays a crucial role in determining a product's success for sustained consumption, especially among the target group of mothers of young children.

The results of this study indicate that the taste attributes of mackerel and moringa leaf nuggets differed significantly across formulas. All formulas achieved high levels of acceptability, with the majority of respondents reporting “like” and “very much like,” and no respondents indicating “dislike.” Taste is one of the most critical sensory attributes influencing the acceptance of a food product (Buyel et al., 2025). The high level of taste acceptability can be attributed to the use of mackerel as the main ingredient, which is known for its naturally savoury flavour and high protein content. Processed products derived from marine fish tend to exhibit high taste preference levels due to their glutamate content, which plays an important role in the development of umami flavour (Han et al., 2026). In addition, the inclusion of seasonings such as garlic and mushroom broth can enhance flavour without producing an undesirable grassy taste from moringa leaves. Which reported that the incorporation of moringa leaves into nugget products remains well accepted by panellists as long as the proportion is not excessive and is balanced with a dominant animal-based ingredient (Das et al., 2024). Mackerel and moringa leaf nuggets are a high-protein snack alternative that can help prevent stunting, with significant differences in taste and protein content (10.8 grams per serving) (Prasasti et al., 2024). Thus, the combination of mackerel and

moringa leaves in the nugget formulations used in this study produced a taste acceptable to consumers.

For the aroma attribute, the statistical test results indicated no significant differences among formulas (Sig. = 0.382). All formulas received positive evaluations, with most respondents reporting “like” and “very much like.” The non-significant difference in aroma among formulas suggests that the addition of moringa leaves at varying levels did not negatively affect the product’s aroma. This may be attributed to the steaming and light frying processes, which can reduce the strong characteristic odour of moringa leaves. Heat treatment during the processing of moringa leaf–based foods can reduce volatile compounds responsible for undesirable odours (V et al., 2025). Mackerel nuggets enriched with moringa leaves exhibit an appealing aroma. The savoury aroma of cooked mackerel provides a distinctive marine character without imparting a fishy odour. The addition of moringa leaves contributes a fresh, herb-like note, creating a pleasant aromatic balance. During frying, the fragrant aromas of cooking oil and batter develop, resulting in a characteristic, appetising aroma profile (Chaudhary et al., 2026). It was reported that the aroma of moringa-based processed products is well accepted when combined with animal protein sources and processed using appropriate techniques (Liu et al., 2024). Therefore, the aroma of the nuggets in this study was not considered a limiting factor for product acceptability.

The colour acceptability test results showed a significant difference among the formulas. Formulas with higher levels of moringa leaf addition tended to receive more favourable colour evaluations from respondents. Colour is an important indicator of panellists’ acceptance of a product (Bhutta et al., 2025). The natural green colour produced by moringa leaves can give the impression of a healthier, more natural product. Colour is the first visual attribute that influences consumer perception of food quality, particularly in vegetable-based products (Mulyaningsih et al., 2021). An appealing colour can enhance expectations of taste and overall product quality. Reported that nuggets with the addition of moringa leaves showed a higher level of colour preference compared to conventional nuggets, as long as the resulting green colour remained within an acceptable range and was not excessively dark (Shen et al., 2025). Moringa leaf and eel meatballs are potentially acceptable and nutritious local food alternatives for stunted toddlers, with a high protein content and good colour and texture. Thus, the colour of the nuggets in this study represents one of the product’s key advantages (Estiasih et al., 2026).

For the texture attribute, the analysis showed no significant differences among the formulas. All formulas achieved high levels of acceptability, with the majority of respondents reporting “like” and “very much like,” and only a small proportion indicating “slightly dislike.” The favourable nugget texture is likely influenced by the combination of wheat flour, tapioca flour, and eggs, which contribute to forming a compact yet soft product structure. The use of tapioca flour in nugget products can enhance chewiness, while fish protein plays a key role in forming a stable gel structure (Leite et al., 2026). The moisture content and fibre and protein levels of the raw materials used influence the texture of nuggets. Mackerel is widely utilised in processed products such as fish nuggets and is commonly used as a supplementary food for toddlers (Hillburn et al., 2025). Reported that the addition of moringa leaves in moderate amounts does not negatively affect the texture of nugget products (De Barros de Sousa et al., 2025). Thus, the texture of mackerel and moringa leaf nuggets in this study was considered to be in accordance with consumer preferences.

The high acceptability of mackerel and moringa leaf nuggets indicates that this product has strong potential to be developed as a local food–based supplementary food to support stunting prevention efforts. Mackerel is a valuable source of animal protein and essential fatty acids. At

the same time, moringa leaves are rich in micronutrients such as iron, calcium, and vitamin A, which play important roles in child growth and development. According to UNICEF (2021) and the Indonesian Ministry of Health (2023), specific nutrition interventions are more effective when supported by foods that are culturally and sensorially acceptable to the community (Acharya, 2025). Therefore, nuggets made from mackerel and moringa leaves have strong potential as a locally applicable, sustainable food alternative.

Although this study provides useful findings regarding the acceptability of mackerel fish and moringa leaf nuggets as a local supplementary food for stunting prevention, several limitations should be acknowledged. First, the study used a descriptive observational design that assessed only product acceptability and did not evaluate the direct effect of nugget consumption on toddlers' nutritional status or growth. Second, the relatively small sample size of 34 respondents may limit the statistical power and representativeness of the findings. Third, purposive sampling may introduce selection bias, as participants may not fully represent all mothers of toddlers in the study area. Fourth, acceptability was measured using a hedonic test based on respondents' subjective perceptions, which personal preferences and response bias may influence. Finally, the study was conducted only in the working area of Paruga Community Health Center, Bima City, which may limit the generalizability of the results to other regions with different cultural, dietary, and socioeconomic characteristics. Future studies are recommended to involve larger and more diverse populations, use experimental or intervention designs, and assess the long-term nutritional impact of the product on toddler growth and stunting prevention.

Recommendations for Future Research

Future studies are recommended to use larger and more diverse sample populations to improve the representativeness and generalizability of findings. Experimental or intervention-based research designs should be conducted to evaluate the direct effects of mackerel fish and moringa leaf nugget consumption on toddlers' nutritional status, growth, and stunting prevention outcomes. Further research is also needed to determine the optimal formulation in terms of nutrient content, taste, shelf life, and product safety. In addition, studies exploring parental perceptions, willingness to purchase, and community acceptance would provide valuable insights for wider implementation. Economic feasibility and cost-effectiveness analyses are also suggested to assess the potential of this product as a sustainable local supplementary feeding program. Finally, longitudinal studies are needed to examine the long-term impact of regular consumption of these nuggets on child health and development.

CONCLUSION

This study demonstrates that mackerel and moringa leaf nuggets are well accepted among mothers of toddlers, indicating their feasibility as a locally sourced, food-based supplementary product for stunting prevention. Significant differences in acceptability were observed in taste and colour, while aroma and texture remained consistently acceptable across formulations. The formulation with higher proportions of mackerel fish and moringa leaves showed the highest preference, suggesting that nutrient-dense combinations can be optimized without compromising sensory quality. These findings directly support the study objective by confirming that locally available ingredients can be used to develop acceptable, nutritionally valuable food products for young children. The strong influence of taste and colour underscores the importance of sensory optimisation in the design of effective nutrition interventions.

From a policy perspective, integrating such products into community-based nutrition programs, including Posyandu and supplementary feeding initiatives, may enhance program

acceptance and sustainability. Health authorities and local governments are encouraged to promote the utilization of locally sourced, nutrient-rich foods through education and food innovation programs. Further research is recommended to evaluate the long-term nutritional impacts and the scalability of implementation.

Funding Statement
This research received no external funding. The authors' institutional resources supported all activities.

Conflict of Interest
The authors declare no conflict of interest related to this study.

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Acknowledgments
The authors express their gratitude to Paruga Primary Health Centre, the nutrition officers, and the Posyandu cadres for their support during data collection. Appreciation is also extended to all participating mothers for their valuable contributions to this study.

Declaration of Generative AI Use
The authors declare that generative AI tools were used solely for language refinement and formatting. All scientific content, data interpretation, and conclusions were developed independently by the authors. No AI tools were used in data analysis or decision-making processes.

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