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Moringa oleifera: A Review on Nutritive properties of Leaves and its Application on Dairy Products

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ABSTRACT: *Moringa oleifera* is a multi-purpose plant, which is highly rich in essential amino acids, vitamins, proteins, antioxidants, etc. It has an extensive range of bioactive components including phenolics and flavonoids, alkaloids, glucosinolates, terpenoids, isothiocyanates, etc. The phytochemicals and secondary metabolites present in *M. oleifera* leaves, have a positive effect on antioxidant properties. The recent increase in consumer interest in health foods has created new opportunities for plant products containing bioactive components in various food compositions. Thus, incorporating *M. oleifera* leaves in dairy products may improve the nutritional value of the products, and also it may help in combating malnutrition in children and adults. This paper demonstrates an overview of recent advancements in discovering *M. oleifera* leaves nutritional value to the food industry and describing information on its application in dairy products.

Keywords: *Moringa oleifera*, bioactive components, nutritional value, phytochemicals, and secondary metabolites.

INTRODUCTION

The dairy sector provides diverse food products ranging from raw milk to novel products aimed at specific markets or consumers and offers ingredients to other industries. Consumers are cautious about accepting completely new substances and food products, preferring to look for additional health benefits in more or less known products, as researched by Jongen *et al.* (2005). Consumer demand for food products shifts over time and these changes would vary from fundamental factors such as enhancing shelf life, improving food safety, and minimizing wastage to requests for increasingly sophisticated foods with unique nutritional value, palatability, and convenience, researched by Winger and Wall (2006); Hall (2007).

Innovation in foods plays a critical role in translating nutritive information into consumer products to create new healthy food ingredients and added specialized nutrients or functional additives. People in modern society expect that functional food should promote their well-being, enjoyment, and active lifestyle, as researched by Hsieh and Ofori (2007). In food processing industries, food manufacturers are adding value to their products to suit the current consumer demand for healthier food products. The innovation success of new food products improves when there is truly added value to the consumer. Increased mineral (Ca, Zn, Fe, Se) and multivitamin consumption are recognized benefits of several public health projects and the food industries, researched by Morris *et al.* (2008); Martindale and Swainson (2008).

Moringa oleifera referred to as the "miracle plant or the tree of life" has gained much economic importance in several countries, based on its application, preferably in medicine and nutrition. It is a plant native to Northwest India, but can also be found in Tropical Asia, North-South Africa, Madagascar, Latin America, and Southwest Asia. *M. oleifera* genus has 14 species in the *Moringaceae* family, researched by Azlan *et al.* (2022). It is the most inexpensive plant to provide good nutritional value and helps to prevent several lifestyle diseases. It has been used as an alternative food source to combat malnutrition in several countries, researched by Islam *et al.* (2021).

Research studies found that the phytochemicals derived from these plant sources such as flavonoids, phenolic acids, carotenoids, alkaloids, tannins, saponins, and glucosinolates have been shown to improve positive effects on global health. *M. oleifera* has various nutritive properties, the leaves are loaded with medicinal benefits as they can inhibit cancer cells. Also, it has various pharmacological activities, such as anti-inflammatory, analgesic, antihypertensive, and antitumor activity effects, as found by Dhakad *et al.* (2019). The leaves contain vitamins A, B, C, D, E, iron, proteins, calcium, potassium, magnesium, copper, and manganese, found by Hekmat *et al.* (2015). Since, the

leaves contain natural antioxidants such as vitamin C, tocopherols, flavonoids, and other phenolic compounds, they might be incorporated into dairy products to improve their shelf life. Furthermore, antioxidant compounds are especially beneficial to human health because they can protect cells from free radicals and reduce oxidative stress, potentially lowering the chance of acquiring diseases such as cancer and heart disease, researched by Rahaman *et al.* (2022). As a result, *M. oleifera* trees are being promoted as a dual solution for increasing the nutritional value and shelf life of dairy products while also offering an alternative source of income for families because they are simple to establish and do not require much maintenance.

Therefore, the main purpose of this review is to collect recent information obtained from scientific journal references where *M. oleifera* leaves have been incorporated into a variety of dairy products (Cheese, buttermilk, ghee, butter, yogurt, curd, and ice cream) and to discover its effect on nutritional properties and sensory acceptance.

MAIN TEXT

A. Nutritional importance of Moringa oleifera

Moringa oleifera is utilized for its highly nutritive and biological properties. The nutritional characteristics of plants are ubiquitous throughout the plant components, such as leaves, roots, seeds, fruit, flowers, pods, and bark can be eaten. Following the discovery of the plant's edible nature, organizations such as Church World Service, Trees for Life, and Educational Concerns for Hunger enacted its widespread usage as a nutritional supplement for underserved populations in the tropics and subtropics, researched by Anwar *et al.* (2007).

In terms of human macronutrient and micronutrient requirements, *M. oleifera* is a powerhouse of nutrients and anti-nutrients. Despite its low carbohydrate and fat content, *M. oleifera* leaf is a good source of protein and essential amino acids and is regarded as a complete nutritional supplement. Several researchers reported that the nutritional composition of *M. oleifera* leaves comprised in terms of fiber, protein, fat, and ash content ranges from 24.66–26.79, 18.67–20.99, 4.98–16.90 and 7.92–11.18 g/100 g, respectively, founded by Yameogo *et al.* (2011); El- massry *et al.* (2013); Gopalakrishnan *et al.* (2016); Dilruni *et al.* (2019). The dry leaves of *M. oleifera* are high in protein (19-29%) and dietary fiber (19-37%), with around 205-350 cal/g which meets the daily requirement, founded by Gopalakrishnan *et al.* (2016); Promkum *et al.* (2010); Jongrungruangchok *et al.* (2010); Moyo *et al.* (2011). The leaves of *M. oleifera* are high in minerals, vitamins like B complex, folate, amino acids, and fatty acids. It provides a lot of minerals that are necessary for the physiological growth and development of humans. It has 17 times the calcium content of milk. It includes 2 mg/100 g iron and 25.5-31.03 mg/kg zinc (Gopalakrishnan *et al.* 2016). It is sufficient to meet the diet's daily zinc requirement, which helps sperm cell development, researched by Barminas *et al.* (1998). Researchers proposed that the *M. oleifera* leaves contain 28 mg of iron; thus, it could be a substitute for iron pills in treating anemia, founded by Fuglie *et al.* (2005). Iron fortifiers such as ferrous sulphate, ferrous gluconate, ferrous lactate, and ferric ammonium citrate are frequently used in the treatment of iron deficiency anemia (IDA), founded by Bathla and Arora (2021). The author discovered that iron from *M. oleifera* leaf could heal iron inadequacy better than the additional fortificant, researched by Saini *et al.* (2014a). The presence of these nutrients helps to improve immunity against several diseases, researched by Busani *et al.* (2011).

M. oleifera leaves contain approximately 43% of the necessary amino acids (lysine, tryptophan, methionine, and cystine), also it has a high concentration of valine and leucine (about 7.08% and 6.65%, 7.17%, and 9.70%, respectively), founded by Mune *et al.* (2016). Research studies found that the fresh leaves of *M. oleifera* have been reported to be high in carotenoids such as trans-lutein (37 mg/100 g), trans-b-carotene (18 mg/100 g), and trans-zeaxanthin (6 mg/100 g) Saini *et al.* (2014c). Similarly, these authors found that the *M. oleifera* leaves showed significant levels of ascorbic acid (271 mg/100 g) and tocopherols (36.9 mg/100 g). They are also high in alpha-linoleic acid and contain a considerable amount of necessary amino acids. The leaves are a rich source of a variety of dietary antioxidants, researched by Moyo *et al.* (2012); Qwele *et al.* (2013); Saini *et al.* (2014b, 2014c); Yang *et al.* (2006). As a result, it is regarded as the lowest-cost protein source, particularly for developing countries with low-income populations, researched by Mune *et al.* (2016).

In terms of antioxidants, the presence of flavonoids and phenolics in *M. oleifera* leaf extract shows antioxidant action both in vivo and in vitro, researched by Khor *et al.* (2018). *M. oleifera* leaf powder's antioxidant capabilities can protect against oxidative damage, founded by Wink (2012). Methanolic extract of *moringa* leaves showed higher antioxidant activity due to the presence of phenolic compounds, researched by Al-Taweel and Al-Anbari (2019). With 65.1 and 66.8% antioxidant activity, methanol and ethanol extracts of *M. oleifera* leaves from India exhibit the maximum antioxidant activity, founded by Siddhuraj *et al.* (2003). Freeze-dried *M. oleifera* also has antioxidant properties, founded by Uphadek *et al.* (2018). Bennett *et al.* (2003) discovered the presence of chlorogenic acid, gallic acid, kaempferol, and glycosides in *moringa* leaves.

B. Application on Dairy products

One of the most researched and published aspects of *M. oleifera* uses in food is its nutritional advantages, particularly in populations with a diet deficient in essential nutrients. As a result, this plant has been employed in the formulation of nutritional supplements against malnutrition and as an additive or fortifier in a wide range of foods. The use of dried and powdered *M. oleifera* leaves to fortify dairy products, boosts the nutritious value of the products.

(i) Yogurt and Buttermilk. Nadeem *et al.* (2012) formulated the buttermilk by blending *M. oleifera* dried leaves which could prevent and correct malnutrition in women and children. The addition of the dried leaves did not affect the pH and acidity of the fortified buttermilk. Protein, ash, iron, and calcium content increased in T_3 level. The sensory acceptability of T_3 was 6.7 out of 9 making up more than 74%. This study reveals that dried leaves supplemented at a level of 3% increased the health benefits as well as obtained the highest score acceptability.

Singh *et al.* (2015) added *moringa* leaves into curd to evaluate their Chemical, microbiological, and organoleptic properties during storage. The authors concluded that the extract improves the nutritional, microbiological, and organoleptic properties of curd.

Kuikman and Connor (2015) formulated that adding 1.7% *M. oleifera* leaf powder and fruits (banana, avocado, and sweet potato at 250 mL per 1000 mL yogurt) helped boost the flavor and appearance of yogurt. In this study, the yogurt made with *M. oleifera* leaf powder had higher nutritional content than the control (without *M. oleifera*), the resultant greenish color and smell was a major barrier to its acceptability by consumers.

Similarly, Hassan *et al.* (2016) formulated yogurt with a 0.5% *M. oleifera* inclusion rate and reported that it had the highest score for taste and flavor compared to the inclusion levels (1%, 1.5%, and 2%) and control (without *M. oleifera* leaf powder). The incorporation of 0.5% of *M. oleifera* leaves significantly showed higher mean values of total solids, total protein, milk fat, total volatile fatty acids, diacetyl, 17 essential amino acids, and acetaldehyde. However, a higher score was reported for the control treatment in terms of color and appearance as compared to the other treatments which had 0.5%, 1%, 1.5%, and 2% *M. oleifera* leaf powder inclusion.

M. oleifera leaves powder was incorporated at different ratios (0.5, 1, 1.5, 2.0g) in the production of yogurt. Results showed that 1g of *M. oleifera* leaves powder in yogurt had the highest score for general acceptability and also it improves the nutritional value of yogurt, founded by Akajiaku *et al.* (2018).

Zhang *et al.* (2019) found that incorporating 0.5–2% of dried *M. oleifera* leaves into yogurt promotes fermentation by increasing the growth of Lactic acid bacteria and improves textural and bioactive qualities. In addition, the author stated that it boosts the radical scavenging activity by 40% in a dose-dependent manner for up to 21 days.

Saeed *et al.* (2021) formulated flavored yogurt by adding *M. oleifera* leaf powder at four different concentrations (0.5%, 1%, 1.5%, and 2%). The Results show that mango-flavored yogurt incorporated with 1% *M. oleifera* leaf powder had the highest score in sensory attributes such as body and texture, flavor, taste, and overall acceptability over the storage period of 15 days at 5±1 °C. There were significant changes in physicochemical properties. Also, it enhances the shelf life of the product.

Gomes *et al.* (2023) evaluated the physicochemical and biological properties of *M. oleifera* leaf powder in yogurt to mitigate children's malnutrition in under-developing countries. According to the author, the sample shows the highest antioxidant activity when compared with the control.

(ii) Butter, and Sour cream. Nadeem *et al.* (2013) studied the effects of ethanolic leaf extract of *M. oleifera* on the stabilization of butter. The inclusion of extract at all concentrations tested had no negative effects on the final product composition. After 90 days of refrigeration storage, integrating at 600 and 800 ppm effectively reduced the oxidative process and caused a decrease in the generation of free fatty acids. However, the maximum concentration (800 ppm) resulted in a negative sensory acceptance of the product and a considerable alteration in the product's organoleptic qualities. There was a residual flavor and odour of phenolic chemicals, which are known to have an astringent taste.

M. oleifera leaves extract is added at the concentration ranges from 600, 800, and 1000 ppm. Study results revealed that the addition of *M. oleifera* leaves extract at all doses has a notable effect on TS, fat, total protein, and lactose. Also, the use of *moringa* leaf extract as a sour cream preservative improves microbiological stability and has no detrimental effect on any of the metrics tested, resulting in improved sensory acceptability and a longer shelf life for sour cream, researched by Salem *et al.* (2015).

(iii) Cheese. Ojoriz *et al.* (2013) formulated the cream cheese from pure buffalo milk which *moringa* leaf powder mixed at various concentrations 0.5%, 1%, 1.5%, and control. The cream cheese's moisture, fat, protein, and calorie content did not alter significantly between treatments, however, crude fibre content increased dramatically with the addition of moringa leaf powder. Consumer acceptability of cream cheese with 0.5, 1, and 1.5% *moringa* leaf powder was lower when compared to the control. According to their findings, a moringa leaf powder inclusion rate of less than 0.5% could be considered in the manufacturing of cream cheese.

Labneh, soft white, and cream cheese were prepared with 1–3% of dry *M. oleifera* leaves or an ethanolic extract of dry leaves. These results showed that they had a lower degree of whiteness than the control, researched by Salama *et al.* (2013); Hassan *et al.* (2017).

El-Sayed *et al.* (2017) reported that the incorporation of *M. oleifera* oil with different ratios (100, 150, and 200 mg/ml) in Labneh increases the total solid, fat, volatile fatty acid, DPPH scavenging activity, tocopherols, and total lactic acid bacterial counts content. The *M. oleifera* oil showed a good effect against Gram-positive, Gram-negative, Yeast, and fungal strains. Furthermore, when compared to control samples, this labneh's sensory characteristics were improved.

Mohamed *et al.* (2018) found that the addition of *M. oleifera* leaf extract to cream cheese at varied ratios of 2.00, 3.00, and 4.00 g/100 g increases the shelf life of

the product up to 4 weeks and increases the total phenol content, probiotic counts, and antioxidant activity.

Bermudez *et al.* (2020) conducted a study on petit suisse cheese by adding cape gooseberry and supplementing it with moringa leaf powder and gelatin with different formulations. a) control, b) a product with 3% gelatin product, and c) 3% gelatin& 2% moringa. The author concluded that 3% gelatin and 2% moringa powder increased the nutritional values of ash, protein, fiber, and fat content when compared to the control.

The author conducted a study on Ewe's diets supplemented with dried *M. oleifera* leaf in processed cheese. The result revealed that the incorporation of *M. oleifera* leaf in ewe's diets not only improves health and animal productivity but also enhances the chemical composition and nutritional value of the processed cheese prepared from the treated ewe's milk (Morsy, 2021).

CONCLUSIONS

In this review, recently published scientific research supports the potential of *Moringa oleifera* as a component in various dairy matrices. It has been incorporated in the majority of cases as dry leaf powder in dairy products. In such circumstances, all of the authors reported an improvement in the nutritional profile of the finished product. Most authors agree that extremely tiny amounts (1-2%) have an effect on color, texture, and flavor alterations in dairy products.

FUTURE SCOPE

Moringa oleifera's use in dairy products demonstrates its long history of human benefits. Recent research studies have verified its suitability for usage in dairy applications. It contains a variety of biological compounds that can be used to make nutraceutical foods. As a result, it can be beneficial to the food and pharmaceutical businesses. *Moringa oleifera* is still under-utilized in the food industry. This review provides information on the nutritional benefits that influence the use of *Moringa oleifera* and dairy applications. As a result, researchers and academics must investigate *M. oleifera* in order to attain food safety and nutritional security.

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Conflict of Interest. None.

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