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**Tanu Narwal**  
 Department of Agriculture,  
 Maharishi Markendeshwar  
 (Deemed to be) University  
 Mullana-Ambala, Haryana,  
 India, India

**MK Rana**  
 Department of Agriculture,  
 Maharishi Markendeshwar  
 (Deemed to be) University  
 Mullana-Ambala, Haryana,  
 India, India

## Drumstick a miracle food of 21<sup>st</sup> century: A review

**Tanu Narwal and MK Rana**

### Abstract

The drumstick tree (*Moringa oleifera*) belonging to Moringaceae family is a tropical perennial, dicotyledonous, deciduous tree widely cultivated in countries, such as India, Pakistan, African countries, South America, Asia and the Middle East. It is known by its numerous names, *i.e.*, *Saijan* (in Hindi), *Shigru* (in Sanskrit), miracle tree, horseradish tree, superfood, novel food and healthy food. Its optimal cultivation requires sandy loamy soil with a pH 5.6-6.5 and temperature between 25 and 35 °C, thriving best in tropical or subtropical climates. Celebrated as a nutritional powerhouse, every part of the *Moringa* tree, including roots, leaves, fruits (pods) and seeds, holds significant nutritional value. Its roots are rich in vitamin C, potassium and iron. The leaves are abundant in protein, fibre, fat and essential minerals, such as magnesium, calcium, potassium, phosphorus, sulphur, iron and copper. The fruits are a rich source of protein and fibre, while the seeds contain 52% protein, 22-40% crude fat and vitamins A and C. *Moringa* also possesses a myriad of therapeutic applications, including the prevention and treatment of various ailments. All parts of the tree, including roots, bark, leaves, sap, flowers, and seeds, provide quick remedy for conditions like stomach ulcers, cancer, high blood sugar, headaches, sore gums and respiratory and gastric problems. Overall, *Moringa* exhibits numerous medicinal properties, such as anti-diabetic, anticancer, antioxidant, antifungal, antihypertensive, anti-asthmatic, anti-clastogenic, anti-cirrhosis, anti-inflammatory, antiviral, hepatoprotective and hypolipidemic effects.

**Keywords:** Drumstick, horseradish tree, miracle tree, superfood, miracle food, novel food

### Introduction

Drumstick (*Moringa oleifera* Lam.), a tropical plant belonging to the family Moringaceae, grows naturally in Pakistan and northwest parts of India, while the other nations where drumstick is cultivated widely are Africa, South America, Asia and the Middle East. Drumstick is also known as horseradish, *Saijan* in Hindi and *Shigru* in Sanskrit (Spandana, 2016)<sup>[64]</sup>, the miracle tree, the tree of long life, or the horseradish tree since flavour of its roots is like horseradish (Chauhan *et al.*, 2018)<sup>[17]</sup>. It is sometimes referred to as super food, novel food, or healthy food due to its high nutritional value (Joshi and Mehta, 2010)<sup>[39]</sup>. The name Miracle Tree has been given to this tree is because of its versatile nutritional uses and ability to cure numerous ailments. It is a tropical perennial dicotyledonous deciduous tree with height 5-10 m (Anwar *et al.*, 2007; Pandey *et al.* 2011)<sup>[7, 50]</sup>. The leaves are 90 cm long and 5 cm apart from the tree's central stalk, and its light brown flowers, which are 90 cm long and 12 mm wide, are produced in axillary panicles throughout the year. *Moringa* is a genus of 13 species, *i.e.*, *Moringa stenopetala*, *Moringa drouhardii*, *Moringa ovalifolia*, *Moringa hildebrandtii*, *Moringa peregrina*, *Moringa concanensis*, *Moringa oleifera*, *Moringa borziana*, *Moringa arborea*, *Moringa longituba*, *Moringa pygmaea*, *Moringa rivae* and *Moringa ruspoliana* that have spread across Bangladesh, Florida, Arabia, Sri Lanka, Pakistan, Africa, West Indies, South America, Peru, Paraguay and Brazil (Fahey, 2005)<sup>[23]</sup>. Its roots, leaves, blossoms, green pods and seeds are all valuable for medical purposes, functional food preparations, nutraceuticals, water filtration and biodiesel generation (Saini, 2015)<sup>[58]</sup>. Its leaves include phytochemicals, such as astragalin, isoquercetin and crypto-chlorogenic acid (Sánchez-Machado *et al.*, 2010)<sup>[59]</sup>, which have analgesic, anti-allergic, anti-asthmatic, antibacterial, anticancerous, antidiabetic, antidiarrheal, anti-epileptic, anti-hypersensitive, anti-inflammatory, antimicrobial, anti-obesity and anti-ulcer properties (Zarina *et al.*, 2024; Bhattacharya *et al.*, 2018)<sup>[13, 79]</sup>. Its excellent antioxidant capabilities are primarily due to the presence of high phenol content (Yang *et al.*, 2006)<sup>[76]</sup>. Its leaves also contain number of minerals, including calcium, potassium, zinc, magnesium, iron and copper.

**Corresponding Author:**  
**Tanu Narwal**  
 Department of Agriculture,  
 Maharishi Markendeshwar  
 (Deemed to be) University  
 Mullana-Ambala, Haryana,  
 India, India

### Cultivation of Drumstick Tree

India is the biggest producer of drumstick fruits (pods), producing 1.1-1.3 million tonnes per year from an area of 38,00 hectares, and Andhra Pradesh is the India's leading producer in terms of area (15665 ha) and production followed by Karnataka 10280 ha and Tamil Nadu 7408 ha (Patel *et al.*, 2015)<sup>[52]</sup>. *Moringa* tree thrives best at a temperature ranging from 25 to 35 °C with minimum and maximum tolerate limit 0 and 48 °C under a variety of soil conditions from slightly acidic to highly alkaline (pH 5.0-9.0) although it prefers sandy loamy soil with a pH between 5.6 and 6.5 and a net rainfall of 250-3000 mm (Thurber and Fahey, 2010; Silva *et al.*, 2010)<sup>[68, 60]</sup>. However, according to Palada (1996)<sup>[76]</sup> drumstick thrives best in dry to moist tropical or subtropical climate with annual precipitation of 760-2500 mm and temperature ranging from 18 to 28 °C in a variety of soil types, including thick clay and wet soils with pH level ranging from 4.5 to 8.0 and an elevation of up to 2000 metres.

### Cultivation

Drumstick is propagated mainly by two methods, *i.e.*, (i) direct seed sowing in field and (ii) stem cuttings. Stem cutting method is adopted when seeds are sparse, or labour is not a constraint (Palada, 1996)<sup>[76]</sup>. According to Ramachandran *et al.* (1980)<sup>[55]</sup>, the plants raised from seeds produce lower-quality fruits, however, Animashaun *et al.* (2013)<sup>[3]</sup> believe that trees developed from seeds have longer roots, which improve stability and access to water as compared to plants raised through cuttings with shorter roots. Seeds germinate in two weeks at a maximum depth of 2 cm, and they can be transplanted as and when the saplings attain a height of 30 cm. Its cultivation is mainly done for its seeds and leaves. Thus, spatial distribution of drumstick is intended to assist harvest and maintenance activities. For leaves production, three types of production system, *i.e.*, (i) intensive, (ii) semi-intensive and (iii) integral agroforestry system with a spatial distribution of 10×10 to 20×20 cm (harvesting between 35 and 45 days), 50×60 cm (harvesting between 50 and 60 days) and 2×4 m (harvesting after 60 days) are used (Animashaun, 2013)<sup>[3]</sup>. For seed production, 2.5×2.5 or 3×3 m triangular pattern is used and harvesting of pods is done after three months with an average seed yield of 15,000 to 25,000 seeds. The branches develop new pods within six months of harvesting.

### Nutritional profile of Drumstick: Unlocking the powerhouse of nutrients

In today's fast-paced society, people often consume calorie-dense food due to over business. Obesity, high blood pressure, diabetes and other chronic heart diseases can be caused by unhealthy eating habits. A balanced lifestyle requires a diet rich in minerals, vitamins and poly unsaturated fatty acids (Fahey, 2005)<sup>[23]</sup>. Different parts of drumstick like roots, leaves, fruits and seeds are linked with the existence of one or more advantages. It contains high levels of phenolic compounds, vitamins and minerals, such as calcium and potassium, amino acids, proteins, carbohydrates and oil (Redha *et al.*, 2021)<sup>[57]</sup>. The tree parts along with their nutritional properties are described below:

#### Roots

Roots include high levels of vitamin C, potassium and iron (Khan and Zulfiqar, 2024)<sup>[79]</sup>. Its roots are boiled with other herbs and steeped in water or alcohol to prepare beverages and infusions that are used as anthelmintic and antiparalytic

for the treatment of toothache (Popoola *et al.*, 2013; Sivasankari *et al.*, 2013; Anwar *et al.*, 2007)<sup>[54, 63, 7]</sup>. These can also be used as a condiment or garnish after peeling, drying and combining with vinegar. Root bark must be peeled off for the removal of toxic substances, *i.e.*, Alkaloids and Moringine- a poisonous chemical similar to ephedrine (Fuglie, 1999)<sup>[25]</sup>.

#### Leaves

*Moringa* plant leaves include nutrients such as magnesium, calcium, potassium, phosphorus, sulphur, iron and copper, along with fibre, fat and protein. Its leaves are highly digestible and rich source of protein (Fahey, 2005)<sup>[23]</sup>, which is made up of long chain essential and non-essential amino acids connected by peptide bonds. The non-essential amino acids are synthesized by the human body itself, but the essential amino acids need to be used externally. Drumstick leaves contain nine essential and seven non-essential amino acids and thus act as a source of protein, especially for vegetarians. The amount of protein present per 100 g of drumstick fresh and dry leaves and dry leaf powder is 6.7, 29.4 and 27.1 g, respectively (Christaki *et al.*, 2011; Ayalew *et al.*, 2017; Yao *et al.*, 2000; Shaheen *et al.*, 2016; Gemede *et al.*, 2021)<sup>[18, 5, 77, 61, 24]</sup>. Its dried leaf powder contains protein in amount similar to other pulses, such as moth bean, soybean and kidney bean (Makkar and Becker, 2017)<sup>[66]</sup>. It also contains valuable substances, such as vitamins, calcium, iron, ascorbic acid and antioxidants, such as carotenoids, flavonoids and phenols. Dried *Moringa* powder is a unique source of calcium as it contains calcium 17 times of the calcium in milk (Gopalkrishan *et al.*, 2016)<sup>[27]</sup>. Its leaves also contain varied phytochemicals, such as sterols, tannins, flavonoids, alkaloids, saponins and terpenoids (Berkovich *et al.*, 2013)<sup>[10]</sup>.

#### Fruit (pods)

The fruits dangle down from the branches and are three lobed pods, which are 20-60 cm in length. After drying, they open into three separate segments and contain 12-35 seeds apiece (Bashir *et al.*, 2006)<sup>[8]</sup>. According to Gopalkrishan *et al.* (2016)<sup>[27]</sup> and Lopez-Teroz *et al.* (2017), the amount of protein and crude fibre in *Moringa* pods is 20.66 and 46.78%, respectively. The pods after boiling and squeezing can be cooked and eaten like cluster bean pods. Fibre content in pods increases with the increase in size of the pods, thus, they are consumed when easily broken into two parts (Makkar and Becker, 2017)<sup>[66]</sup>.

#### Seeds

Spherical seeds of *Moringa* have a brownish semi-permeable hull with a yield of 15,000 to 25,000 seeds per tree per year (Lijesh and Malhotra, 2016). Seeds are edible in both forms, *i.e.*, fresh and dried (Berger, 1984)<sup>[9]</sup>. Its seeds contain vitamins A, vitamin C,  $\alpha$ -tocopherol, beta-carotene,  $\beta$ -sitosterol, phenolic compounds quercetin and kaempferol, anthocyanins, flavonoids, glucosinolates, isothiocyanates and alkaloids (Shah *et al.*, 2022)<sup>[59]</sup>. They contain 30-42% oil, which is bright yellow in colour. Press-cake, a by-product of oil extraction, has significant levels of proteins (Stadtlander and Becker, 2017)<sup>[66]</sup>. They also have a high-quality protein of 52%, which includes all the essential amino acids and 22-40% crude fat (Shah *et al.*, 2022; Tang *et al.*, 2021; Ghazali and Abdulkarim, 2011)<sup>[59, 67, 25]</sup>. *Moringa* seeds have a carbohydrates content of 9.17 to 53.36% (Compaoré *et al.*, 2011; Compaoré *et al.*, 2011)<sup>[18, 19]</sup>. Its seeds contain

numerous fatty acids, *i.e.*, palmitic acid, erucic acid and eicosenoic acid and sterols, such as clerosterol, campesterol, 24-methylenecholesterol, avenasterol, campestanol and stigmastanol.

### Therapeutic Applications of Drumstick

The *Moringa oleifera* tree has several medicinal uses, including prevention and treatment. Its roots, bark, leaves, sap, flowers, seeds and oil are employed in traditional medicine. It offers a quick cure for conditions including stomach ulcers, catarrh, cancer, blood sugar, nerves, cramps, haemorrhoids, headaches, sore gums, respiratory and gastric problems. *Moringa oleifera*, known as a panacea for several diseases, has been shown to treat over 300 diseases because of the presence of phytochemicals (Bancesi *et al.*, 2020) [7], which are an effective therapeutic agent. *Moringa* is very advantageous due to its high nutritional content and capacity to combat illness (Bancesi *et al.*, 2020) [7]. It has significant levels of antioxidants, such as vitamin C, flavonoids and polyphenols, which can help in combating oxidative stress and inflammation in human body. Its leaf extract possesses antimicrobial activity and antioxidant properties and elevates cytotoxicity in chemotherapy based on apoptosis (Kumar *et al.*, 2018; Berkovich *et al.*, 2013) [10]. *Moringa* contains antibacterial properties, making it effective against bacteria, viruses and fungi (Ghosh *et al.*, 2023) [26]. *In vitro*, ethanolic extract from its seeds has antifungal action (Das, 2012) [20]. Its pods contain significant fibre content, which can help in curing colon cancer and digestive disorders. Overall, drumstick contains various therapeutic properties, like anti-diabetic, anticancerous, antioxidant, antifungal, antipertensive, anti-asthmatic, anti-clastogenic, anti-cirrhosis, anti-inflammatory, antiviral, hepatoprotective and hypolipidemic (Srivastava *et al.*, 2023) [64].

### Anti-diabetic property

*Moringa* leaf extract has been shown to improve diabetic nephropathy in rats produced by streptozotocin. The extract effectively lowered excessive blood glucose levels, poor renal function and oxidative stress markers in rats. Its leaves extract reduces the levels of glucose in blood, oxidative stress and fibrosis development *via* decreasing the expression of TGF- $\beta$ 1 and type IV collagen genes (Thongrungsri *et al.*, 2023) [68]. Aljazzaf *et al.* (2023) [2] studied the anti-diabetic and antioxidant effects of its leaves, seed and combined extracts in alloxan diabetes-induced mice. Its extract can prevent diabetes in rats treated with streptozotocin. It has been shown to treat both Type 1 and Type 2 diabetes. Type 1 diabetes is caused by a lack of insulin synthesis. Insulin regulates blood glucose levels in the body. Type 2 diabetes is associated with insulin resistance. Type 2 diabetes is often caused by faulty beta-cell activity. In this disease, beta-cells fail to detect glucose levels, leading to reduced insulin signalling and elevated blood glucose levels (Chaudhary, 2017) [15].

### Anti-cancerous property

*Moringa* has been explored for its biological activities, including anti-cancerous properties in its leaves, fruits, flowers, bark and roots (Brilhante *et al.*, 2017) [14]. Its leaves can restore oxidative DNA damage in animal cells, especially in cases of cancer or degenerative illnesses (Boopathi and Raveendran, 2021) [13]. The chemo-preventive quality of drumstick suppresses the proliferation of human cancer cells. According to many investigations, its extracts have been shown to exhibit anti-proliferative and pro-apoptotic effects

(Karim *et al.*, 2011) [25]. *Moringa* leaf extract inhibited oral squamous cell carcinoma in mice *via* regulating expression of Caspase3, VEGF and HSF1 (Syahputri *et al.*, 2020; Hartono *et al.*, 2019) [66, 28]. Ethanolic extract of *Moringa* has shown anti-cancer action and proved effective growth suppressors against human breast cancer MDA-MB-231 cells (Wisitpongpun *et al.*, 2020) [72]. Its stem and leaf extract inhibited cell growth and promoted apoptosis in 4T1 breast cancer cells obtained from a mouse BALB/c strain's mammary gland (Yousefirad *et al.*, 2023) [76]. Its anti-cancer action is attributed to niazimicin, quercetin, niazinin and glycerol-1-carbamate (Rath *et al.*, 2021) [54].

### Antioxidant property

*Moringa* leaves, flowers and seeds contain flavonoids, polyphenols and ascorbic acid, which act as antioxidant and offer several health benefits. A study indicates that its leaf extract has greater antioxidant activity, free radical scavenging ability and prevention of lipid, protein and DNA oxidation as compared to the extract of flowers and seeds, which inhibits cells degradation in many organs caused by free radicals, ensuring optimal health and performance (Dixit *et al.*, 2016) [21]. The active compounds, *i.e.*, niazirin and isothiocyanate, have been authorised for their antioxidant activity and potential utility in managing oxidative stress (Wang *et al.*, 2021) [70]. Its leaf extract has been found to increase total antioxidant capacity and to improve immune tolerance (Wen *et al.*, 2022; Tuorkey, 2016) [71, 69]. Alcoholic extract of *Moringa* has been recognised to protect the stomach from ulcers caused by bisphenol *via* antioxidant activity (Abo-Elsoud *et al.*, 2022) [1].

### Anti-inflammatory property

*Moringa* extract shows promise for treating chronic and acute inflammations, which can cause chronic illnesses, such as diabetes, respiratory issues, cardiovascular disease, arthritis and obesity. *Moringa* suppresses inflammatory enzymes and proteins in the body, and its leaf concentrate can considerably decrease inflammation in cells (Chaudhary and Chaurasia, 2017) [15]. Its root extract has been shown to have anti-inflammatory properties in rats with carrageenan-induced paw edoema, while the *n*-butanol extract of seeds has shown anti-inflammatory action in guinea pigs with ovalbumin-induced airway inflammation (Bhattacharya *et al.*, 2014) [12].

### Conclusion

*Moringa oleifera*, commonly known as the drumstick tree, stands out for its exceptional nutritional and therapeutic properties, making it a significant plant in various global regions. Its diverse parts like roots, leaves, pods and seeds are rich in essential nutrients, such as vitamins, minerals, proteins and antioxidants. These contribute to its recognition as a *miracle tree* and *superfood*. The plant's extensive medicinal benefits include anti-diabetic, anticancer, antioxidant, anti-inflammatory and antimicrobial properties. These therapeutic applications are supported by numerous studies, highlighting *Moringa's* potential in preventing and treating various ailments, including diabetes, cancer and cardiovascular diseases. Additionally, its adaptability to different climatic conditions and soil types makes it a viable crop in tropical and subtropical regions. Overall, *Moringa oleifera* is a valuable resource for enhancing nutrition and health, emphasizing the need for its broader cultivation and utilization.



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