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Literature Review. The acceptability of Moringa Leaf (*Moringa Oleifera*) enriched foods in Indonesia

Literatur Review. Penerimaan makanan yang diperkaya dengan Daun Katuk (Moringa Oleifera) di Indonesia

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Abstract

Moringa leaves (Moringa oleifera) have many health benefits and have been used by the wider community to support health. The purpose of this review is to provide an overview of the acceptability of food products substituted with moringa leaves, based on studies conducted in Indonesia. Indosesia's reference database, Garuda (Garba Rujukan Digital), was used for the eligible studies. The search terms used to obtain relevant studies were "Moringa leaf," "organoleptic," and "acceptability" published between 2016 and 2021. The inclusion criteria were full-text articles written in Indonesian or English and published in Sinta 1-4 indexed journals. This study used a completely randomized design and sensory testing in humans. Results: Nine studies qualified for this review, with a variation substitution of moringa leaf in instant noodles, jelly candy, cookies, biscuits, and pancakes. The addition of moringa leaves to the products was carried out in the form of powder, protein concentrate, flour, and puree–1,5-5% to improve the content of certain nutrients, such as protein, beta-carotene, iron, calcium, vitamin C, or overall nutrients. Untrained panelists of 15-33 were used to select consumer preferences for the products, followed by nutrient analysis to determine the increase in the content of certain nutrients by adding moringa leaves. In conclusion, the more moringa leaves were added to the food products, the lower the panelists' preference for aroma, color, texture, and taste.

Keywords: Food products, moringa leaves, *Moringa oleifera*, organoleptic

Abstrak

Daum kelor (*Moringa oleifera*) memiliki banyak manfaat kesehatan dan telah dimanfaatkan masyarakat luas untuk menunjang kesehatan. Tujuan penelitian ini adalah memberikan gambaran mengenai akseptabilitas produk pangan substitusi daun kelor berdasarkan penelitian yang dilakukan di Indonesia. Database dari Garuda (Garba Rujukan Digital) digunakan sebagai rujukan mencari artikel yang sesuai, dengan kata kunci "daun kelor, organoleptik, dan akseptabilitas". Kriteria inklusi meliputi *full* artikel ditulis dalam bahasa Indonesia atau Inggris, diterbitkan dalam rentang 2016-2021 pada jurnal yang terindeks Sinta 1-4, penelitian menggunakan rancangan acak lengkap dan pengujian sensorik pada manusia. Hasil, sembilan artikel memenuhi syarat untuk review ini dengan variasi substitusi daun kelor pada mie instan, permen jelly, cookies, biskuit, dan pancake. Penambahan daun kelor pada produk dilakukan dalam bentuk bubuk, konsentrat protein, tepung terigu, dan puree sebesar 1,5-5% untuk meningkatkan kandungan zat gizi tertentu, seperti protein, betakaroten, zat besi, kalsium, vitamin C, atau zat gizi keseluruhan. Panelis tidak terlatih berusia 15-33 tahun digunakan untuk memilih preferensi konsumen terhadap produk, dilanjutkan dengan analisis zat gizi untuk mengetahui peningkatan kandungan nutrisi tertentu dengan menambahkan

daun kelor. Kesimpulan, semakin banyak daun kelor yang ditambahkan pada produk pangan maka kesukaan panelis terhadap aroma, warna, tekstur, dan rasa semakin menurun.
Kata Kunci: Produk pangan, daun moringa, *Moringa oleifera*, organoleptic

Introduction

Moringa oleifera is a versatile tree that is considered a wild plant but is an abundant source of nutrients that can be used for alleviating mineral micronutrient deficiencies. It is recommended as a nutritional supplement for pregnant women, nursing mothers, and malnourished children. In many low-to middle-income countries, the leaves have been used to improve nutrient quality in several foods in Africa, fortified in soups, biscuits, bread, cakes, and yogurt (Oyeyinka & Oyeyinka, 2018).

In Indonesia, moringa leaves have been widely used for many purposes, such as traditional rituals and medicine, beauty, environmental management, and food fortification/supplementation, that is, for malnourished toddlers, anemic pregnant women, and diabetic treatment (Ahmad et al., 2019; Indriani et al., 2019; Isnan & Nurhaedah, 2017; Mayangsari & Rasmiati, 2020). The prevalence of exclusive breastfeeding and continued breastfeeding at 1 and 2 years is low among breastfeeding mothers in Indonesia (Nurokhmah et al., 2022). Moringa leaves are usually consumed by breastfeeding mothers as a supplement or vegetable/side disk to increase milk production. Many culinary products or snacks enriched with moringa leaves have also been introduced, such as moringa leaf cookies (. Erniyanti et al., 2019), bun (*Bakpao* in Indonesian) (Darmawan, 2017), ice cream (Wijayanti & Ismawati, 2016), yogurt (Ilona & Ismawati, 2015), wet noodles (Salim et al., 2017), and instant porridge (Zakaria et al., 2020).

The diversity of these products indirectly indicates the efforts of the community to consume healthy food, which needs to be continuously improved (Islam et al., 2021). Research comparing the acceptability of Moringa leaf-enriched food products introduced in the community is limited in Indonesia. This review aims to provide an overview of the formulation and acceptability of food products substituted with moringa leaves based on studies conducted in Indonesia. This study is expected to help in the development of other food products substituted with moringa leaves and to improve the quality of research related to the development of new food products that are based on nutritional principles and are acceptable to the community.

Methods

Search Strategy

An Indonesian digital reference database, *Garuda* (*Garba Rujukan Digital*, available at https://garuda.kemdikbud.go.id/), was used for eligible studies. The search terms used to obtain relevant studies were moringa leaf, organoleptic "*Moringa* leaf," "organoleptic," and "acceptability." Articles published between 2016 and 2021 were selected for this review. An article search was conducted on April 27, 2021.

Eligibility Criteria and the Study Selection

The included studies had completely randomized designs and full-text articles published in a reputed Indonesian journal database, Sinta 1-4 (https://sinta.kemdikbud.go.id/). The exclusion criteria included research on beauty products, livestock, medicine, and sensory tests without human panelists. Based on these criteria, 9 articles were included in the review (Figure 1).

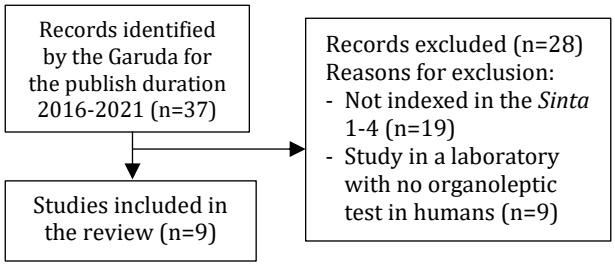

Figure 1. The studies selection process for the review

Data Extraction and Presentation

Data extraction is presented in the form of tables to answer the objectives of this review: 1) study

and characteristics of moringa leaf substitution (i.e., author or citation detail, type of food, moringa leaf substitution form, and nutrient improvement target), 2) formulation of the most preferred products and its nutrient analysis (i.e., the composition or formulation, nutrient analysis (unit, method, value, and statistical analysis), and 3) acceptance data of the preferred product (i.e., number of panelists and type, the instrument used to measure the acceptance test and scores of the acceptance test for flavor, color, taste, texture, and overall).

Result and Discussion

Study and Moringa Leaf Substitution Characteristics

Moringa plants and their potential use in food products have been extensively explained in the literature. The abundance of antioxidants and nutrients (i.e., high content of protein, fiber, iron, calcium, beta carotene, and vitamin C) in its leaves is the main reason for the suggestion to add these leaves to food products, especially to overcome the nutritional problems of the community (Islam et al., 2021).

Our study showed that the moringa leaves have been substituted in various food products, including instant noodles, jelly candy, cookies, biscuits, and pancakes by adding its leaves in the form of moringa leaf powder, protein concentrate, flour, and puree. The purpose of adding the leaf was to improve specific nutrient content, such as protein, beta-carotene, iron, calcium, and vitamin C, as well as overall nutrients.

Formulations of the Most Preferred Products and Its Nutrients Analysis

All studies determined the best formula based on the results of the acceptability or organoleptic tests. The best-selected formula was then tested for its specific nutrient content in a laboratory and compared to the control formula to determine whether the addition of moringa leaf increases the specific nutritional content by statistical analysis.

According to all the studies, only one article did not analyze the nutrient content of their preferred product, and two studies compared the control product. The ratio of adding moringa leaf was around 1,5% to 5% in the form of 2% moringa leaf extract (Darpy & Syukri, 2016) or 5 g of moringa leaf flour in instant noodles (Agus & Ismawati, 2018); 2% moringa leaf powder in jelly candy (Rahmawati & Adi, 2016); 1,5% moringa leaf protein concentrate (Saholaa et al., 2017) or 3% (Sari & Adi, 2017) or 6% (E. Erniyanti et al., 2019) moringa leaf flour in coco, moringa leaf flour (Augustyn et al., 2017) or 25% composite flour substitution with moringa leaf (Kusumawardani et al., 2018) in biscuits; and 15 g moringa leaf pancakes (Dinda & Luki, 2018) (Table 1).

The amount of different nutrients in food products containing moringa leaves depends on the composition of the ingredients used in formulating the product and the cooking technique applied. The substitution of moringa leaves in food products can affect their acceptability; therefore, it is important to select the best formula preferred by consumers. Furthermore, the appropriate substitution form of leaves during the manufacturing process to maintain nutrient quality is also important. For example, fresh moringa leaves contain 6,7 g of protein (% dry matter) and dry leaves contain 29,4 g (Gopalakrishnan et al., 2016); a higher quantity of 30,52% exists in the flour form, whereas the highest of 38,12% is found in the extract form (Becker, 2003).

Panelist's Acceptance of the Moringa Leaf Enriched Foods

All studies used untrained panelists in the range of 15 to 33 to determine the acceptability of food products, including aroma, color, taste, texture, and overall acceptance. The panelists were selected based on the target of the product being developed, that is, schoolchildren as panelists for moringa leaf jelly candy and pancake, mothers with toddlers, and pregnant women as panelists for moringa leaf biscuits and instant noodles, respectively (Table 2). These studies concluded that the addition of moringa leaves affects the aroma, color, taste, texture, and overall acceptance of food products. The addition of moringa leaves tends to decrease panelists' preference for the aroma, color, taste, and texture of food products.

Despite the many positive health benefits of moringa leaf, the excessive addition of leaves to food products can reduce the odor, taste, and color of the food. The dark color, astringent

taste, and off-flavor of moringa leaves are significant obstacles in processing or substituting the leaves in food products, thus affecting the sensory aspect of the products. Preparation of moringa leaves before cooking, including soaking in ice water or boiling in salt water (Andarwulan, 2011), blanching before cooking (Darpy & Syukri, 2016; Dinda & Luki, 2018; Saholaa et al., 2017), and adding other ingredients to diminish the unpleasant aroma can reduce the unpleasant aroma of moringa leaf-enriched food products. Adding kaffir lime leaves can minimize the unpleasant smell of moringa leaf flour during the noodle steaming process (Agus & Ismawati, 2018).

Table 1. Formulation and nutrients analysis of foods enriched with *Moringa* leaf[a] based on the selected studies

Authors	Type of food products	*Moringa* leaf substitution forms	Nutrient improvement target	*Moringa* leaf substitution	Nutrients analysis		
					Nutrients	The preferred products	Control
Darpy and Syukri (2016)	Instant noodles	Extract	Protein	The combination ratio of wheat flour, modified cassava flour, and *Moringa* leaf extract = 85:13:2	Water (%) Ash (%) Protein (%) Water absorption (%) Elasticity (cm)	7,36 0,27 3,79 90 1,10	n/a
Agus and Ismawati (2018)	Instant noodle	Flour	Protein and calcium	5 g *Moringa* leaf flour was added to 25 g yellow sweet potato and 20 g soy protein isolate	Protein (g) Calcium (g)	8,3 30,8	4,7[b] 6[b]
Rahmawati and Adi (2016)	Jelly candy	Powder	Beta-carotene	2% *Moringa* leaf powder	Vit. A (β-carotene (mcg/100g) Energy (kcal/100g)	0,178 205,8[c]	n/a
Saholaa et al., (2017)	Cookies	Protein concentrate	Protein	1.5% *Moringa* leaf protein concentrate	n/a	n/a	n/a
Sari and Adi (2017)	Cookies	Flour	Iron	10 g *Moringa* leaf flour was added to 40 g of soybean sprout flour	Protein (g) Iron (mg)	9 3,88	n/a
Erniyanti et al. (2019)	Cookies	Flour	Nutritional content	The combination ratio of wheat flour, *Moringa* leaf flour, and Red bean flour = 70:6:24	Moisture (%) Ash (%) Protein (%) Fat (%) Carbohydrate (%)	5,82 1,41 17,03 13,27 62,38	n/a
Augustyn et al. (2017)	Biscuits	Flour	Nutritional content	3% *Moringa* leaf flour	Moisture (%) Ash (%)	2,74 1,41 10,12	n/a

					Protein (%) Fat (%) Fiber (%) Carbohydrate (%)	11,15 2,20 72,12	
Kusumawardani et al. (2018)	Biscuits	Flour	Vitamin C	25% composite flour substitution with *Moringa* leaf	Energy (kcal) Vitamin C (mg)	531,18 77,076	514,91 76,11 No statistical test
Dinda and Luki (2018)	Pancake	Puree	Protein and calcium	15 g *Moringa* leaf was added to 35 g of wheat flour and red beans	Protein (g) Calcium (mg)	5,8 125,1	4,9 62,6[b]

[a]the most preferred products selected by panelists based on organoleptic tests; [b]Significantly difference at p<0.05; All the nutrients analysis based on laboratory test, except for [c]based on the list of Indonesian Food Composition (2014); n/a, not available

Table 2. The most preferred *Moringa* leaf enriched foods acceptance test data

Panelists (n)	Method used to measure the acceptance	Mean of the acceptance scores[a] of the most preferred food products				
		Flavor	Color	Taste	Texture	Overall
15	A 5-point *Likert* scale questionnaire	3,77[b,d]	4,08[b,d]	4,03[b,d]	4,16[b,d]	n/a
33 pregnant women	A 5-point *Likert* scale questionnaire	4,20	3,70	3,80	n/a	3,80
32 untrained panelists, the elementary school students in 4th grade	A 4-point *Likert* scale questionnaire	3,31[c]	3,21[c]	3,53[c,d]	3,56[c]	n/a
15	A 5-point *Likert* scale questionnaire	4,41	4,58	4,55	4,50	n/a
30 mothers of toddlers aged 1-3 years	A 4-point Likert scale questionnaire	n/a	n/a	n/a	n/a	n/a
30 untrained panelists	A 5-point *Likert* scale questionnaire	3,90[b]	4,21[b]	4,17[b]	3,91[b]	n/a
30	n/a	3,22	3,20	3,67	3,32	3,41
30 semi-trained panelists	n/a	n/a	n/a	n/a	n/a	n/a
30 elementary school students in 5th grade	A 4-point *Likert* scale questionnaire	1,97	1,78	2,2	2,1	n/a

high score for the acceptance (flavor, color, taste, texture, and overall) referred to the maximum Likert score point used in each study; [b]Significant values were measured to analyze whether the addition of Moringa leaf influenced the acceptance of the products using Analysis of Varian (ANOVA) followed by Duncan's Multiple Range Test (DMRT) and [c]Kruskal Wallis and Mann Whitney tests; [d]significantly difference based on the statistical test used (p<0,05); n/a, not available

Preprocessing of moringa leaves by alkali treatment before they are processed into food products has been shown to decrease the anti-nutrient content and improve the functional properties of moringa leaf flour, making it acceptable for use in food formulations (Devisetti et al., 2016). In addition, it reduces the composition and content of phenolic compounds and glucosinolates in Moringa leaf flour (Andarwulan, 2011). Glucosinolates, especially glubraningin and glucosoonjnain, are the predominant phytochemicals found in moringa (Chodur et al., 2018) that have some potential medicinal properties (e.g., cancer treatment,

blood glucose regulation, and antibiosis) (Fahey, 2017); however, they also have a negative impact in the form of noticeable harsh or bitter taste (Chodur et al., 2018). Adding flavor enhancers or other ingredients such as flour, eggs, milk, and sugar may reduce the unpleasant taste.

The content of chlorophyll in moringa leaves can affect the assessment of the color of the product; therefore, the assessment of color may decrease when more leaves are added. Generally, the acceptance of the first material is color. This may explain the decrease in panelists' preference for other sensory assessments, including aroma, texture, and taste. However, there are no additional data in the reviewed studies, which could enlighten us on this particular point. The difference in the form of substitution of moringa leaves and the processing technique of food products affects the elasticity or texture of the product. The particle size of moringa leaf flour and other ingredients can affect the elasticity of moringa biscuits (Erniyanti & Sadimantara, 2019). Water can also be used to dissolve the material (Augustyn et al., 2017; Rahmawati & Adi, 2016).

Taste determines a consumer's acceptance of a product. It is a combination of olfactory stimuli and experiences that involve the tongue, and is formed from sensations that come from the combination of constituent ingredients and their composition in a food product. As more moringa leaves are added to food products, the preference of panelists for taste decreases. Nutrient analysis of the best formula is aimed at determining the nutritional content of the product and comparing it with control products; hence, it can be concluded that the addition of moringa leaf may increase the active compounds or nutritional contents of the product.

Implications for food production

The addition of moringa leaves in food production should adjust the main composition of the ingredients used and the type of food product produced. Other food additives, such as flavor and aroma enhancers, may be added to reduce the unpleasant taste associated with active compounds naturally present in moringa leaves.

There are still many opportunities to develop moringa leaves for food processing to address nutritional issues in Indonesia for various age groups and certain conditions. In addition, the products reviewed in this study could be used as examples to design practical solutions in the form of dietary supplementation by utilizing local food to improve the quality of nutritional intake and overcome nutritional problems that exist in the community, such as the low prevalence of mothers who breastfeed their babies in low- and middle-income countries (Bhattacharjee et al., 2021) where one of the reasons is less breast milk production.

Implications for future research

Research related to the development of food products substituted with moringa leaves should also measure control products (e.g., moringa leaf biscuits vs. plain biscuits) to determine changes in the nutritional/compound content of the resulting product and test the changes statistically. Hence, it can be used to prove claims of an improvement in the nutritional/compound content announced to consumers regarding the product being developed.

Strengths and Limitations

This study is the first review article that presents the results of studies conducted in Indonesia to find the best formulation for food enriched with moringa leaves that can be developed for other food products based on laboratory and sensory tests in humans.

The food products in this study may be less accepted and need to be reformulated or modified, especially if other researchers want to apply them to other groups or places because of different cultural backgrounds and eating cultures that may affect the acceptance of different food types. The current study also did not cover clinical interventions involving biochemical tests or human bioavailability, which might be useful for understanding the health effects of consuming food fortified with moringa leaves.

Conclusion

In Indonesia, various food products have been substituted with moringa leaves, including instant noodles, jelly candy, cookies, biscuits, and pancakes. Moringa leaf substitution was carried out in the form of moringa leaf powder, protein concentrate, flour, and puree around 1,5-5% to improve

specific nutrient contents, that is, protein, beta-carotene, iron, calcium, vitamin C, and overall nutrition. The best formulation of the food products enriched with moringa leaves was selected based on an acceptance test, followed by nutrient analysis to determine the increase in the specific nutrient content by adding the leaves.

However, most of the studies did not compare the best formulation of food enriched with moringa leaves to general products. When more moringa leaves were added to the food products, the panelists' preference for aroma, color, texture, and taste decreased.

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