Mikrogum: Innovative Chewable Gummy of Moringa Leaves and Pumpkin Seeds as Biodiversity-Based Preventive Against Malnutrition

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Article Info
Article History
Submitted, 2025-11-02
Accepted, 2025-11-30
Published, 2025-12-31
Keywords: Moringa leaves, pumpkin seeds, malnutrition, chewable gummy

Abstract
Malnutrition remains a major global health problem, especially in developing countries with limited dietary diversity and restricted access to nutrient-rich foods. inefficiencies in iron, zinc, vitamin A, and magnesium create risks of stunting, cognitive decline, weakened immunity, and metabolic disorders. Despite abundant biodiversity, local food sources with high nutritional potential are often underutilized due to limited public awareness and weak food innovation strategies, such as Moring leaves (Moringa Oleifera) and Pumpikin seeds (Cucurbita Moschata). This study examine the potential of combining Moringa leaves and pumpkin seeds as base ingredients for developing chewable gummies to support preventive nutrition in children and adolescents. A literature review method was employed, involving the analysis of relevant national and international journal articles about Moringa leaves and Pumpkin seeds potential to micronutriet deficiencies and also integrating local source in an appealing and easy to consume form such as cheawable gummy formulation. The result shows that both Moringa leaves and pumpkin seeds are rich in iron, calcium, vitamin A, magnesium, vitamin C, and unsaturrated fatty acid which are essential for growth regulation, enzymatic activity, neurological development, potentially reducing the prevalence of anemia while enhancing metabolic health and overall nutritional status. The combination of these natural ingredients offer a synergistic nutritional effect in a chewable gummies form is an innovative and child-friendly approach to combat malnutrition and strengthen community nutrition resilience. This innovation aligns with the Sustainable Development Goals (SDGs), especially Goal 2 (Zero Hunger) and Goal 3 (Good Health and Well-being), emphasizing the importance of utilizing local biodiversity to achieve long-term health improvement and food security

Introduction

Nutritional problems remain a major public health concern in Indonesia. According to the 2018 National Basic Health Research (RISKESDAS), the prevalence of anemia among adolescent girls reached 32%, while deficiencies in iron, vitamin A, and zinc remain considerably high (Trisasmita et al., 2025). These conditions not only contribute to stunting but also increase the risk of metabolic disorders. Micronutrient deficiencies can impair brain development, weaken the immune system, cause growth retardation, and elevate the risk of metabolic diseases in adulthood, including emerging forms of diabetes such as malnutrition-related diabetes mellitus (MRDM) or severe insulin-deficient diabetes (SIDD), as reported by the International Diabetes Federation (Haftu et al., 2020).

One of the main causes of malnutrition is the imbalance in nutrient intake and the limited knowledge and access to local, nutrient-rich food sources (Shahzad et al., 2025). Indonesia, however, possesses rich biodiversity that can serve as potential sources of functional foods to improve community nutrition such as Moringa (Moringa oleifera) and pumpkin (Cucurbita moschata). Moringa is known as miracle of tree because all of the plants parts have a benefit if it's consumed, moringa rich in micronutrient such as zinc, vitamin A, and magnesium, and also antioxidants activity (Fatmawati et al., 2024). Pumpkin seeds is rich for its bioactive compound

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such as amino acid, criptoxathine, β-carotene and tocopherol (Sunnah et al., 2024). Both of moringa leaves and pumpkin seeds known for their high micronutrient content and ease of local cultivation, but the utilization of these local sources are remains low, while pumpkin seeds treated as waste. Therefore, developing innovative food products based on local resources is essential to enhance their value and community acceptance.

The government's efforts to achieve zero stunting and strengthen national nutritional resilience continue to face significant behavioral and sensory challenges, particularly the low adherence to nutritional supplement intake among children. Many available products fail to attract children's preferences due to their unappealing taste, aroma, and form, leading to poor compliance. Meanwhile, children are generally more attracted to food products that are colorful, chewy, and naturally sweet, which opens opportunities for creative nutritional interventions through functional food innovation. To address these issues, an innovative product was developed that is designed to be easily accepted by the public, possesses sensory appeal favored by children, has an attractive shape, and is safe for regular consumption by utilizing a combination of Moringa oleifera leaves extract and pumpkin seeds (Cucurbita moschata) in the form of chewable gummy preparations. This innovation not only aims to enhance micronutrient intake among children and adolescents but also to promote the sustainable utilization of Indonesia's biodiversity.

Methods

This study uses a literature review method to examine the potential of Moringa leaves (Moringa oleifera) and pumpkin seeds (Cucurbita moschata) as raw materials for chewable gummy formulations in preventing malnutrition. Relevant scientific publications were collected from national and international journals using databases such as Google Scholar, PubMed, and ScienceDirect, published from 2019 to 2025. The search strategy used keywords: Moringa leaves, pumpkin seeds, malnutrition, and chewable gummy. The obtained articles were 33 articles that were subjected to data reduction, where researchers identified the most relevant and important information related to the potential of Moringa leaves (Moringa oleifera) and pumpkin seeds (Cucurbita moschata) as raw materials for chewable gummy formulations. The primary literature used must include the inclusion criteria, namely (1) Subjects discussing the potential of Moringa leaves, (2) Subjects discussing the content of pumpkin seeds, (3) Subjects discussing the potential of processed Moringa leaves and pumpkin seed products, (4) Articles published between 2019 and 2025. Articles published before 2019 were excluded. There were 10 articles reviewed and 23 articles excluded. Furthermore, the reduced data will be presented in the form of a summary, table, or graph. This data presentation will facilitate understanding of the findings in the literature sources that have been reviewed. The data is presented clearly and systematically so that it is easy to understand and compare. After the data is presented well, the final stage is drawing conclusions. At this stage, the researcher will conclude the results of the analysis of the literature review data that has been carried out.

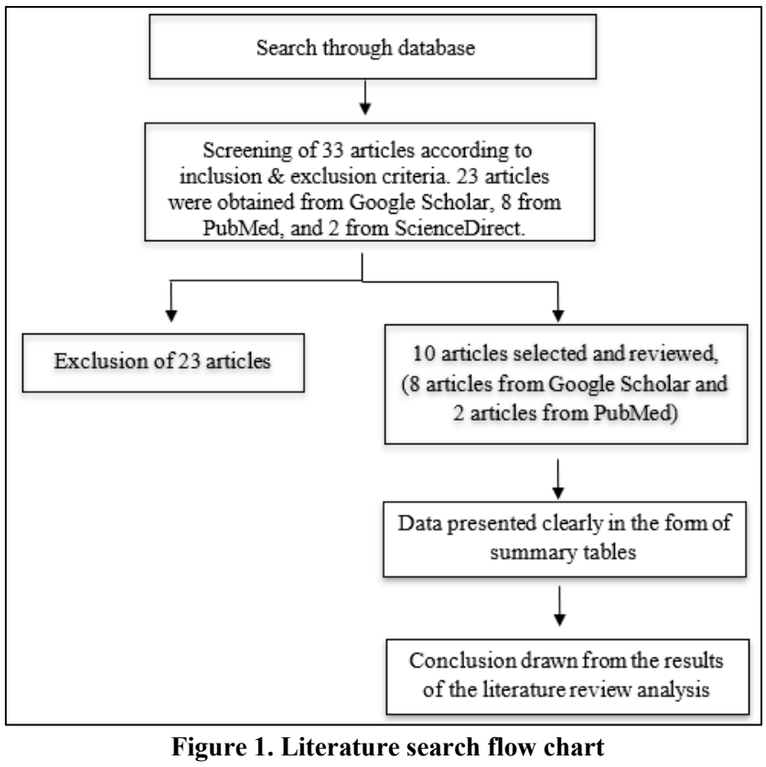

Figure 1. Literature search flow chart

Results and Discussion

Indonesia continues to face chronic malnutrition issues such as stunting, anemia, underweight, and micronutrient deficiencies (iron, vitamin A, zinc, and magnesium), all of which affect the growth, cognitive function, and long-term metabolic health of children and adolescents (Kemenkes RI, 2018).

Moringa oleifera thrives in tropical regions and has long been recognized as a vegetable and traditional medicinal plant. Moringa leaves are rich in essential nutrients, such as protein, calcium, phosphorus, iron, and zinc (Irwan, 2020). However, their nutrient content can vary depending on the drying and processing methods used, as exposure to heat and oxygen during these processes can potentially affect the stability and concentration of nutrients contained therein. It can be shown in table 1.

Table 1. Micro-nutriens based on Drying method of 100 gram ingredient

Nutrient	Drying Method		
	Blanching	Wither	Sun-dried
Protein (g)	28,66	27,83	26,65
Calcium (mg)	929,29	1014,81	962,28
Phosphor (mg)	715,32	700.65	445,18
Ferros (mg)	9,99	11,41	4,95
Zink (mg)	2,32	2,16	2,01

(Source: (Irwan, 2020))

Pumpkin seeds (Cucurbita moschata) contain a variety of essential minerals. These minerals demonstrate that pumpkin seeds are a rich natural source of micronutrients that play a key role in metabolism, bone formation, and immune function, making them valuable for malnutrition prevention. Malnutrition is strongly associated with deficiencies in various micronutrients, including vitamins and minerals. Micronutrients such as vitamin A, B-complex vitamins, vitamin C, folate, zinc, calcium, iodine, and iron are crucial in addressing nutritional deficiencies, including vitamin A deficiency which can be seen in table 2.

Table 2. Mineral Composition of Pumpkin Seed

Nutrient	Pumpkin Seed (mg/32.25 g)
Calcium	14.84
Iron	2.84
Magnesium	190.92
Phosphorous	397.64
Potassium	260.90
Sodium	2.26
Zinc	2.52
Copper	0.43
Manganese	1.47

(Source: (Batool et al., 2022))

The combination of moringa leaves and pumpkin effectively increases the nutritional value and antioxidant activity of food products without significantly reducing organoleptic quality, and has strong potential as a local fortification ingredient to support stunting and malnutrition prevention programs in Indonesia. However, further research is needed to optimize the formulation, maintain nutritional stability during processing, and conduct broader clinical evaluations so that the benefits of this local food ingredient can be comprehensively proven and applied sustainably in efforts to improve nutrition. Table 3 shows the result of development for moringa leaves and or pumpkin in many products.

The nutritional stability of chewable gummies made from moringa leaf extract and pumpkin seeds is greatly influenced by processing and storage, even though pumpkin seeds (Cucurbita moschata) are a natural source of essential minerals such as zinc, calcium, magnesium, and iron that play a role in metabolism, bone formation, and immune function. During processing, exposure to high temperatures, oxygen, and light can cause a decrease in heat-sensitive vitamins such as vitamin C, β-carotene, and vitamin E, as well as reduce the activity of bioactive compounds, while minerals are relatively more stable but their bioavailability can be reduced due to interactions with other components. Therefore, controlling the temperature and heating time, proper pH formulation, and the use of protective packaging are necessary to maintain the nutritional quality of chewable gummies during storage.

Table 3. Research Results

No	Author and year	Desain Study	Research Results
1	(Ismawati & Anjar Sasmita	Experimental research	Each serving (35 g) of Moringa leaves biscuits contains 140.53 kcal of energy, 5.28 g of protein, 1.72 g of fat, and 1.25 mg of iron. One serving of Moringa

	Rustamaji, 2021)		leaves biscuits can meet toddlers' energy, protein, and iron needs from snacks, but it has not yet met their fat requirements.
2	Pratiwi et al., 2023	Pre-experimental design with one-shot case study research type.	From the results of the research that has been carried out, the analysis results show that the addition of pumpkin flour (20 g) and moringa leaves flour (15 g) to sample F3 compared to F1 increases the protein content by 5.63 g, iron by 17.61 mg, and vitamin C by 15.12 mg.
3	Masithah, 2023	Experimental research design conducted in a laboratory in two stages	The addition of moringa leaves flour and pumpkin to cookies increases the vitamin C and zinc content compared to regular cookies. cookies as a PMT contain moringa leave still meets the micronutrient needs (vitamin C and zinc) of infants aged 6–11 months and children aged 1–3 years.
4	(Nugraha et al., 2024)	Quasi Eksperimental dengan rancangan desain One Group Pre Test Posttest	Administration of 10 grams of Moringa leaves extract for 14 days resulted in ten malnourished toddlers improving to a good nutritional status, with an average weight gain of 0.8 kg and an average height increase of 0.9 cm.
5	(Juhász et al., 2025)	Systematic review	The addition of plant proteins from pumpkin seeds, yellow peas, brown rice, and flax seed to green lentil cookies increased the protein content by 20%, but decreased polyphenol and antioxidant activity. Changes in color, texture, and flavor depended on the protein type, with inulin helping to improve texture and sensory perception. Overall, plant protein fortification enhanced the nutritional value of the cookies, but a balance was needed to maintain optimal organoleptic quality.
6	(Vanda Editia et al., 2023)	Pre Eksperimental dengan pendekatan Pre test – post test One Group	Moringa leaves ice cream has been shown to be effective in increasing toddler weight, with a z-score of -5.826. Therefore, the Gemeh Community Health Center is advised to develop innovative moringa leaves-based food supplements as an effective way to improve nutritional status, especially for toddlers with malnutrition and stunting.
7	(Istianatus Sunnah et al., 2024)	Systematic Review	The formulation of gummy candies containing pumpkin seed extract includes secondary metabolite compounds such as flavonoids and terpenoids, and possesses physical characteristics—such as pH, weight uniformity, syneresis, swelling ratio, and dispersion time—that meet quality standards. This gummy product has the potential to be utilized as a natural source of antioxidants.
8	Sa'adah & Silvia, 2022	True Eksperimental dengan Rancangan Acak Lengkap (RAL)	Based on the hedonic test results, it was found that pumpkin can be processed into gummy jelly candies, a snack with a high vitamin A content. The protein and vitamin A content of the candies per serving (40 g) are 20.5 g and 37.75 mcg, respectively.
9	(Rani et al., 2022)	Ekesperimental study	The best gelling agent formula for Moringa oleifera chewable gummies was obtained using 0.75% konjac glucomannan and 2.0% kappa carrageenan, with kappa carrageenan producing gummies that were stronger and more elastic.
10	(Čakarević et al., 2021)	Eksperimental study	This study reports a new approach to utilizing pumpkin seed oil cake as a carrier material for the encapsulation of red beet juice, aimed at producing food products with high bioactive content without compromising technological or sensory quality.

Previous studies have shown the high potential of Moringa leaves (Moringa oleifera) and pumpkin seeds (Cucurbita moschata) as local food sources rich in micronutrients. Processed products such as biscuits and cookies made from these ingredients have been proven to increase the levels of protein, iron, vitamin C, and zinc compared to conventional products (Pratiwi et al., 2023). In addition, functional food formulations such as chewable gummies and Moringa leaves ice cream have demonstrated effectiveness in improving children's body weight and nutritional status, while also exhibiting sensory characteristics that are acceptable to children (Vanda Editia et al., 2023).

Furthermore, (Sunnah et al., 2024) reported that gummies formulated with pumpkin seed extract contain flavonoid and terpenoid compounds and possess physical characteristics that

meet quality standards, making them potential sources of natural antioxidants. From a formulation perspective, the type and concentration of gelling agents, such as konjac glucomannan and kappa carrageenan, greatly influence the physical properties of gummies, including texture, elasticity, syneresis, and disintegration time. The optimal formula was found at a combination of 0.75% konjac glucomannan and 2.0% kappa carrageenan, producing gummies that are firm and elastic (Rani et al., 2022).

The development of functional foods based on Indonesia's biodiversity is urgently needed to prevent various diseases and serve as a preventive measure against malnutrition. The utilization of Moringa oleifera (moringa) as a fortifying ingredient to enhance the nutritional value of food products requires further research to determine the optimal formulation with adequate nutrient content and acceptable sensory properties for consumers (Marhaeni, 2021). Formulating chewable gummies using extracts of Moringa leaves and pumpkin seeds is an innovative and practical approach that supports adequate micronutrient supply while ensuring high acceptability among children. However, one of the key scientific considerations in developing micronutrient-enriched gummies is the stability of the active compounds during processing and storage (Delgado-Durán et al., 2025). Micronutrients such as vitamin A, vitamin C, zinc, and iron are known to be sensitive to heat, light, oxidation, and pH changes, which may lead to significant degradation if not properly protected. The gummy matrix can serve as a semi-protective medium, yet stability can still be compromised without appropriate formulation strategiessuch as controlling temperature during cooking, incorporating natural antioxidants, optimizing pH, and selecting suitable packaging. Ensuring micronutrient stability is crucial because even small losses during production or shelf life can reduce the intended nutritional benefits, ultimately affecting the effectiveness of the intervention for children at risk of micronutrient deficiencies.

From an acceptability perspective, chewable gummies generally possess colors, aromas, textures, and flavors that appeal to children particularly when formulated with balanced natural ingredients. Children perceive these products as more attractive and easier to consume than conventional supplements such as capsules or syrups (Sa'adah & Silvia, 2022). This indicates that micronutrient-enriched gummies are a child-friendly nutritional intervention that not only fulfills nutrient needs but also improves consumption compliance through enjoyable sensory characteristics.

Utilizing pumpkin seeds or other local agricultural resources for functional food and micronutrient-rich supplement production expands opportunities for local food innovation. The formulation of chewable gummies made from Moringa leaves and pumpkin seeds contributes to local food security, increases the economic value of agricultural commodities, and supports community-based economic development, particularly in rural areas. This initiative aligns with the United Nations Sustainable Development Goals (SDGs) 2030, especially Goal 2: Zero Hunger, which aims to end hunger and improve nutrition, and Goal 3: Good Health and Well-being, which promotes healthy lives for all at all ages.

Conclusion and Suggestion

The review highlights the strong potential of Moringa oleifera leaves and Cucurbita moschata (pumpkin) seeds as functional food ingredients to combat malnutrition in Indonesia. Both materials are rich in essential micronutrients such as iron, zinc, calcium, magnesium, and vitamin A that play vital roles in growth, immune function, and metabolic health. Studies consistently demonstrate that incorporating these local ingredients into food products (such as biscuits, cookies, and chewable gummies) enhances their nutritional value without compromising sensory quality. Furthermore, the formulation of chewable gummies using Moringa and pumpkin seed extracts offers a practical and appealing approach for improving children's nutrient intake, particularly among those suffering from stunting and anemia.

This innovation aligns with national nutrition programs and supports the Sustainable Development Goals (SDGs), especially Goal 2 (Zero Hunger) and Goal 3 (Good Health and Well-being). Future research should focus on optimizing the formulation of Moringa leaves–pumpkin seed chewable gummies to ensure nutrient stability during processing and storage while maintaining desirable sensory characteristics. Clinical or community-based intervention studies are also recommended to evaluate their real-world effectiveness in improving nutritional status among children and adolescents. Moreover, strengthening local production and utilization of these ingredients can promote sustainable food systems, empower rural economies, and support the broader goal of achieving nutrition security through locally sourced, culturally acceptable, and child-friendly functional foods

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