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Formulation of Nutraceutical Products Based on Multigrain and Moringa Leaves (*Moringa oleifera* L.) as Anti-stunting Innovations

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Abstract: Stunting is a nutritional problem that requires innovation in functional food products made from natural ingredients that are nutritious and easy to consume. This study aimed to formulate an anti-stunting nutraceutical product based on multigrain ingredients and moringa leaves *(Moringa oleifera L.)* in the form of a cereal-like health drink. Product evaluation was conducted through organoleptic testing, pH stability testing, proximate analysis, and hedonic testing. The organoleptic results showed that the three formulations had relatively similar color, taste, aroma, and texture characteristics and remained stable during one month of storage. The pH values were also stable, indicating good chemical stability of the product. Proximate analysis showed that the protein content of 8.14-9.13%, ash content of 1.36-1.74%, and carbohydrate content of 75.15-77.88% met the requirements of SNI 01-4270-1996. However, the moisture content of 7.56-8.01% still exceeded the maximum limit, while the fat content of 4.49-6.19% remained below the standard. The hedonic test results showed that all formulations were accepted and preferred by the panelists, with an average score exceeding 4. Formulation 3 showed superiority in the color parameter, while Formulation 2 was more preferred in terms of taste. Overall, this product has the potential to be developed as an anti-stunting nutraceutical innovation. However, further optimization of the drying process and the composition of fat-source ingredients is still required.

Keywords: Anti-stunting; Moringa leaves *(Moringa oleifera L.)*; Multigrain; Nutraceutical,

Introduction

Stunting is a condition in which a child has a height shorter than his or her age standard due to growth disorders affected by lack of nutritional intake and health conditions, both before and after birth (Rantini et al., 2025). In general, stunting is defined as height by age that is below -2 standard deviations based on the growth curve (Lumley et al., 2026). This condition describes linear growth failure in children that occurs due to long-term malnutrition (Khoo & Azlan, 2026; Rahayu et al., 2026). The main factors that cause stunting include a lack of nutritious food intake and infectious diseases (Mersha et al., 2021). From a nutritional aspect, a history of energy, fat, protein, and iron consumption is known to be related to an increased risk of stunting in children (Sateikaite et al., 2026).

Stunting not only impacts physical growth but can also increase the risk of death in children, inhibit cognitive and motor development, decrease academic achievement, increase the risk of overnutrition and non-communicable diseases in the future, and reduce productivity in adulthood (Mekuriaw et al., 2025). Some of the factors that play a role in the occurrence of

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stunting include malnutrition, poor maternal nutritional conditions since adolescence, pregnancy, and breastfeeding, and the presence of infections in the mother (Hailu et al., 2025). In addition, low food quality and lack of intake of vitamins, minerals, and high-protein foods also contribute to stunting incidence (Agushybana et al., 2025). Therefore, nutritional fulfillment is one of the important efforts in stunting prevention, especially because deficiencies in vitamins A, D, E, K, calcium, iron, and folic acid can inhibit children's growth and development (Ernawati et al., 2025).

Based on data from the Ministry of Health submitted at the BKKBN National Working Meeting related to the Indonesian Nutrition Status Survey (SSGI), the prevalence of stunting in Indonesia decreased from 24.4% in 2022 to 21.5% in 2023 (Lybaws et al., 2025). However, this figure still does not reach the WHO target, which is less than 20% by 2024 (Sari et al., 2022). This condition shows that stunting is still a nutritional problem that requires serious attention, including through the development of functional food innovations that have high nutritional value, are easy to consume, and can be accepted by the community (Fauza et al., 2026).

One approach that can be developed is the use of nutraceutical products (Rahimah et al., 2026). Nutraceuticals are compounds derived from plants, microbes, and animals that can be consumed by humans to provide health benefits, including in disease prevention (Fawzya & Irianto, 2020). Today, nutraceutical products are getting more and more attention because they have good nutritional value and therapeutic potential (Thakur et al., 2026). Modern society also tends to choose nutraceutical products as a source of nutrition to support the prevention and maintenance of health, rather than relying solely on chemical drugs (Gayatri, 2026). One popular form of nutraceutical product is multigrain, which is a mixture of different types of grains and nuts (Anjali & Vijayaraj, 2020).

Multigrain products are a combination of two or more types of grains in one food product (Muzaffar & Wani, 2025; Taha & Al-suwayeh, 2009). Multigrains can include rice, wheat, seeds, and legumes that have a positive impact on health when consumed appropriately (Paul et al., 2020). The combination of these various ingredients has the potential to help overcome nutrient deficiencies because each ingredient can complement the nutritional content of the others (Xu et al., 2026).

In addition to multigrains, one of the local food ingredients that has high nutritional content and has the potential to be developed is moringa leaves (Wilcaso et al., 2025). Moringa leaves (*Moringa oleifera* L.) are tropical plants known as miracle *trees* because they have various benefits for living beings (Panova et al., 2025). Moringa leaves are also often referred to as *a superfood* because they contain complete and high nutrients compared to some other foods (Sandhya & Kanniammal, 2024).

Moringa leaves are known to contain vitamin C of 220 mg/100 g, potassium 1324 mg/100 g, vitamin A 6.78 mg/100 g, calcium 440 mg/100 g, and protein 6.7% per 100 g (Marin et al., 2025). This content is higher than some other foods, such as oranges with vitamin C of 58.30 mg/100 g, bananas with potassium 275-375 mg/100 g, milk with calcium 83.33 mg/100 g, and yogurt with protein of 3.24% per 100 g (Gohil et al., 2025). With this nutritional content, moringa leaves are considered to have the potential to help overcome the problem of malnutrition and hunger, and support the prevention of various diseases (Mandal et al., 2025). Therefore, moringa leaves can be used as an additive in food products to increase the nutritional value of the product (Kambuno et al., 2025). Based on this description, this study aims to formulate nutraceutical products based on multigrain and moringa leaves (*Moringa oleifera* L.) as functional food innovations that have the potential to support stunting prevention efforts.

Method

This research is an experimental study conducted through the formulation of nutraceutical products using *the dry mixing* method. This method is used to mix all dry ingredients until a homogeneous preparation is obtained. Product evaluation was carried out through several tests, namely organoleptic tests, physical stability tests, nutritional content analysis using proxy methods, and hedonic tests to determine the level of panelists' acceptance of the products produced.

Tools and Materials

The tools used in this study include digital scales, parchment paper, *grinders*, blenders (Miyako), stoves (Rinnai), frying pans, baking sheets, 80 mesh sieves, spoons, stirrers, measuring cups (Pyrex), glass jars, ovens, dough flakers, pH meters, *seal packaging*, and *sealer press*.

The ingredients used consist of the main ingredients and additives. The main ingredients include multigrains, namely sacha inchi beans, mung beans, almonds, oats, barley seeds, and arrowroot bulbs, as well as moringa leaf powder (*Moringa oleifera* L.). Additional ingredients used include wheat flour, tapioca flour, sweetened condensed milk, etawa goat milk, *non-dairy creamer*, and palm sugar.

Sample Preparation

Multigrain ingredients consisting of sacha inchi beans, mung beans, almonds, oats, and barley seeds are obtained in whole form. Next, the ingredients are sorted to separate the unsuitable parts, then mashed using a grinder until a powder form is obtained. Arrowroot tubers, wheat flour, tapioca flour, sweetened condensed milk, etawa goat's milk, non-dairy creamer, and palm sugar are obtained in powder or ready-to-use form. All materials are sourced from the nearest market and through online purchases. The moringa leaf powder (*Moringa oleifera* L.) is obtained from the Solo Herbal Hut.

Formula

Multigrain nutraceutical product formulations are made in three variations, namely F1, F2, and F3, with a total weight of 30 g of each formulation. F1 uses the highest moringa leaf flakes, which are 7 g, and the lowest sacha inchi nuts, which are 0.5 g. On the other hand, F3 uses the lowest moringa leaf flakes, which are 5 g, and the highest sacha inchi nuts, which are 2.5 g. Meanwhile, the composition of other ingredients such as mung beans, almonds, barley seeds, oats, arrowroot starch, etawa goat's milk, non-dairy creamer, and palm sugar is made to remain in each formulation. The nutraseutical formula developed can be seen in Table 1.

Table 1. Moringa Leaf-Based Multigrain Nutraceutical Formula

Composition	F1 (g)	F2 (g)	F3 (g)
Flakes of Moringa leaves	7	6	5
Sacha inchi beans	0,5	1,5	2,5
Green beans	1	1	1
Almonds	1	1	1
Barley seeds	1	1	1
Oats	3,5	3,5	3,5
Arrowroot starch	2	2	2
Goat's Milk	5	5	5
Krimer non-dairy	4	4	4
Palm sugar	5	5	5
Total	30	30	30

Moringa Leaf Flakes Formulation

The manufacture *of flakes* is carried out using several ingredients, namely wheat flour, tapioca flour, sweetened condensed milk, food coloring, and moringa leaves (*Moringa oleifera* L.). All ingredients are mixed to form a homogeneous dough. Next, the dough is flattened using a flattening tool until a uniform thickness is obtained. The flaky dough is then baked in an oven until dry. Once the baking process is complete, the *flakes* are crushed into small pieces for easy mixing into the formulation of multigrain nutraceutical products.

Manufacture of Nutraceutical Preparations

The preparation of nutraceutical preparations begins with the preparation of tools and ingredients. The main ingredients are moringa leaf powder *(Moringa oleifera L.)* and multigrain, consisting of sacha inchi beans, mung beans, almonds, oats, and barley seeds, which are first pollinated, then sifted to obtain a more uniform particle size. Furthermore, ingredients in the form of sacha inchi beans, mung beans, almonds, oats, barley seeds, arrowroot bulb flour, and moringa leaf powder are roasted for 7-10 minutes to reduce moisture content and improve the aroma of the ingredients. After the roasting process, the ingredients are sifted again to obtain a smooth and homogeneous powder.

The next stage is the manufacture of moringa leaf flakes *(Moringa oleifera L.)* as one of the components in the formulation. Once all the ingredients are ready, each is weighed according to the set formulation composition. The weighed materials are then mixed using the dry mixing method, which is a method of mixing ingredients in dry conditions until a homogeneous mixture is obtained. The final preparation produced was then evaluated through organoleptic tests, physical stability tests, proxy analysis, and hedonic tests.

Preparation Evaluation

Organoleptic Tests

Organoleptic testing, also known as sensory testing, is a testing method that uses the human senses as the primary tool to assess the characteristics and acceptance rate of a product. This test is carried out by observing several parameters, including color using the sense of sight, smell using the sense of smell, taste using the sense of taste, and texture using the sense of touch (Nethaji et al., 2025).

Physical Stability Test

The physical stability test was carried out for one month by storing the preparations at room temperature. Observations were made periodically every seven days, namely on days 0, 7, 14, 21, and 28. The parameters observed in the stability test include pH values and organoleptic characteristics of the preparation, such as color, aroma, taste, and texture (Ogrodowczyk et al., 2025).

Proximate test

Proximate testing is a chemical analysis conducted to determine the nutritional content of a food ingredient. In this study, proximate testing was used to determine the moisture, ash, protein, fat, and carbohydrate content of the product. The test results were then analyzed and compared with relevant standards to assess product quality (Rani et al., 2025).

Hedonic Test

The hedonic test was carried out to determine the panelists' level of preference for the prepared product. This test involved 30 panelists with assessment parameters including color, aroma, taste, solubility, and overall level of liking the product (Tassoult et al., 2021).

Result and Discussion

The manufacture of moringa leaf flakes (*Moringa oleifera* L.) is carried out to improve the texture, taste, and acceptability of the final product. In this study, nutraceutical preparations were developed in the form of health drinks that resemble cereals, so a piece-shaped component is needed to provide more attractive product characteristics. Multigrain ingredients, such as green beans, almonds, oats, and barley seeds, are first processed into powders to make them easy to mix and produce a homogeneous preparation. Furthermore, a formulation based on a combination of multigrain and moringa leaves *(Moringa oleifera L.)* was evaluated through a series of tests to determine the physical characteristics, nutritional content, stability, and acceptance rate of the product. *Flakes* of moringa leaves (*Moringa oleifera L.*) can be seen in Figure 1.

Figure 1. *Flakes* of Moringa Leaves (*Moringa oleifera L.*)

Based on the results of visual observation, moringa leaf flakes appear to be in the form of small pieces with non-uniform sizes, light green, and have a dry and brittle texture. These characteristics indicate that the drying process produces flakes that are easily destroyed and can be mixed with other powdered components in the preparation. The shape of the flakes on moringa leaf flakes gives it a distinctive visual character, so the product not only resembles a powdered drink, but also has a cereal-like character. The addition of moringa leaf flakes *(Moringa oleifera L.)* plays a role in increasing the functional value of the product because moringa leaves are known as a plant food ingredient that is rich in nutrients. In addition, the presence of flakes can also increase visual appeal and provide texture variation to the final product. The results of the formulation of nutraceutical multigrain based on moringa leaves can be seen in Figure 2.

Figure 2. Moringa Leaf-Based Multigrain Nutraceutical

Organoleptic testing is an important aspect in assessing the sensory characteristics and initial quality of a food product, including color, taste, aroma, and texture. Based on the results of organoleptic tests before brewing, the three formulations of nutraceutical multigrain preparations based on moringa leaves *(Moringa oleifera L.)* show relatively uniform characteristics. In the color parameters, F1, F2, and F3 have a brownish-white color with light green flakes. The brownish-white color is thought to come from a mixture of powdered ingredients, such as sacha inchi nuts, green beans, barley seeds, oats, arrowroot starch, etawa goat's milk, non-dairy creamer, almonds, and palm sugar. Meanwhile, light green flakes come from moringa leaf flakes added to the formulation. Organoleptic test results of moringa leaf-based nutraceutical multigrain preparations before brewing can be seen in Table 2.

Table 2. Organoleptic Test Results of Moringa Leaf-Based Nutraceutical Multigrain Preparations Before Brewing

Description	F1	F2	F3
Color	Brownish-white and light green	Brownish-white and light green	Brownish-white and light green
Taste	Sweet	Sweet	Sweet
Aroma	Nuts	Nuts	Nuts
Texture	Soft	Soft	Soft

In terms of taste parameters, all three formulations show relatively the same sweetness. The sweetness is thought to come from the addition of palm sugar and other supporting ingredients that contribute to the taste of the product. The aroma produced throughout the formulation is the typical aroma of nuts, which comes from a combination of sacha inchi nuts, green beans, almonds, oats, and barley seeds. In addition, the process of roasting ingredients can strengthen the distinctive aroma. In terms of texture, all three formulations have a soft texture, which indicates that the process of refining, sifting, and mixing dry ingredients has resulted in preparations with fairly fine and even particle sizes.

Overall, the results of organoleptic tests before brewing showed that the variation in the number of moringa leaf flakes and sacha inchi nuts at F1, F2, and F3 did not cause a striking difference in the color, taste, aroma, or texture characteristics of the preparation. This shows that the three formulations have relatively uniform initial organoleptic qualities and are acceptable as moringa leaf-based multigrain nutraceutical products. Organoleptic test results of moringa leaf-based nutraceutical multigrain preparations after brewing can be seen in Table 3.

Table 3. Organoleptic Test Results of Moringa Leaf-Based Nutraceutical Multigrain Preparations After Brewing

Description	F1	F2	F3
Color	Light green	Light green	Light green
Taste	Sweet	Sweet	Sweet
Aroma	Nuts	Nuts	Nuts
Texture	Soft	Soft	Soft

Taste is a sensory response that arises as a result of chemical stimuli received by the taste buds (Brahmi et al., 2024). Based on the results of organoleptic tests, the three formulations of multigrain nutraceutical preparations based on moringa leaves *(Moringa oleifera L.)* show a relatively similar taste, namely, sweetness. Although the amounts of moringa leaf flakes and sacha inchi nuts vary across formulations, the differences do not noticeably affect taste. This is suspected to be due to the use of palm sugar and other supporting ingredients in equal amounts throughout the formulation, so that sweetness still dominates the characteristics of the product.

Aroma is an important parameter in sensory testing because it shapes panelists' initial perception of a food product through the sense of smell (Rawat et al., 2024). The test results show that the entire formulation has a typical nutty aroma. The aroma is thought to come from a combination of multigrain ingredients, such as sacha inchi beans, mung beans, almonds, oats, and barley seeds. In addition, the process of roasting ingredients before formulation can strengthen the distinctive aroma of nuts and reduce the languorous aroma of plant ingredients.

Texture is also one of the important factors in determining the quality and acceptance of food products (Pérez-Herrera et al., 2020). In organoleptic tests, the entire formulation showed a soft texture. This characteristic is supported by the process of smoothing and sifting the material, resulting in a more uniform particle size. In addition, the dry mixing method helps to maintain the homogeneity of the preparation, so that the texture of the product becomes more even. Once brewed, the soft texture also supports the ease of the product as a health drink, resembling cereal.

Physical stability testing is an important stage in the development of formulations to ensure that the product can maintain its quality and characteristics during the storage period (Thi et al., 2024). In this study, physical stability was observed organoleptically through color, aroma, taste, and texture parameters during one month of storage. The results of observations showed that all three formulations did not undergo significant organoleptic changes during the storage period. Thus, nutraceutical multigrain preparations based on moringa leaves *(Moringa oleifera L.)* can be said to have good physical stability based on the observed sensory parameters. pH stability test of moringa leaf-based nutraceutical multigrain preparations can be seen in Fugure 3.

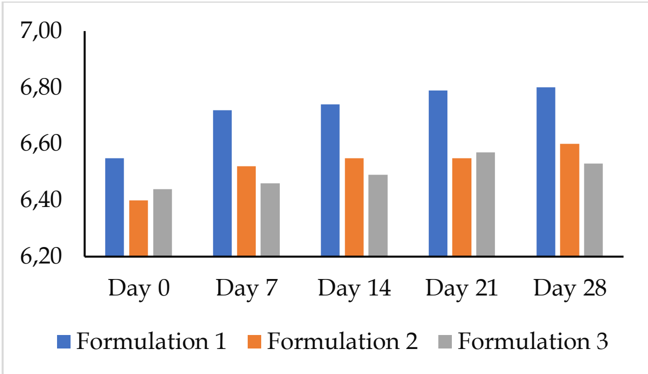

Figure 3. pH Stability Test of Moringa Leaf-Based Nutraceutical Multigrain Preparations

The degree of acidity or alkalinity of a solution can be expressed through the pH value. pH measurements can be carried out using simple indicators such as litmus paper or pH meter instruments that provide more accurate results (Devanadera et al., 2025). In this study, a pH test was carried out to determine the chemical stability of the preparation and assess the suitability of the pH of the product so that it is safe and suitable for consumption. A good pH value for cereal powder preparations is in the range of 5-7 (Dukhanin & Chuvichkina, 2025). Tests were conducted on days 0, 7, 14, 21, and 28 on three formulations of moringa leaf-based nutraceutical multigrain preparations *(Moringa oleifera L.)* stored at room temperature for 28 days.

Based on the observation results, the three formulations showed a pH value that was still in the range of 6.4-6.8 during the storage period. This value still meets the pH requirements of cereal powder preparations, which is 5-7. Formulation 1 showed a pH value that tended to be higher than Formulation 2 and

Formulation 3 at each observation time. Nonetheless, the change in pH value throughout the formulation did not show a drastic decrease or increase during storage.

The stability of this pH value indicates that the preparation has good chemical stability. This shows that the components of the ingredients in the formulation, such as moringa leaves *(Moringa oleifera L.)*, nuts, seeds, arrowroot starch, etawa goat's milk, non-dairy creamer, and palm sugar, do not undergo significant chemical changes during storage. Thus, all three formulations can be declared stable based on pH parameters during 28 days of storage at room temperature.

Proximate tests are performed to determine the macronutrient content of the preparation, including moisture content, ash content, fat content, protein content, and carbohydrate content (Niazi et al., 2025). This analysis aims to evaluate the nutritional quality of the final product and assess its conformity with the quality standards set in SNI 01-4270-1996. In addition, the results of the proximate test are also used as a basis to assess the potential of nutraceutical multigrain products based on moringa leaves *(Moringa oleifera L.)* as candidates for stunting prevention support products. Proximate test of moringa leaf-based nutraceutical multigrain preparations can be seen in Table 4.

Table 4. Proximate Test of Moringa Leaf-Based Nutraceutical Multigrain Preparations

Sample	Water Content (%)	Ash Content (%)	Fat Content (%)	Protein Content (%)	Carbohydrate Content (%)
Formula 1	7.92 ±0.13	1.42 ± 0.08	4.51 ± 0.02	8.31 ± 0.24	77.86 ± 0.04
Formula 2	7.86 ±0.17	1.59 ± 0.01	4.63 ± 0.08	8.60 ± 0.04	77.33 ± 0.25
Formula 3	7.71 ±0.21	1.74 ± 0.01	5.98 ± 0.30	9.10 ± 0.04	75.48 ± 0.47
Method	Oven	Tannur	Soxhlet	Kjeldahl	By Different

Based on the results of the test using the oven method, the moisture content of the three formulations is in the range of 7.71-7.92%. This value still exceeds the maximum limit of moisture content set in SNI 01-4270-1996, which is 3%. The high moisture content indicates that the preparation has not met the quality requirements in the moisture content parameters. High moisture content can affect the stability and shelf life of products because excess moisture can increase the risk of microorganism growth during storage (Ligarda-Samanez et al., 2025). This condition is suspected to be related to the drying process that is not optimal, especially at the stage of drying moringa leaf flakes *(Moringa oleifera L.)*, which is carried out using an oven at a temperature of 50-60°C for 30 minutes. In addition, some ingredients in the formulation, such as palm sugar, non-dairy creamer, and etawa goat milk, have hygroscopic properties, so they have the potential to absorb moisture from the environment. If the ambient humidity and packaging system are not properly controlled, the product can reabsorb water from the air during storage (Tawalbeh et al., 2025).

Ash content is one of the important parameters in food quality analysis because it describes the total amount of minerals contained in food. (Qiu et al., 2026). In this study, the ash content was analyzed using the kiln method of fracking at 550°C for 3 hours until the sample turned into grayish ash. The change shows that the adoption process has gone well. After the fermentation process is completed, the sample is weighed to determine the amount of ash produced.

The test results showed that the ash content in the three formulations was in the range of 1.42-1.74%. This value is still below the maximum limit set in SNI 01-4270-1996, which is 4%. This shows that the ash content in the preparation still meets the quality requirements. The difference in ash content between formulations is thought to be influenced by variations in the composition of the ingredients, especially the amount of sacha inchi nuts and moringa leaves used. Formulation 3 has the highest ash content, which is 1.74 ± 0.01%, which can be attributed to the mineral content of the constituent materials. Moringa leaves are known to contain several important minerals, such as iron, calcium, potassium, and zinc, so their addition can contribute to the ash content of the product.

Protein is one of the macronutrients that plays an important role in growth, body tissue formation, and metabolic processes (Dewie et al., 2026). In this study, protein levels were analyzed using the Kjeldahl method. Based on the test results, the protein content of the three formulations was in the range of 8.31-9.10%. This value meets the minimum protein content requirement of SNI 01-4270-1996, which is at least 5%. These results show that nutraceutical multigrain preparations based on moringa leaves have a fairly good protein content.

The highest protein content is found in Formulation 3, which is 9.10 ± 0.04%. This is thought to be related to the higher number of sacha inchi in the formulation. Sacha inchi beans are known as one of the best sources of vegetable protein. In addition, other multigrain ingredients, such as green beans, almonds, oats, and barley seeds, also contribute to the protein content of the product. The higher the protein content in the product, the greater its potential in supporting the fulfillment of protein needs. This is important because protein plays a role in supporting the growth and repair of body tissues, so it is relevant to the development of food products aimed at supporting stunting prevention (Regnier et al., 2025).

Fat content analysis was carried out using the Soxhlet method. The principle of this method is fat extraction using organic solvents, such as hexane. During the heating process, the solvent will evaporate and carry the fat component from the sample, so that the fat content can be calculated based on the extraction results (Kolarič & Šimko, 2022). Based on the test results, the fat content of the third formulation is in the range of 4.51-5.98%. This value is still below the minimum limit of fat content set in SNI 01-4270-1996 for cereal products, which is at least 7%. Thus, the parameters of the fat content in this preparation do not meet the required standards.

Formulation 3 shows the highest fat content, which is 5.98 ± 0.30%. The increase in fat content in this formulation is thought to be related to a higher amount of sacha inchi nuts than in other formulations. Sacha inchi nuts naturally contain fats, especially unsaturated fatty acids, including omega-3s and omega-6s, which play an important role in supporting healthy metabolism and brain development. Despite this, the level of fat obtained still does not reach the minimum standard. Therefore, formulation optimization is needed, for example, by increasing the proportion of healthy fat source ingredients or adjusting the composition of the ingredients so that the fat content of the product can meet applicable standards.

Carbohydrates are macronutrients that act as the main source of energy for the body. In this study, carbohydrate content was calculated using the by difference method, namely by reducing the total content of water, ash, fat, and protein from 100%. Therefore, changes in the content of water, ash, fat, and protein will affect the value of the carbohydrate content obtained (Kawasaki et al., 2025).

The results of the analysis showed that the carbohydrate content in the three formulations was in the range of 75.48-77.86%. This value meets the minimum carbohydrate content requirement of SNI 01-4270-1996, which is at least 60%. Formulation 1 has the highest carbohydrate content, which is 77.86 ± 0.04%. This is suspected to be related to the use of the highest amount of moringa leaf flakes, which is 7 g. The flakes are made from ingredients that contribute to the carbohydrate content, such as wheat flour, tapioca flour, and sweetened condensed milk. In addition, Formulation 1 contains the lowest amount of sacha inchi nuts, which is 0.5 g, so the fat and protein content is relatively lower than that of other formulations. According to the principle of calculation by difference, low fat and protein content can cause higher carbohydrate content values.

Overall, the results of the proximate test showed that the ash, protein, and carbohydrate content in the three formulations met the SNI 01-4270-1996 standard. However, the moisture content still exceeds the maximum limit, while the fat content is still below the required minimum. Therefore, product formulations still need optimization, especially in the drying process to reduce moisture content, as well as adjusting the composition of fat source ingredients to increase the fat content of the product. Hedonic test of moringa leaf-based nutraceutical multigrain can be seen in Figure 4.

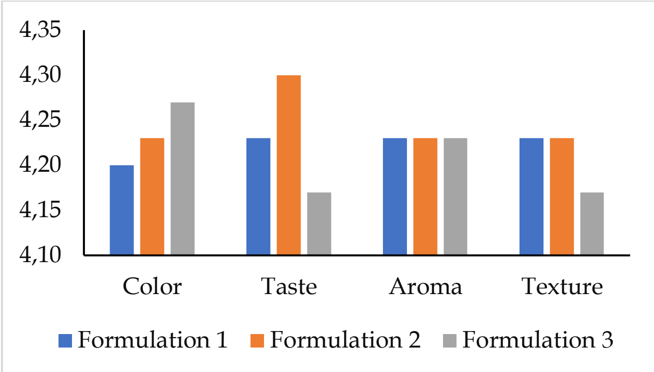

Figure 4. Hedonic Test of Moringa Leaf-Based Nutraceutical Multigrain

The hedonic test was conducted to determine the level of acceptance of the panelists' acceptance of moringa leaf-based nutraceutical multigrain preparations *(Moringa oleifera L.)* based on color, taste, aroma, and texture parameters. The assessment was conducted using a scale of 1-5, with higher scores indicating a greater level of likability. Based on the test results, all formulations obtained an average score above 4 on each parameter, so that they could be categorized as preferred by the panelists.

In the color parameter, Formulation 3 obtained the highest score, which was 4.27. This is allegedly related to the use of the least moringa leaf flakes, which is 5 g, so that the color of the product looks more natural and is not too dominated by green. In the taste parameters, Formulation 2 shows the highest value, which is 4.30. The composition of sacha inchi beans of 1.5 g in this formulation is thought to provide a more balanced nut flavor and is well received by the panelists.

Meanwhile, the aroma value of the three formulations was relatively similar, which was in the range of 4.23, which suggests that the variation in the number of moringa leaf flakes and sacha inchi nuts did not make a striking difference in aroma acceptance. In terms of texture parameters, Formulation 1 and Formulation 2 obtained relatively higher values than Formulation 3. Overall, the results of the hedonic test showed that all three formulations had a good acceptance rate, with Formulation 2 tending to be superior in taste parameters, while Formulation 3 was preferred in terms of color.

Conclusion

Based on the results of the study, nutraceutical multigrain preparations based on moringa leaves *(Moringa oleifera L.)* show good quality characteristics based on organoleptic evaluation, physical stability, proxy analysis, and hedonic tests. All three formulations have relatively stable color, taste, aroma, and texture characteristics during 28 days of storage at room temperature. The pH values of the entire formulation are also within the appropriate range, thus indicating the physical and chemical stability of the preparation during the storage period. The results of the proximate analysis showed that the ash content, protein content, and carbohydrate content had met the requirements of SNI 01-4270-1996. However, the moisture content still exceeds the maximum limit, while the fat content is still below the required minimum. Formulation 3 exhibits the best proximate characteristics, especially at higher levels of protein and fat than other formulations. Meanwhile, the results of a hedonic test of 30 panelists showed that all formulations had a good acceptance rate, with an average score of more than 4. Formulation 2 is the most preferred formulation, especially in the taste parameters. Overall, multigrain nutraceutical products based on moringa leaves have the potential to be developed as an antistunting functional food innovation. However, further optimization is needed in the drying process and adjustment of the composition of fat source materials so that the product can meet all quality requirements according to applicable standards.

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Conceptualization, R. S., A. P. A., and S. I.; methodology, S. I.; investigation, M. A. A.; data curation, A. P. A. and M. A. A.; validation, R. S., S. I.; formal analysis, S. I.; resources, R. S.; writing—original draft preparation, R. S. and A. P. A.; writing—review and editing, S. I. and R. S.; supervision, S. I., and R. S.; project administration, R. S.; translation, S. I. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analysis, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

References

Agushybana, F., Ashari, A., Nuridzin, D. Z., Hakam, M. A., Siramaneerat, I., & Fitri, I. A. (2025). Multifaced Approach in Reducing Stunting in Semarang Municipality: a Policy Brief. *Public Health of Indonesia*, *11*(3), 142–147. https://doi.org/10.36685/phi.v11i3.1034

Anjali, P., & Vijayaraj, P. (2020). Functional food ingredients from old age cereal grains. In *Functional and Preservative Properties of Phytochemicals* (pp. 47–92). Elsevier. https://doi.org/10.1016/B978-0-12-818593-3.00002-6

Brahmi, F., Oufighou, A., Smail-Benazzouz, L., Hammiche, N., Hassaine, L., Boulekbache-Makhlouf, L., Madani, K., & Blando, F. (2024). Assessment of the Chemical Composition and Antioxidant Capacity of Flowers, Seeds, and Seed Cake of Cactus Pear (Opuntia ficus-indica L.) and Their Application in Biscuits. *Resources*, *13*(9), 124. https://doi.org/10.3390/resources13090124

Devanadera, M. K., Bungato, M. A., Labatos, M. J. M., Manalaysay, A. X., Abuel, Z. E., Bitao, K. M., Tan, S. M., Abion, T. J., Cantillano, T. M., Vibat, A. A., Labrador, A., & Santos, A. C. (2025). Nutraceutical and therapeutic potential assessment of lipote (Syzygium curranii) fruit juice: Effects on lipid profile and glucose lowering. *Food Chemistry Advances*, *8*, 101100. https://doi.org/10.1016/j.focha.2025.101100

Dewie, A., Susetyowati, S., & Hadiati, D. R. (2026). Identification and Prediction of Bioactive Peptides from Anchovy (Engraulidae) Based on Processing Methods: Sub-Fragment Analysis via LC-HRMS Proteomics. *Trends in Sciences*, *23*(7), 12467. https://doi.org/10.48048/tis.2026.12467

Dukhanin, A. S., & Chuvichkina, A. G. (2025). Pharmacological rationale for choosing a drug containing potassium and magnesium citrate. *Russian Medical Inquiry*, *9*(9), 682–687. https://doi.org/10.32364/2587-6821-2025-9-9-21

Ernawati, F., Tanumihardjo, S. A., Aji, G. K., Retiaty, F., Arifin, A. Y., Efriwati, E., Sundari, D., Nurjanah, N., Julianti, E. D., Salimar, S., Setyawati, B., Andarwulan, N., Fuada, N., Rizki, M. A. D., & Aidi, M. N. (2025). Micronutrient Deficiency and Nutritional Status Among Indonesian Children Under Five Years of Age: Evidence from National Survey Data. *Nutrients*, *17*(24), 3926. https://doi.org/10.3390/nu17243926

Fauza, A., Rosdiana, D. S., Abidin, H., Novitasari, P., Wulan, A. N., Damayanti, S. T., & Salsabila, N. F. (2026). The Potential of Indonesian Indigenous Functional Foods as a Sustainable Strategy for Stunting Alleviation: A Systematic Review of Quasi Experimental Research. *Nutrición Clínica y Dietética Hospitalaria*, *46*(1). https://doi.org/10.12873/461afauza

Fawzya, Y. N., & Irianto, H. E. (2020). Fish Protein Hydrolysates in Indonesia: Their Nutritional Values, Health Benefits, and Potential Applications. In *Marine Niche: Applications in Pharmaceutical Sciences* (pp. 283–297). Springer Singapore. https://doi.org/10.1007/978-981-15-5017-1_16

Gayatri, T. (2026). Overexpression of Forsythia intermedia pinoresinol lariciresinol reductase gene in Sesamum indicum increases secoisolariciresinol diglucoside content. *Transgenic Research*, *35*(1), 3. https://doi.org/10.1007/s11248-025-00479-0

Gohil, D., Kokas, M., & Maheshwari, R. (2025). Moringa oleifera: A Short Review of its Health Benefits. *Journal of Natural Remedies*, 1501–1509. https://doi.org/10.18311/jnr/2025/45035

Hailu, B. A., Daba, C., Tsega, Y., Asaminew, A., Miheretu, B. A., & Endawkie, A. (2025). Geospatial distribution and multilevel determinants of inadequate minimum dietary diversity and its consequences for children aged 6–23 months in Sub-Saharan Africa. *PLOS One*, *20*(5), e0321254. https://doi.org/10.1371/journal.pone.0321254

Kambuno, N. T., Putra, A. G. A., Louisa, M., Wuyung, P. E., Timan, I. S., Silaen, O. S. M., Sukria, H. A., & Supali, T. (2025). Moringa oleifera Leaf Extract Improves Cognitive Function in Rat Offspring Born to Protein-Deficient Mothers. *Biomedicines*, *13*(2), 346. https://doi.org/10.3390/biomedicines13020346

Kawasaki, T., Zen, H., Nogami, K., Hayakawa, K., Sakai, T., & Hayakawa, Y. (2025). Direct Analysis of Solid-Phase Carbohydrate Polymers by Infrared Multiphoton Dissociation Reaction Combined with Synchrotron Radiation Infrared Microscopy and Electrospray Ionization Mass Spectrometry. *Polymers*, *17*(17), 2273. https://doi.org/10.3390/polym17172273

Khoo, L. Y., & Azlan, A. (2026). A narrative review of food bar composition to address energy and protein deficits in stunted children. *Food Production, Processing and Nutrition*, *8*(1), 18. https://doi.org/10.1186/s43014-026-00366-z

Kolarič, L., & Šimko, P. (2022). Simultaneous determination of cholesterol, stigmasterol, and β-sitosterol contents in milk and dairy products. *Journal of Food Processing and Preservation*, *46*(1). https://doi.org/10.1111/jfpp.16146

Ligarda-Samanez, C. A., Ccana-Buleje, T. G., Choque-Quispe, D., Palomino-Rincón, H., Taipe-Pardo, F., Moscoso-Moscoso, E., Muñoz-Melgarejo, M., Luciano-Alipio, R., Carrión, J. C., Muñoz-Saenz, J. C., Quispe-Quezada, U. R., & Jilaja-Carita, E. E. (2025). Spray-Dried Porcine Collagen Microcapsules in Tara Gum–Maltodextrin Matrices: A Sustainable Approach to By-Product Valorization for Functional and Nutraceutical Applications. *Applied Sciences*, *15*(23), 12667. https://doi.org/10.3390/app152312667

Lumley, C., Voth-Gaeddert, L., Montenegro-Bethancourt, G., Ratner, L., Sridhar, S., Venzor-Strader, A., Alajajian, S., & Rohloff, P. (2026). Modeling Growth Trajectories in Stunted Children Under 5 Years of Age: A Retrospective Analysis of Clinical Data from Guatemala. *Food and Nutrition Bulletin*. https://doi.org/10.1177/03795721261437900

Lybaws, L., Baliwati, Y. F., & Tanziha, I. (2025). Determinan Food Waste Rumah Tangga Wilayah Perkotaan dan Perdesaan Kabupaten Bogor. *Amerta Nutrition*, *9*(1), 1–13. https://doi.org/10.20473/amnt.v9i1.2025.1-13

Mandal, S., Shankar, R., Rao, K., Kalaivanan, D., Kumar, P. C., & Dutta, S. (2025). Genetic dissection of moringa (Moringa oleifera L.) gene pool for leaf micronutrient and phytochemical qualities for bio-fortification. *Genetic Resources and Crop Evolution*, *72*(3), 2725–2741. https://doi.org/10.1007/s10722-024-02113-0

Marin, M. V., Wang, N.-Y., Turechek, W. W., & Peres, N. A. (2025). Thermotherapy via Aerated Steam is an Effective Alternative for Nonchemical Management of Cryptic Infection of Strawberry by Colletotrichum acutatum. *Plant Disease*, *109*(8), 1745–1752. https://doi.org/10.1094/PDIS-03-24-0700-RE

Mekuriaw, B. Y., Molla, A., Negash, M., Teferi, T., Habtamu, E., Aschale, M., & Tsega, A. (2025). Predictors of depression among caregivers of children with malnutrition in Gedeo zone public hospitals, Southern Ethiopia: case-control study. *BMC Psychiatry*, *25*(1), 500. https://doi.org/10.1186/s12888-025-06959-1

Mersha, J., Tariku, A., & Gonete, K. A. (2021).

Undernutrition and Associated Factors Among School Adolescent Girls Attending Schools in Mirab-Armachiho District, Northwest Ethiopia. *Ecology of Food and Nutrition*, *60*(4), 473–490. https://doi.org/10.1080/03670244.2021.1872022

Muzaffar, H., & Wani, I. A. (2025). Formulation and evaluation of multigrain flatbread containing bitter gourd juice powder. *Food and Humanity*, *4*, 100582. https://doi.org/10.1016/j.foohum.2025.100582

Nethaji, D. K., Alagu, T., Sankar, D., & Thiyagarajan, S. (2025). Nutraceuticals potential of Zingiber officinale and Linum usitatissimum: A comprehensive analysis of macroscopic, microscopic, physico-chemical and phyto-chemical properties. *Current Pharmaceutical Analysis*, *21*(2), 45–53. https://doi.org/10.1016/j.cpan.2025.01.001

Niazi, S. K., Shaikh, H. Y., Rudrappa, M., Bepari, A., Altamimi, H. N., Rudrakshi, P. N., Nayaka, S., & Agadi, S. N. (2025). Comprehensive evaluation of phytochemicals from Cleome simplicifolia stem for its In-vitro antioxidant, anticancer efficacy on HepG2 Cells, In-silico molecular docking and In-vivo hepatoprotective activity against CCl4 induced hepatotoxicity in Swiss albi. *Pharmacological Research - Natural Products*, *9*, 100399. https://doi.org/10.1016/j.prenap.2025.100399

Ogrodowczyk, A. M., Markiewicz, L., Szmatowicz, B., Koźniewski, B., & Wróblewska, B. (2025). Improved quality, sensory properties and nutraceutical potential of the fermented beverages fortified with freeze-dried berries and acacia honey. *Food Chemistry*, *486*, 144469. https://doi.org/10.1016/j.foodchem.2025.144469

Panova, N., Gerasimova, A., Tumbarski, Y., Ivanov, I., Todorova, M., Dincheva, I., Gentscheva, G., Gledacheva, V., Slavchev, V., Stefanova, I., Petkova, N., Nikolova, S., & Nikolova, K. (2025). Metabolic Profile, Antioxidant, Antimicrobial, Contractile, and Anti-Inflammatory Potential of Moringa oleifera Leaves (India). *Life*, *15*(4), 583. https://doi.org/10.3390/life15040583

Paul, A. A., Kumar, S., Kumar, V., & Sharma, R. (2020). Milk Analog: Plant based alternatives to conventional milk, production, potential and health concerns. *Critical Reviews in Food Science and Nutrition*, *60*(18), 3005–3023. https://doi.org/10.1080/10408398.2019.1674243

Pérez-Herrera, A., Martínez-Gutiérrez, G. A., León-Martínez, F. M., & Sánchez-Medina, M. A. (2020). The effect of the presence of seeds on the nutraceutical, sensory and rheological properties of Physalis spp. Fruits jam: A comparative analysis. *Food Chemistry*, *302*, 125141. https://doi.org/10.1016/j.foodchem.2019.125141

Qiu, Z., Zhang, X., Ren, S., Jiang, B., Zhao, J., Zhu, M., Zhou, D., Li, Q., Zhang, M., Li, T., & Shu, L. (2026). Cauliflower mushroom (Sparassis): a promising functional food with nutritional and medicinal properties. *Critical Reviews in Food Science and Nutrition*, *66*(2), 352–368. https://doi.org/10.1080/10408398.2025.2524473

Rahayu, H. K., Khotimah, S., & Fikriah, I. (2026). The effect of fish protein hydrolysate from Kryptopterus lais on nutritional status in stunting animal models. *Discover Food*, *6*(1), 211. https://doi.org/10.1007/s44187-026-00944-7

Rahimah, S., Tallei, T. E., Savitri, M., Yamada, C., Kim, H. J., Choi, M., Park, M. N., Ophinni, Y., & Kim, B. (2026). Nutraceutical Interventions in Stunting: Advances, Challenges, and Prospects. *Food Science & Nutrition*, *14*(5). https://doi.org/10.1002/fsn3.71910

Rani, R., Kaushik, D., Oz, F., Avila-Quezada, G. D., Abd_Allah, E. F., Hashem, A., & Kumar, M. (2025). Polyphenol-rich extract from Cyamopsis tetragonoloba straw: Characterization, bioactivity, cytotoxicity, and anti-obesity potential. *Environmental Technology & Innovation*, *40*, 104569. https://doi.org/10.1016/j.eti.2025.104569

Rantini, D., Najiyya, S. I., Ghani, M., Yasmirullah, S. D. P., Fahmiyah, I., Ramadan, A., Othman, F., & Alya, N. A. (2025). Understanding the Spatial Distribution of Stunting in East Java, Indonesia: A Comparison of GWR and MS-GWR Models. *Statistics, Optimization & Information Computing*, *15*(1), 311–323. https://doi.org/10.19139/soic-2310-5070-3066

Rawat, M., Varshney, A., Gupta, A. K., Jha, A. K., Naik, B., & Kumar, V. (2024). Nutritional, techno-functional properties, and metabolite profiling of Arenga obtusifolia griff. (Tassey) flour in the formulation of functional food. *Food Bioscience*, *62*, 105502. https://doi.org/10.1016/j.fbio.2024.105502

Regnier, T., Tswaai, P., Augustyn, W., & Linde, J. (2025). African mushrooms as a preventative healthcare and nutrition intervention. *BIO Web of Conferences*, *187*, 01004. https://doi.org/10.1051/bioconf/202518701004

Sandhya, J. J., & Kanniammal, C. (2024). Development and sensory evaluation of Moringa oleifera–enriched snack bar for micronutrients deficiency in adolescents. *International Journal of Nutrition, Pharmacology, Neurological Diseases*, *14*(4), 425–431. https://doi.org/10.4103/ijnpnd.ijnpnd_102_24

Sari, A. N., Qurotu'ain, D. H., Harianto, F., & Jannah, S.

Z. (2022). Regional Mapping In Bangkalan District Based On Potential Indicators Of Total Stunting Using K-Mode Cluster Algorithm. *Media Gizi Indonesia*, *17*(1SP), 76–82. https://doi.org/10.20473/mgi.v17i1SP.76-82

Sateikaite, I., Samaei, Y., Khan, M., Carvalho, I., & Lazarte, C. E. (2026). Nutritional status of children under-five in rural mozambique: the role of phytate intake and mineral bioavailability. *Journal of Health, Population and Nutrition*, *45*(1), 74. https://doi.org/10.1186/s41043-026-01247-4

Taha, E. I., & Al-suwayeh, S. A. (2009). *Preparation , in vitro and in vivo evaluation of - solid-state self-nanoemulsifying drug delivery system (SNEDDS) of vitamin A acetate*. *17*(March), 468–473. https://doi.org/10.1080/10611860903002761

Tassoult, M., Kati, D. E., Bachir-bey, M., Benouadah, A., & Rodriguez-Gutiérrez, G. (2021). Valorization of date palm biodiversity: physico-chemical composition, phenolic profile, antioxidant activity, and sensory evaluation of date pastes. *Journal of Food Measurement and Characterization*, *15*(3), 2601–2612. https://doi.org/10.1007/s11694-021-00844-7

Tawalbeh, D., Ahmad, F., Alu'datt, M. H., & Sarbon, N. M. (2025). Production improvement of Kabuli chickpea (Cicer arietinum L.) protein hydrolysates through ultrasonic pre-treatment approach: Impact on techno-functional properties and antioxidant activity. *Food Chemistry Advances*, *9*, 101175. https://doi.org/10.1016/j.focha.2025.101175

Thakur, A., Pandey, K. K., Borker, S. S., Rai, S., Tochhawng, L., & Kumar, R. (2026). A comprehensive review of shiitake mushroom's cultivation, nutritional attributes, therapeutic potential, and sustainable applications. *Discover Food*, *6*(1), 215. https://doi.org/10.1007/s44187-026-00937-6

Thi, P. A. T., Thi, T. V. T., Thi, L. P., & Thi, K. V. P. (2024). Potential use of Polyphenol-Enriched Extract from Moringa oleifera Leaves as an Active Ingredient in Sunscreen. *Natural and Life Sciences Communications*, *23*(2). https://doi.org/10.12982/NLSC.2024.016

Wilcaso, P., Landázuri, A. C., Castelló, M. L., & Ortolá, M. D. (2025). Comprehensive characterization of nutritional, phytochemical, optical, and electrical properties of Moringa oleifera Lam. parts from Ecuador. *LWT*, *228*, 118108. https://doi.org/10.1016/j.lwt.2025.118108

Xu, Q., Tan, H., Zhang, T., Han, D., Wang, Y., Ma, M., & Hu, Q. (2026). Ammonium-regulated high-cell-density heterotrophic cultivation enhances cost-effective chrysolaminarin production in Poterioochromonas malhamensis. *New Biotechnology*, *93*, 194–207. https://doi.org/10.1016/j.nbt.2026.03.006