Vol. 15, No. 4 (2026): 1323 - 1333 http://dx.doi.org/10.23960/jtepl.v15i4.1323-1333

JURNAL TEKNIK PERTANIAN LAMPUNG

ISSN 2302-559X (print) / 2549-0818 (online)
Journal homepage : https://jurnal.fp.unila.ac.id/index.php/JTP

Formulation of Nutrient-Dense Snack Bars Based on Local Food Sources for Stunting Prevention: Proximate and Micronutrient Characteristics

Naema Bora[1,✉], Jhon Tibo Kana Tiri[1], Marthen Y. Saubaiki[1]

[1] Department of Food Engineering Technology, State Agricultural Polytechnic of Kupang, Kupang, INDONESIA.

Article History:

Received : 22 December 2025
Revised : 17 March 2026
Accepted : 07 May 2026

Keywords:

Local food,
Micronutriens,
Proksymate analysis,
Snack bar,
Stunting prevention.

Corresponding Author:
✉ naemabora69@gmail.com
(Naema Bora)

ABSTRACT

Stunting remains a significant public health concern in Indonesia, particularly in regions with limited access to nutritious foods, such as East Nusa Tenggara Province (NTT). This study aimed to develop and evaluate a high nutrient snack bar formulated from a combination of four local ingredients (purple sweet potato, mung beans, anchovies, and moringa leaves). A completely randomized design (CRD) of five formulations was performed in triplicates. Proximate composition (moisture, protein, fat, carbohydrate, and ash) and selected micronutrients (vitamin C, iron, and omega-3 fatty acids) were analyzed. Results indicated that ingredient composition significantly influenced the nutritional profiles of the snack bars. Formulations F3 and F4 exhibited superior nutrient density, characterized by higher levels of protein, fat, and omega-3 fatty acids, along with lower moisture content, whereas formulation F2 showed the highest sensory acceptability. In terms of micronutrient content, F1 and F5 contained higher levels of vitamin C and iron, while F3 and F4 were richer in omega-3 fatty acids. These findings highlight a trade-off between nutritional quality and sensory acceptance, with each formulation demonstrating distinct functional properties. The development of snack bars based on local ingredients shows strong potential as a functional food for stunting prevention through a food-to-food fortification approach.

1. INTRODUCTION

Stunting is a chronic nutritional disorder characterized by impaired linear growth, in which a child's height falls below the age-specific standard due to prolonged inadequate nutrient intake. This condition not only affects physical development but also has significant implications for cognitive function, learning capacity, and future productivity (McGovern *et al*., 2017). In Indonesia, stunting remains a major public health priority. East Nusa Tenggara Province (NTT) is among the regions with the highest prevalence, reaching 37.9% (Kementerian Kesehatan Republik Indonesia, 2022). The high prevalence of stunting in this region is influenced by multiple interrelated factors, including limited access to nutritious foods due to geographical constraints, low house-hold purchasing power, inadequate nutritional knowledge at the family level, and socioeconomic conditions that hinder household food security (Wicaksono *et al*., 2021; Suratri *et al*., 2023; Picauly *et al*., 2024; Hariawan *et al*., 2024).

Despite these challenges, NTT possesses abundant and diverse local food resources. However, their utilization as functional food ingredients for nutritional interventions remains suboptimal (Bora *et al*., 2025). Several locally available food commodities with high nutritional value include purple sweet potatoes (*Ipomoea batatas*), mung beans, anchovies, and moringa leaves (*Moringa oleifera*). Purple sweet potatoes are rich in complex carbohydrates and bioactive compounds such as anthocyanins with antioxidant properties. Mung beans provide plant-based protein, dietary fiber, and iron. Anchovies are an excellent source of high-quality animal protein, omega-3 fatty acids, and vitamin D. Meanwhile, moringa leaves are widely recognized as a nutrient-dense local "superfood" due to their high content of protein, vitamins, minerals, and phenolic compounds (Nordhagen *et al*., 2020; Kotsou *et al*., 2023).

Previous studies have developed supplementary food products based on local ingredients, including snack bars derived from moringa leaves, tubers, or selected ingredient combinations (Den *et al*., 2018; Hartati & Ridhoi, 2021). However, most of these studies have focused on the use of one or two ingredients, leaving the potential nutritional synergy from combining multiple local food sources largely unexplored. The integration of purple sweet potatoes, mung beans, anchovies, and moringa leaves offers a promising approach to producing nutrient-dense food products through synergistic interactions. For instance, the combination of plant-based and animal-based proteins may enhance amino acid balance and improve overall protein quality (Aliya *et al*., 2016).

Snack bars are convenient, ready-to-eat products with flexible formulations that can incorporate a wide range of functional ingredients. This makes them a promising vehicle for delivering essential nutrients to prevent stunting through supplementary feeding programs (Dewanti *et al*., 2025). Therefore, this study focuses on the development of nutrient-dense snack bars based on a combination of purple sweet potatoes, mung beans, anchovies, and moringa leaves as sources of carbohydrates, protein, and essential micronutrients.

The objective of this study was to formulate nutrient-dense snack bars using a combination of purple sweet potatoes, mung beans, anchovies, and moringa leaves, and to evaluate the proximate and micronutrient characteristics of five different formulations.The novelty of this study lies in the integration of four local food ingredients into a single product formulation to produce snack bars with enhanced proximate and micronutrient characteristics, supporting stunting prevention through a food-to-food fortification approach.

2. MATERIALS AND METHODS

2.1. Materials

This study was conducted from June to September 2025 at the Agricultural Product Technology Laboratory and the Food Quality Control Laboratory (PMP), State Agricultural Polytechnic of Kupang, as well as at the Food and Nutrition Laboratory, Universitas Gadjah Mada, Yogyakarta.

The primary materials consisted of purple sweet potatoes, mung beans, dried anchovies, and fresh moringa leaves, which were processed into flour. Flour preparation involved drying the raw materials in a Memmert UN55 drying oven (Memmert GmbH, Germany) at 60 °C for 8 h, followed by grinding using a Philips HR2115 blender and sieving through an 80-mesh sieve to obtain uniform particle size. Additional ingredients included wheat flour, granulated sugar, margarine, chicken eggs, and butter. The main equipment used in this study included a drying oven (Memmert UN55), mixer (Philips HR3745), digital balance (Ohaus Pioneer), baking oven (Oxone OX-858), aluminum baking trays, and standard laboratory glassware. Analytical instruments included a muffle furnace, pH meter, Atomic Absorption Spectrophotometer (AAS), and Gas Chromatograph (GC).

2.2. Experimental Design and Snack Bar Formulation

The study employed a single-factor Completely Randomized Design (CRD) consisting of five snack bar formulations (F1, F2, F3, F4, and F5) baseb on local food materials, namely purple sweet potato (PS), mung bean (MB), anchovy (An), and moringa leaf (ML). Each treatment was replicated three times, resulting in a total of 15 experimental units.

The composition of each treatment was detailed in Table 1. These formulations were developed based on the nutritional characteristics of the raw materials and preliminary trials to achieve a balance between texture, nutritional value, and sensory acceptability. Purple sweet potato functioned as the primary carbohydrate source, while mung beans, anchovies, and moringa leaves served as sources of protein and micronutrients.

Table 1. Ingredient composition (%) of snack bar

Formula	Purple Sweet Potato	Mung Bean	Anchovy	Moringa Leaf	Additional	Total
F1	45	20	10	10	15	100
F2	45	20	15	5	15	100
F3	40	15	20	10	15	100
F4	40	15	15	15	15	100
F5	50	10	10	15	15	100

All ingredients were weighed according to the formulation and mixed until homogeneous using a dough mixer. The dough was then molded into bars (10 × 3 × 1.5 cm) and baked at 160 °C for 25 min to obtain a compact and uniformly cooked product.

2.3. Measured Parameters

Proximate analysis was conducted according to AOAC standard methods (AOAC, 2019), including moisture content (AOAC 925.10, oven method), protein content (AOAC 2001.11, Kjeldahl method), fat content (AOAC 920.39, Soxhlet method), and ash content (AOAC 923.03, gravimetric method using a muffle furnace). Carbohydrate content was calculated using the Luff–Schoorl method.

Vitamin C content was determined by iodimetric titration following extraction with 0.4% oxalic acid solution. Iron (Fe) content was analyzed using Atomic Absorption Spectrophotometry (AAS) after wet digestion with a nitric acid (HNO_3) and perchloric acid ($HClO_4$) mixture. Omega-3 fatty acids were analyzed using Gas Chromatography (GC) after Soxhlet extraction and methylation to produce fatty acid methyl esters (FAME).

2.4. Data Analysis

Data obtained from proximate and micronutrient analyses were subjected to Analysis of Variance (ANOVA) at a 5% significance level. When significant differences among treatments were observed, mean comparisons were tested using the Honestly Significant Difference (HSD) test. Statistical analyses were done using IBM SPSS Statistics version 25.

3. RESULTS AND DISCUSSION

3.1. Proximate Characteristics of Nutrient-Dense Snack Bars

Proximate analysis of the five snack bar formulations based on purple sweet potato flour, mung bean flour, anchovy flour, and moringa leaf flour showed that variations in ingredient composition significantly affected the nutritional profile, including macronutrients (carbohydrates, protein, and fat) and the mineral indicator (ash). These differences indicate that formulation design determines the functional orientation of the product, whether as energy-dense, nutrient-dense, or sensory-acceptable food. The proximate characteristic for the five formulations are presented in Figures 1–5.

3.1.1. Moisture Content

Analysis of variance showed that formulation differences significantly affected snack bar moisture content ($p < 0.05$). Product moisture ranged from 3.59% to 10.65%, with F3 showing the lowest value (3.59%) and F5 the highest (10.65%). This pattern indicates that ingredient composition plays an important role in determining final product moisture (Figure 1).

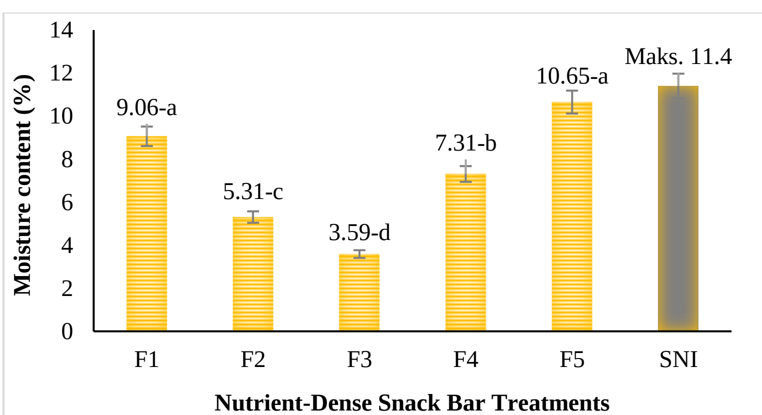

Figure 1. Moisture content of snack bars composed of purple sweet potato, mung bean, anchovy, and moringa leaf flours.

Differences in moisture content were mainly associated with the proportions of anchovy flour and purple sweet potato flour. F3, which contained the highest anchovy flour proportion (20%) and the lowest purple sweet potato flour proportion (40%), produced the lowest moisture level. Anchovy flour is relatively dry and protein-rich, with strong water-binding capacity, thereby reducing final moisture content. In contrast, F5, with the highest purple sweet potato flour proportion (50%) and the lowest anchovy proportion (10%), showed the highest moisture value. Purple sweet potato is known to be hygroscopic and to have high water-retention capacity, which can increase moisture in the product matrix. This finding is consistent with Squeo *et al*. (2023), who reported that increasing the proportion of high-protein, low-moisture ingredients tends to reduce moisture in snack bars.

All formulations complied with SNI 01-4216-1996 for snack bars, which specifies a maximum moisture content of 11.4%. Technologically, this indicates that the products are relatively safe from microbiological deterioration and have good shelf-life potential. Low moisture values, as observed in F3 and F2, are desirable in dry foods because they inhibit microbial growth and help maintain textural and sensory stability during storage. The moisture range obtained in this study is also comparable to that reported in similar studies (approximately 5–10%), depending on raw material type and baking conditions (Rabadán *et al*., 2021).

3.1.2. Carbohydrate Content

Analysis of variance showed that formulation differences significantly affected carbohydrate content ($p < 0.05$). Carbohydrate values ranged from 25.61% to 36.78% (Figure 2), with F5 showing the highest carbohydrate content (36.78%) and F3 the lowest (25.61%). This difference is primarily attributable to the proportion of purple sweet potato flour as the principal carbohydrate source. Increasing purple sweet potato flour increased total carbohydrate content, whereas increasing protein-rich ingredients, especially anchovy flour, reduced carbohydrate percentage (Rabadán *et al*., 2021). Carbohydrates in these snack bars are dominated by complex carbohydrates from purple sweet potato, which provide sustained energy release and contribute bioactive compounds such as antioxidant anthocyanins (Squeo *et al*., 2023). The carbohydrate range remained within that of comparable cereal- and tuber-based products (approximately 25–80%) (Drewnowski *et al*., 2022). Functionally, high-carbohydrate formulations such as F5 are more suitable as energy-dense snacks, whereas lower-carbohydrate but higher-protein formulations such as F3 are better classified as nutrient-dense functional foods.

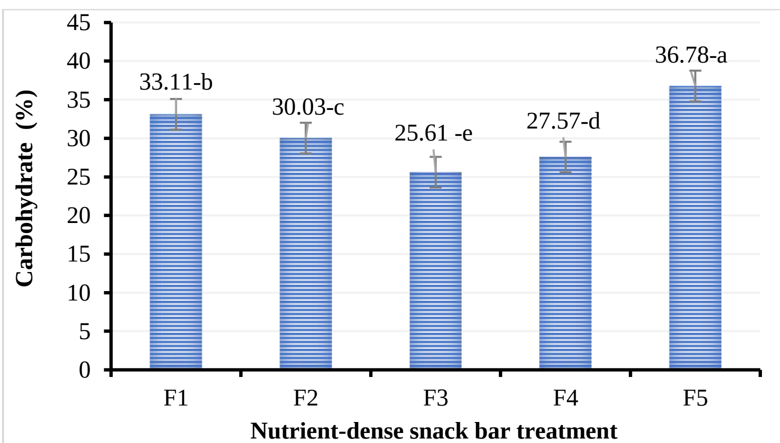

Figure 2. Carbohydrate content (%) of nutrient-dense snack bars based on a combination of purple sweet potato, mung bean, anchovy, and moringa leaf flours.

3.1.3. Protein Content

Formulation significantly affected protein content ($p < 0.05$), with values ranging from 7.76% to 16.34%. Formulation F4 exhibited the highest protein content, followed by F3, while F2 showed the lowest value. The observed variation in protein content was primarily influenced by the proportion of protein-rich ingredients, particularly anchovy flour and moringa leaf flour, which contributed substantially to the overall protein content. Anchovy flour serves as a high-quality animal protein source, while moringa leaves and mung beans provide plant-based proteins with complementary essential amino acids. The combination of plant and animal protein sources may enhance amino acid balance and improve overall protein quality compared to a single-source protein (Aliya *et al.*, 2016). The higher protein content observed in formulations F3 and F4 is consistent with findings by Squeo *et al.* (2023), who reported that increasing the proportion of protein-rich ingredients significantly enhances protein levels in snack bar products.

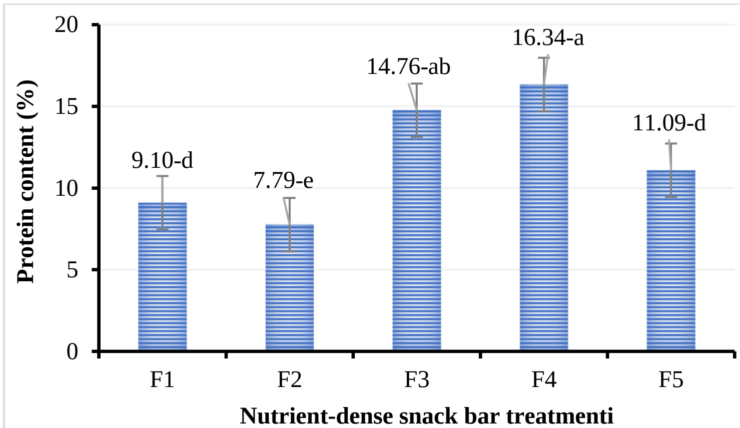

Figure 3. Protein content (%) of nutrient-dense snack bars based on a combination of purple sweet potato, mung bean, anchovy, and moringa leaf flours.

In the context of stunting prevention, the relatively high protein content in F3 and F4 (≥14%) represents a significant nutritional advantage, as protein plays a crucial role in supporting tissue growth, muscle development, and cognitive development in children. The protein values obtained in this study fall within the range reported for similar products (approximately 6–17%) (Squeo *et al.*, 2023). At an estimated serving size of 25–30 g, these high-protein snack bars may contribute meaningfully to daily protein intake in young children, supporting their development as locally sourced functional foods for populations at risk of stunting.

3.1.4. Fat Content

Formulation significantly affected fat content ($p < 0.05$), with values ranging from 35.66% to 54.71%. Formulation F4 exhibited the highest fat content, whereas F1 showed the lowest. This variation was primarily associated with the proportion of anchovy flour, which serves as the main source of animal-derived lipids, particularly polyunsaturated fatty acids (PUFAs).

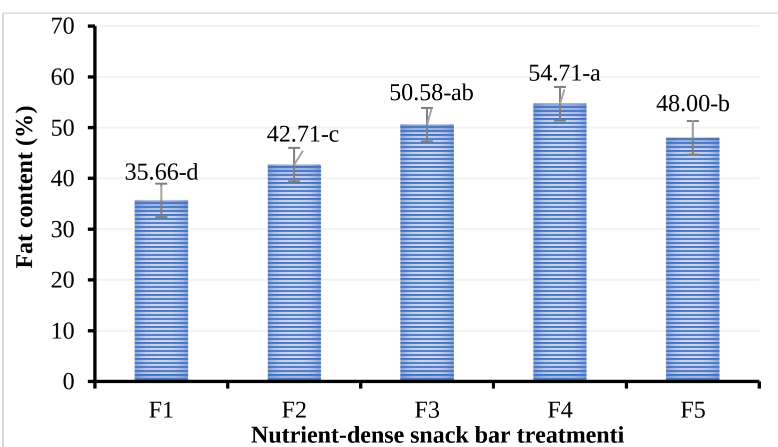

Figure 4. Fat content (%) of nutrient-dense snack bars based on a combination of purple sweet potato, mung bean, anchovy, and moringa leaf flours.

The higher fat content observed in formulations F3 and F4 corresponds to their greater inclusion of anchovy flour, which is rich in omega-3 fatty acids such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (Pal *et al.*, 2018). In contrast, formulations with higher proportions of plant-based ingredients, such as purple sweet potato and mung beans, exhibited lower fat content, as these materials naturally contain relatively low lipid levels. Moringa leaves also contributed to the lipid profile, although to a lesser extent, due to their relatively low total fat content despite containing PUFAs (Kashyap *et al.*, 2022).

From a functional perspective, higher fat content dominated by omega-3 fatty acids is nutritionally advantageous, as it supports brain development, nervous system function, and cognitive performance in children, which are critical factors in stunting prevention (Pal *et al.*, 2018). However, a high proportion of PUFAs may increase susceptibility to lipid oxidation. In this context, natural antioxidants present in purple sweet potato and moringa leaves, including anthocyanins and phenolic compounds, may help inhibit oxidation and enhance product stability (Peñalver *et al.*, 2022; Kotsou *et al.*, 2023).

The fat content range observed in this study is consistent with that reported for similar products (approximately 1–55%), depending on formulation objectives and ingredient composition (Squeo *et al.*, 2023). Therefore, formulations F4 and F3 are more suitable for development as functional foods rich in healthy fats for nutritional intervention, whereas lower-fat formulations such as F1 may be positioned as more balanced products for regular consumption.

3.1.5. Mineral Content (Ash Content)

Formulation significantly affected ash content ($p < 0.05$), with values ranging from 2.42% to 3.84%. Formulation F1 exhibited the highest ash content, whereas F4 showed the lowest value. These differences reflect variations in total mineral content, which are influenced by the proportion of mineral-rich ingredients in each formulation.

Anchovy and moringa leaves were the primary contributors to mineral content in the snack bars, while purple sweet potato and mung beans contributed to a lesser extent. Anchovies are recognized as a rich source of calcium and phosphorus, particularly because they are consumed along with their bones. Moringa leaves also have a high mineral density, including calcium, iron, and potassium (Pal *et al.*, 2018; Peñalver *et al.*, 2022). The relatively high ash content observed in formulation F1 is likely associated with a balanced proportion of anchovy and moringa leaves, which contributed to greater mineral accumulation.

In the context of stunting prevention, minerals—as indicated by ash content—play a crucial role in supporting bone growth, brain development, and oxygen transport. Mineral deficiencies, particularly iron deficiency, are major risk factors for stunting and anemia in young children. As a source of non-heme iron, moringa leaves may help improve mineral intake, especially when combined with vitamin C-rich ingredients such as purple sweet potato, which enhances iron bioavailability (Kashyap *et al.*, 2022). Therefore, formulation F1 is more suitable for a mineral-fortified approach, while other formulations may be optimized based on specific nutritional targets and consumer needs.

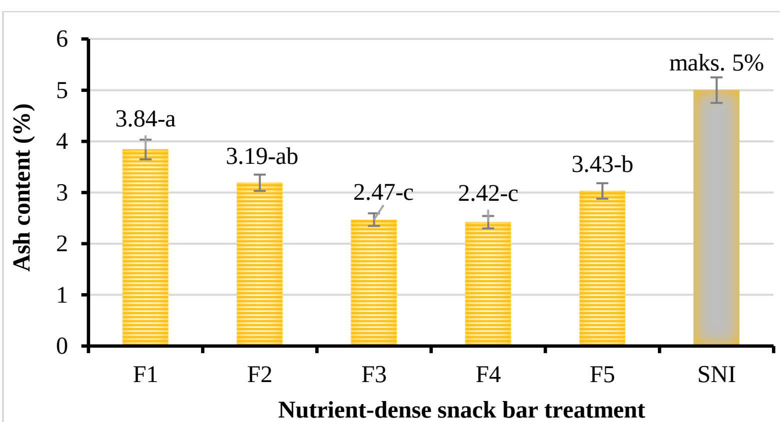

Figure 5. Ash content (%) of nutrient-dense snack bars based on a combination of purple sweet potato, mung bean, anchovy, and moringa leaf flours.

3.2. Micronutrient Characteristics of Nutrient-Dense Snack Bars

In addition to proximate composition, micronutrient analysis was conducted to evaluate the potential of these nutrient-dense snack bars as functional foods capable of contributing to essential nutrient adequacy, especially in populations at risk of stunting. Iron (Fe), vitamin C, and omega-3 fatty acids were selected as primary micronutrient indicators because they play direct roles in growth, brain development, immune function, and tissue formation. Deficiencies in these nutrients are recognized risk factors for stunting and developmental disorders in children, particularly in regions where diets are dominated by carbohydrate-rich staples with relatively low intake of animal protein and vitamin-mineral-rich foods. The micronutrient results for the five formulations are presented in Figure 6–8.

3.2.1. Vitamin C Content

Vitamin C content varied among the formulations, with the highest values observed in F5 and F1 and the lowest in F2. This pattern reflects differences in the proportion of vitamin C-rich ingredients used in each formulation. Moringa leaves (*Moringa oleifera*) are known to contain substantial amounts of vitamin C and phenolic compounds, while purple sweet potato also contributes vitamin C and anthocyanin pigments with antioxidant properties (Kotsou *et al*., 2023). The lower vitamin C content in F2 is consistent with its reduced proportion of moringa leaf.

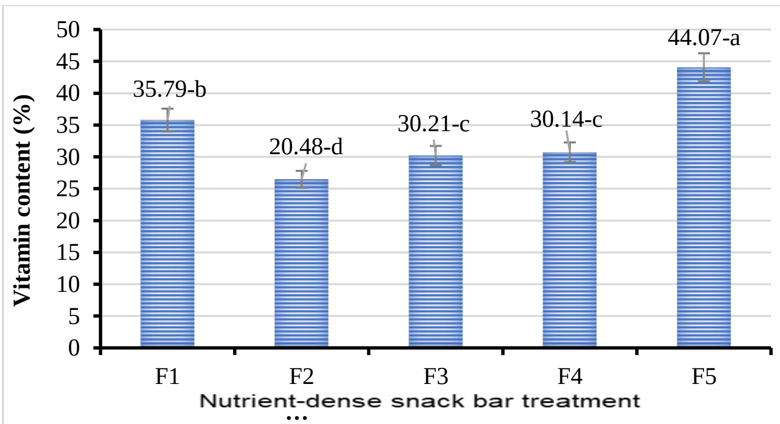

Figure 6. Vitamin C content (%) of nutrient-dense snack bars based on a combination of purple sweet potato, mung bean, anchovy, and moringa leaf flours.

Although vitamin C is thermolabile and susceptible to degradation during thermal processing, the results of this study indicate that a portion of vitamin C was retained in the snack bar matrix after baking. This retention may be attributed to relatively controlled baking conditions (temperature and time) as well as the compact structure of the product, which may limit oxygen exposure during heating. These findings are consistent with those of Peñalver *et al*. (2022), who reported that vitamin retention and antioxidant activity in moringa-based products can be maintained under moderate thermal conditions.

In addition to its antioxidant role, vitamin C enhances the bioavailability of non-heme iron by reducing ferric (Fe^{3+}) to ferrous (Fe^{2+}) form, which is more readily absorbed in the human body. Therefore, formulations with higher vitamin C content, such as F5 and F1, may provide synergistic benefits in improving iron utilization. This is particularly relevant for the prevention of anemia and stunting in young children (Kashyap *et al*., 2022).

3.2.2. Iron (Fe) Content

Iron content varied among the formulations, with the highest values observed in F1 and F5, followed by F2 and F3, while F4 exhibited the lowest iron level. This variation reflects differences in the proportions of mineral-rich ingredients, particularly moringa leaves and anchovies, which serve as the primary sources of iron in these formulations.

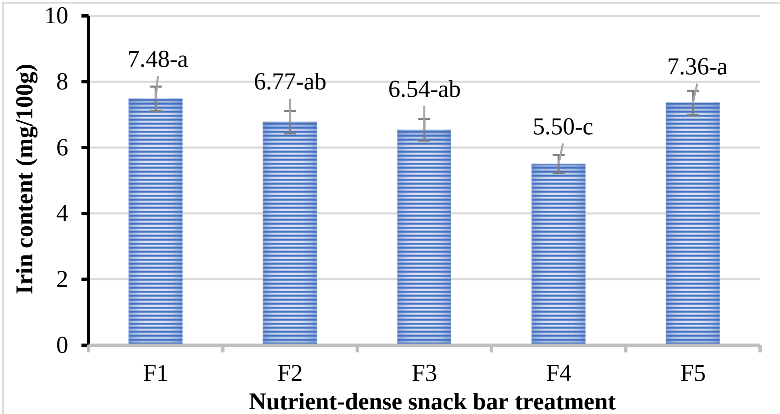

Figure 7. Iron content (mg/100g) of nutrient-dense snack bars based on a combination of purple sweet potato, mung bean, anchovy, and moringa leaf flours.

Moringa leaves are known to contain relatively high levels of non-heme iron, whereas anchovies provide iron in forms with generally higher bioavailability compared to plant sources (Pal *et al*., 2018; Peñalver *et al*., 2022). The higher iron content observed in F1 and F5 is likely associated with their greater proportion of moringa leaves. In contrast, F3 and F4, despite containing higher levels of animal protein, showed lower total iron content, possibly due to compositional differences and a dilution effect within the product matrix.

It is important to note that total iron content does not necessarily reflect its biological availability. In plant-based matrices, iron is predominantly present as non-heme iron and may bind to antinutritional compounds such as phytates and oxalates, thereby reducing its absorption. However, combining plant-based ingredients with anchovy-derived animal protein may enhance iron absorption through the meat factor. In addition, vitamin C from purple sweet potato and moringa leaves can improve iron bioavailability by reducing ferric (Fe^{3+}) to the more absorbable ferrous (Fe^{2+}) form (Kashyap *et al*., 2022). Therefore, although F1 and F5 exhibited higher total iron content, formulations F3 and F4 may offer improved iron utilization due to their higher proportions of animal protein and lipid components.

In the context of stunting prevention, iron is an essential micronutrient involved in hemoglobin synthesis, oxygen transport, and cognitive development. Iron deficiency is strongly associated with anemia and impaired linear growth in young children, particularly in populations with low intake of animal-source foods. Therefore, the snack bars used in this study have potential as locally based nutritional intervention products to support iron adequacy, either by increasing total iron content or by enhancing its bioavailability through formulation strategies (Hariawan *et al*., 2024).

Overall, these findings indicate that iron content in snack bars can be optimized by adjusting the proportions of plant- and animal-based ingredients. Formulations F1 and F5 are more suitable for total iron fortification, whereas F3 and F4 may offer greater potential in terms of biological effectiveness due to the synergistic effects of animal protein and vitamin C. This highlights the relevance of developing snack bars based on local food resources using a food-to-food fortification approach for stunting prevention.

3.2.3. Omega-3 Fatty Acid Content

Omega-3 fatty acid content varied among the formulations, with the highest value observed in F4, followed by F3, then F2 and F5, while F1 exhibited the lowest level. This trend is consistent with the proportion of anchovy flour, which serves as the primary source of omega-3 fatty acids in the formulations, particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA).

Formulations F3 and F4, which contained higher proportions of anchovy flour, showed significantly greater omega-3 content compared to the other formulations. As a small pelagic fish, anchovy is well recognized for its high omega-3 density and its contribution to essential fatty acid intake in fish-based foods (Pal *et al*., 2018). In contrast, formulations with lower anchovy content, such as F1 and F5, exhibited lower omega-3 levels, despite minor contributions of polyunsaturated fatty acids (PUFAs) from moringa leaves (Kashyap *et al*., 2022).

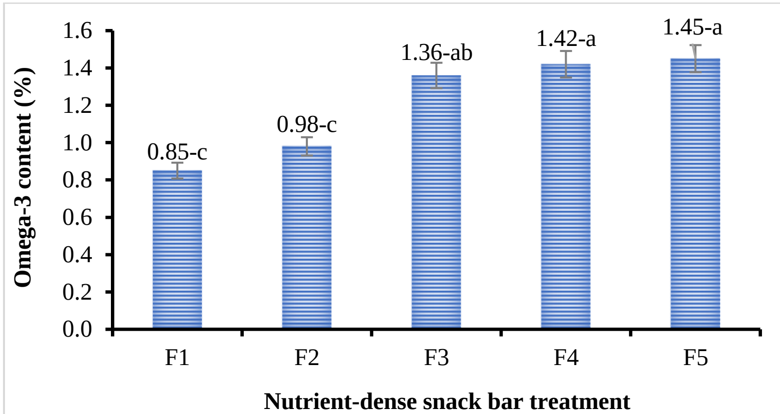

Figure 8. Omega-3 content (%) of nutrient-dense snack bars based on a combination of purple sweet potato, mung bean, anchovy, and moringa leaf flours.

Although high levels of PUFAs may increase susceptibility to lipid oxidation, the presence of natural antioxidants from purple sweet potato and moringa leaves—such as anthocyanins and phenolic compounds—may help inhibit oxidative degradation and preserve omega-3 stability during processing and storage (Peñalver *et al*., 2022; Kotsou *et al*., 2023). This suggests a synergistic interaction between lipid components and bioactive compounds within the snack bar matrix.

From a nutritional perspective, omega-3 fatty acids play a crucial role in brain development, nervous system maturation, and cognitive function, particularly during early childhood. Insufficient intake of omega-3 fatty acids, especially DHA, has been associated with impaired cognitive development and immune function in children. Therefore, formulations F3 and F4, which contain higher omega-3 levels, may provide greater functional benefits as nutritional intervention products for populations at risk of stunting (Pal *et al*., 2018).

Accordingly, formulations F4 and F3 are more suitable for development as functional foods rich in healthy fats and omega-3 fatty acids, whereas other formulations may be optimized for regular consumption by balancing nutritional value, product stability, and sensory acceptability.

4. CONCLUSION

This study demonstrates that snack bar formulations based on a combination of purple sweet potato, mung beans, anchovies, and moringa leaves significantly influence both the proximate and micronutrient characteristics of the final product. Formulations F3 and F4 exhibited higher protein, fat, and omega-3 contents, along with lower moisture levels, compared to the other formulations. In contrast, formulations F1 and F5 showed higher levels of vitamin C and iron. These findings indicate that the combination of locally available food resources can be effectively utilized to develop nutrient-dense snack bars with strong potential as functional foods. The application of a food-to-food fortification approach further enhances their relevance as sustainable nutritional intervention products to support stunting prevention.

AUTHOR CONTRIBUTION

Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
NB	✓	✓	✓	✓							✓	✓		
JTKT	✓				✓	✓	✓	✓						
MYS	✓								✓	✓			✓	✓

C: Conceptualization	Fo: Formal Analysis	O: Writing - Original Draft	Fu: Funding Acquisition
M: Methodology	I: Investigation	E: Writing - Review & Editing	P: Project Administration
So: Software	D: Data Curation	Vi: Visualization	
Va: Validation	R: Resources	Su: Supervision	

ACKNOWLEDGMENTS

The authors gratefully acknowledge the Center for Research and Community Service of the State Agricultural Polytechnic of Kupang for funding this study under the 2025 Riset Unggulan scheme.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE MANUSCRIPT PREPARATION

Not applicable. The authors did not use any generative AI tools or services in the preparation of this manuscript. All content is entirely the intellectual work of the authors.

REFERENCES

Aliya, L.S., Rahmi, Y., & Soeharto, S. (2016). Mi “Mocafle”: Peningkatan kadar gizi mie kering berbasis pangan lokal fungsional. *Indonesian Journal of Human Nutrition*, ***3***(1), 32–41. https://doi.org/10.21776/ub.ijhn.2016.003.Suplemen.4

AOAC (Association of Official Analytical Chemists). (2019). *AOAC Official Method 2015.01 Heavy Metals in Food. Inductively Coupled Plasma-Mass Spectrometry First Action 2015*. Association of Official Analytical Chemists, Washington DC

Bora, N., Kana-Tiri, J.T., & Saubaki, M.Y. (2025). Preferensi sensorik dan karakteristik fisik snack bar padat gizi berbasis kombinasi pangan lokal untuk penanganan stunting. *Jurnal Partner*, ***30***(2), 276–289. https://doi.org/10.35726/jp.v30i2.7527

Den, M., Kinabo, J., Mwanri, A.W., & Ekesa, B. (2018). Modification of local diets to improve vitamin A, iron, and protein contents for children aged 6 to 23 months in Kagera, Tanzania. *African Journal of Food, Agriculture, Nutrition and Development*, ***18***(1), 13129–13153. https://doi.org/10.18697/ajfand.81.17025

Drewnowski, A., Maillot, M., Papanikolaou, Y., Jones, J.M., Rodriguez, J., Slavin, J., Angadi, S.S., & Comerford, K.B. (2022). A new carbohydrate food quality scoring system to reflect dietary guidelines: An expert panel report. *Nutrients*, ***14***, 1485. https://doi.org/10.3390/nu14071485

Hariawan, H.H., Hasanbasri, M., & Arjuna, T. (2024). Stunting and dietary diversity in children aged 24–59 months in Indonesia (analysis of Indonesian Family Life Survey 2014–2015). *Amerta Nutrition*, ***8***(3SP), 380–389. https://doi.org/10.20473/amnt.v8i3SP.2024.380-389

Hartati, Y., & Ridhoi, M. (2021). Snack bar from catfish bone meal and red bean flour for malnourished children: Nutritional content and sensory properties. In *Proceedings of the First International Conference on Health, Social Sciences and Technology (ICoHSST 2020) (Vol. 521, pp. 1–4). Advances in Social Science, Education and Humanities Research*. Atlantis Press. https://doi.org/10.2991/assehr.k.210415.001

Kashyap, P., Kumar, S., Riar, C.S., Jindal, N., Baniwal, P., Guiné, R.P.F., Correia, P.M.R., Mehra, R., & Kumar, H. (2022). Recent advances in *Moringa oleifera* leaves bioactive compounds: Composition, health benefits, bioaccessibility, and dietary applications. *Antioxidants*, ***11***, 402. https://doi.org/10.3390/antiox11020402

Kementerian Kesehatan Republik Indonesia. (2022). *Laporan Nasional Status Gizi Indonesia*. https://www.kemkes.go.id

Kotsou, K., Chatzimitakos, T., Athanasiadis, V., Bozinou, E., Rumbos, C.I., Athanassiou, C.G., & Lalas, S.I. (2023). Enhancing the nutritional profile of Tenebrio molitor using the leaves of *Moringa oleifera*. *Foods*, ***12***, 2612. https://doi.org/10.3390/foods12132612

McGovern, M.E., Krishna, A., Aguayo, V.M., & Subramanian, S.V. (2017). A review of the evidence linking child stunting to economic outcomes. *International Journal of Epidemiology*, 1–21. https://doi.org/10.1093/ije/dyx017

Nordhagen, A., Rizwan, A.A.M., Aakre, I., Reksten, A.M., Pincus, L.M., Bøkevoll, A., Mamun, A., Thilsted, S.H., Htut, T., Somasundaram, T., & Kjellevold, M. (2020). Nutrient composition of demersal, pelagic, and mesopelagic fish species sampled off the coast of Bangladesh and their potential contribution to food and nutrition security. *Foods*, ***9***(6), 730. https://doi.org/10.3390/foods9060730

Pal, J., Shukla, B.N., Maurya, A.K., Verma, H.O., Pandey, G., & Amitha. (2018). A review on the role of fish in human nutrition with special emphasis on essential fatty acids. *International Journal of Fisheries and Aquatic Studies*, ***6***(2), 427–430.

Peñalver, R., Martínez-Zamora, L., Lorenzo, J.M., Ros, G., & Nieto, G. (2022). Nutritional and antioxidant properties of *Moringa oleifera* leaves in functional foods. *Foods*, ***11***, 1107. https://doi.org/10.3390/foods11081107

Picauly, I., Adi, A.A.A.M., Meiyetriani, E., Mading, M., Weraman, P., Nashriyah, S.F., Boeky, D.L.A., Lobo, V., Saleh, A., Peni, J. A., Hidayat, A.T., & Marni, M. (2024). Determinants of child stunting in the dryland area of East Nusa Tenggara Province, Indonesia: insights from a national-level survey. *Journal of Medicine and Life*, ***17***(2), 147–156. https://doi.org/10.25122/jml-

2023-0313

Rabadán, A., Nieto, R., & Bernabéu, R. (2021). Food innovation as a means of developing healthier and more sustainable foods. *Foods*, ***10***(9), 2069. https://doi.org/10.3390/foods10092069

Squeo, G., Latrofa, V., Vurro, F., De Angelis, D., Caponio, F., Summo, C., & Pasqualone, A. (2023). Developing a clean-labelled snack bar rich in protein and fibre with dry-fractionated defatted durum wheat cake. *Foods*, ***12***(13), 2547. https://doi.org/10.3390/foods12132547

Suratri, M.A.L., Putro, G., Rachmat, B., Nurhayati, Ristrini, Pracoyo, N.E., Yulianto, A., Suryatma, A., Samsudin, M., & Raharni. (2023). Risk factors for stunting among children under five years in East Nusa Tenggara (NTT), Indonesia. *International Journal of Environmental Research and Public Health*, ***20***(2), 1640. https://doi.org/10.3390/ijerph20021640

Wicaksono, R.A., Arto, K.S., Mutiara, E., Deliana, M., Lubis, M., & Batubara, J.R.L. (2021). Risk factors of stunting in Indonesian children aged 1 to 60 months. *Paediatrica Indonesiana*, ***61***(1), 12–19. https://doi.org/10.14238/pi61.1.2021.12-9

Widyaningsih, T.D., Hidayatullah, A., Hapsari, T.K., Kinanti, A.A., & Febriyantiningtyas, S. (2025). Optimized supplementary food bar using pumpkin, edamame, moringa leaves, and snakehead fish to prevent stunting: Integrating nutrition and sustainable development goals. *Journal of Lifestyle and SDGs Review*, ***5***(7), e7266. https://doi.org/10.47172/2965-730X.SDGsReview.v5.n07.pe07266