The Importance of Moringa: Exploring the Health, Nutritional, and Functional Properties of Moringa Leaf Powder

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ABSTRACT

Moringa oleifera, a perennial tree belonging to the Moringaceae family, is still regarded as an underutilized plant. In India, it is commonly known as drumstick, sahjan, or sohanjana. The plant is recognized for its remarkable range of functional and nutraceutical properties, making it a versatile biomaterial suitable for food and related applications. The high nutritional value of its edible portions makes Moringa an important food source. The leaves of the drumstick tree are highly nutritious and entirely edible. They are rich in protein, carbohydrates, fiber, minerals, vitamin C, and essential minerals**.** In the present study the nutritional and functional properties of different edible parts specifically leaves of Moringa plant were discussed vastly with facts collection from different research papers and sites. The study could further support value added product preparation.

Keywords: beta carotene; functional Properties; fiber; moringa; nutraceutical Properties

INTRODUCTION

The drumstick tree (Moringa oleifera) is recognized for its potential to enhance nutrition, improve food security, and promote rural development. This small, fast-growing tree is native to India**,** originating from the Agra and Oudh regions in the northwest and spreading towards the southern Himalayan foothills. It is widely cultivated in Asia, Africa, the Middle East, and South America**.** Its drought resistance allows it to thrive in various soil and rainfall conditions, making it available throughout the year (1). Due to its resilience and availability, it is often referred to as the "Miracle Tree"**,** as its leaves remain accessible even during summer when other vegetables are scarce. The nutritional composition of the plant varies based on soil, climate, and environmental conditions**,** while processing and storage further influence its nutrient content (2). Although fresh leaves contain higher nutrient levels, processing the leaves is essential to extend their shelf life. The leaves of the drumstick tree are highly nutritious and fully edible (3). They are an excellent source of protein, carbohydrates, and fiber, while also being rich in different micronutrients like beta carotene, vitamin C, and essential minerals like calcium, potassium, iron, and phosphorus (4). Additionally, Moringa leaves contain antioxidant compounds such as ascorbic acid, flavonoids, phenolic compounds, and carotenoids, making them a natural source of antioxidants (5). The presence of numerous antioxidant compounds makes Moringa leaves a valuable source of natural antioxidants (1) and an excellent candidate for nutraceutical and functional food applications.

METHODOLOGY

The topic was discussed under different heads with the collections from different research papers. Main motto was to cover the health, nutritional and functional aspects of moringa leaf powder for further application in different products in value addition**.**

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Functional Applications of Moringa Plants in Food Products: Due to their rich nutritional profile and functional properties, Moringa plants have significant potential for use in various food processes and formulations in the food industry (6). The bioactive compounds present in Moringa have been shown to offer technological advantages in the development of functional food products. Around the world, dehydrated Moringa seeds and leaf powder are incorporated into a variety of edible products to create fortified or functional foods (7).

Food Applications of Moringa and Intellectual Protection: Despite extensive research on the functional properties and bioactive compounds of Moringa, there are no known patents related to its use in food products . This indicates that most research aims to generate scientific knowledge rather than focus on securing intellectual property rights. Consequently, food products developed from Moringa and its bioactive components remain largely unpatented, reflecting a focus on basic scientific exploration rather than commercial protection (8) .

Moringa Leaf Powder

Nutritional Composition:

The protein content of dried Moringa oleifera leaf powder is comparable to certain pulses, such as moth beans, soybeans, and kidney beans, which contain around 22–24% protein**,** making it a valuable dietary ingredient. The leaves also provide essential amino acids like methionine, cysteine, tryptophan, and lysine, making them ideal for regular consumption. Moringa leaf powder is a nutrient-dense superfood packed with essential macronutrients, micronutrients, and bioactive compounds**,** making it highly valuable for human health and functional food applications **(**9**).** Moringa leaf powder is a nutrient-dense packed with a variety of macronutrients, micronutrients, and bioactive compounds(10). It is a rich source of plant-based protein, accounting for approximately 25–30% of its weight. Unlike many plant proteins, Moringa contains all nine essential amino acids**,** making it a complete protein source (11). It is particularly abundant in leucine, lysine, and phenylalanine**,** which are essential for muscle growth and repair. In terms of carbohydrates, Moringa leaf powder consists of around 30–40%**,** with a significant portion being dietary fiber **(**~20–25%**),** which supports digestion and promotes a feeling of fullness . Although low in fat **(2–5%),** it offers a healthy balance of omega-3, omega-6, and omega-9 fatty acids**,** along with polyunsaturated fatty acids (PUFAs)**,** which contribute to heart health (12). Rich in essential vitamins and minerals, Moringa leaf powder provides a substantial dose of vitamin C**,** which strengthens the immune system and acts as a powerful antioxidant (13). It is also a good source of vitamin A (beta-carotene)**,** vital for vision health and antioxidant defense, and vitamin E**,** which protects cells from oxidative stress and supports skin health. The B-complex vitamins (B1, B2, B3, B6, and B9) present in Moringa aid in energy metabolism and promote nervous system health (14). In terms of minerals, Moringa is exceptionally high in calcium**,** containing approximately 2000 mg per 100g, which is crucial for bone strength. It also offers 28–30 mg of iron per 100g**,** essential for red blood cell production and anemia prevention (15). Additionally, it contains potassium **(**~1300 mg/100g**),** which helps regulate blood pressure and fluid balance, while magnesium and zinc support muscle, nerve function, and immune health (16). Furthermore, Moringa leaves are rich in chlorophyll**,** which aids in detoxification and promotes healthy blood circulation. Beyond its macronutrients and micronutrients, Moringa leaf powder is packed with bioactive compounds that contribute to its health benefits (17). It contains polyphenols and flavonoids such as quercetin, kaempferol**,** and myricetin**,** which exhibit potent antioxidant and anti-inflammatory properties. The presence of glucosinolates and isothiocyanates provides antimicrobial, anticancer, and anti-inflammatory effects (18). Additionally, Moringa is a valuable source of carotenoids**,** including lutein and zeaxanthin**,** which support eye health and protect against oxidative damage. Overall, the impressive nutritional profile of Moringa leaf powder makes it a powerful functional food with a wide range of health benefits (19).

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Figure 1 Moringa Leaf Powder

Functional properties

Moringa leaf powder possesses a wide range of functional properties, making it highly beneficial for health, wellness, and food applications (20). It is rich in phenolic compounds, flavonoids, and vitamin C, which contribute to its strong antioxidant activity (21). These compounds help neutralize free radicals, protecting cells from oxidative damage and reducing the risk of chronic diseases such as cancer, diabetes, and heart disease (22). Moringa also exhibits anti-inflammatory effects due to its abundance of flavonoids, isothiocyanates, and polyphenols, which lower inflammation markers and offer relief from conditions like arthritis and metabolic disorders (23). Additionally, Moringa leaf powder demonstrates antimicrobial and antibacterial properties. Its content of isothiocyanates and glucosinolates inhibits the growth of harmful bacteria, including Escherichia coli, Salmonella, and Staphylococcus aureus, making it effective in combating various pathogens (24). The powder also offers hypoglycemic and antidiabetic benefits, as it helps lower blood sugar levels by enhancing insulin sensitivity and slowing the digestion and absorption of carbohydrates (25). This reduces postprandial glucose spikes, making it valuable for managing diabetes and preventing insulin resistance (26). The cardioprotective properties of Moringa leaf powder stem from its rich content of potassium, magnesium, and omega-3 fatty acids, which support cardiovascular health (27). It helps reduce cholesterol levels, lower blood pressure, and prevent atherosclerosis (28), while its antioxidants combat lipid oxidation, thereby lowering the risk of heart disease. Moringa also offers detoxifying and hepatoprotective effects by promoting the production of detoxifying enzymes, protecting the liver from oxidative stress, and improving liver function in cases of toxicity (29).

Moringa leaves can be dried using different methods, including sun drying, shade drying, and oven drying. Among these**,** oven drying is the most commonly used technique. The drying process generally involves the same preliminary steps**,** starting with leaf collection**,** washing them under running water, and removing excess water by spreading them out. The leaves are then dried using the chosen method. Pretreatments**,** such as blanching and cutting, reduce the moisture removal time but can darken the color and alter the flavor of the final dehydrated product.

Health Properties

Moringa leaf powder offers a wide range of health benefits, thanks to its nutrient-dense and bioactive composition. It plays a significant role in strengthening the immune system, as its high levels of vitamin C, zinc, and antioxidants help protect the body against infections and diseases (33). Its rich calcium, phosphorus, and magnesium content supports bone health by enhancing bone density and preventing conditions like osteoporosis and bone degeneration (34). Additionally, Moringa is highly beneficial for blood health due to its abundance of iron, which helps prevent and treat iron-deficiency anemia by boosting hemoglobin production and improving oxygen transport throughout the body. The skin and hair benefits of Moringa leaf powder are attributed to its vitamin E and antioxidant content. It promotes healthy skin, protects against UV damage, and reduces skin inflammation (35), while also strengthening hair follicles and minimizing hair fall (36). Moringa is also effective for weight management, as its high fiber content promotes satiety, reducing overall calorie intake and aiding in weight loss by preventing excess fat accumulation. In terms of digestive health, Moringa's dietary fiber promotes bowel regularity, preventing constipation and improving overall digestive function (37).

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Furthermore, it offers benefits for women's health by helping to alleviate menopausal symptoms (13). The phytoestrogens present in Moringa help balance hormone levels, reducing the severity of hot flashes, mood swings**,** and fatigue **(**38). Overall, the exceptional nutritional and bioactive properties of Moringa leaf powder make it a powerful natural supplement for promoting overall health and well-being (39).

Functional food perspective

Moringa leaf powder has notable water-holding and oil-holding capacities, which enhance the moisture content and texture of food products. Its emulsifying and stabilizing properties make it a valuable natural additive, improving the viscosity and consistency of sauces, soups, and beverages (30). Furthermore, its high dietary fiber content supports gut health by promoting regular bowel movements and acting as a prebiotic, fostering the growth of beneficial gut bacteria. Overall, the diverse functional properties of Moringa leaf powder make it a powerful ingredient with numerous health benefits and versatile applications in the food and wellness. However it's found in some studies that moringa leaf powder has the toxicological effects but the use of this ingredient, should be below the harmful doses. The adverse effects of moringa powder may stem from its chemical constituents, potential interactions with medications, or contamination. However, the precise mechanism behind its cutaneous toxicity remains unclear, as the majority of studies highlight its anti-inflammatory properties. To date, no research has demonstrated the mutagenic or carcinogenic effects of moringa leaf powder, as it is widely recognized in scientific literature for its anticancer properties (31). When incorporating moringa leaf powder into functional foods, its potential toxicological impacts should be considered, and consumption should remain within safe dosage limits to avoid adverse effects (32).

Role in Culinary and Food Industry

Moringa leaf powder is extensively utilized in the culinary and food industry, particularly in functional foods, nutraceuticals, and dietary supplements due to its rich nutritional profile (33). It is commonly used for food fortification, where it is added to smoothies, soups, and sauces to enhance their nutritional value. It also serves as a fortifying ingredient in baked goods, pasta, and snacks, boosting their vitamin and mineral content (34). In the beverage industry, Moringa is incorporated into herbal teas, green juices**,** and various health drinks, enriching them with antioxidants and essential nutrients.The powder is a popular component in nutritional supplements, often formulated into capsules, powders, and tablets for daily consumption. It is widely featured in health and wellness products due to its numerous health benefits (22). Additionally, Moringa is used in functional foods, including protein bars, energy balls, and granola, as well as in plant-based protein blends, enhancing their nutritional density(39). Beyond human consumption, Moringa leaf powder is also applied in animal feed as a nutritional supplement for livestock, owing to its high protein content, which supports animal growth and health.

CONCLUSION

Moringa leaf powder serves as a valuable functional ingredient in the food industry, offering a rich source of protein, vitamins, minerals, and health-enhancing phytonutrients. It significantly contributes to the intake of essential nutrients and beneficial phytochemicals in humans. Moringa leaf powder exhibits various pharmacological properties, including anticancer, anti-inflammatory, hepatoprotective, cardioprotective, and antioxidant effects. So the present study highlights the application of moringa leaf powder in various food products, emphasizing its numerous benefits for the food and health industries in addressing current health challenges.

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