



Nutritional value and value-addition in Drumstick-A review

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Abstract

Moringa oleifera tree is also known as a miracle tree due to its rich source of micro and macronutrients of great importance in human nutrition. Moringa plant has medicinal properties and can fulfil the human daily requirement diet. Almost every part of moringa has their importance and edible for example seed, bark, fruit, root, flower, and gum is rich in protein, minerals including calcium, iron, potassium, phosphorus, beta- carotene and respiratory of protein. This review paper covers the nutritional value, health benefits, and value-added products of moringa.

Keywords: moringa, medicinal use, nutrients, value-added products

Introduction

Moringa oleifera species is one of the majors from 13 species in the genus *Moringa*, have family Moringaceae (Prota, 2017). Many species are not reported yet, especially in Africa (Olson, 2017) [31]. Drumstick (*Moringa oleifera*) belongs to the family Moringaceae with chromosome number $2n=28$. The common name of moringa is drumstick tree due to its triangular seed pods, long, slender, it is resembling with horseradish due to taste of the roots and the oil which is derived from seeds also called by Ben oil tree (Niphm.gov.in). Other names of moringa are kelor, moonga, nebeday, mlonge, mulangay, saijhan. Drumstick comes from the sub-Himalayan region in Northern India. Now, moringa is mainly cultivated in sub-tropical and tropical areas where it is consumed as a vegetable (leaves and young seed pods). Moringa word derived from the Tamil language 'murungai'. (Niphm.gov.in).

In India, the annual production of Drumstick is 2.20 to 2.40 million tonnes of tender fruits along with an area of 38,000ha and productivity of around 63 tonnes per ha. along with the 3 different states, Andhra Pradesh in both production and area by 15,665ha followed by Karnataka and Tamil Nadu that is 10,280 ha. and 13,250ha. (Sekhar *et al.*, 2017) [41]. In other states, a total of 4,613-hectare area. According to global data India contributes more than other countries in moringa production that is 41% followed by West Africa, Malaysia, Philippines, China, and Venezuela by 33%, 12%, 8%, and 6%) (Zameer, 2018). Chattisgarh is a major moringa producing district with a 2556 hectare area under cultivation and 19426 metric tons production (Anonymous, 2017-2018, Department of horticulture). *M. oleifera* Lam. belongs to the trees of moringaceae along with the monogeneric family of shrubs which includes the approximately 13 species from these 13 species 12 are popular in different regions that is *M. concanensis*, *M. hildebrandtii*, *M. arborea*, *M. ovalifolia*, *M. borziana*, *M. peregrina*, *M. rivae*, *M. drouhardii*, *M. pygmaea*, *M. longituba*, *M. ruspoliana*, *M. oleifera* Lam. and *M. stenopetala*. Moringa oleifera Lam. is most cultivated species (Foidl *et al.*, 2001; Fuglie, 2002) [7,9]. Moringa oleifera is a cheap and reliable alternative that has good nutritious values as well as prevents various disorders Dhakad *et al.* (2019) [6]. Drumstick is a rapidly growing, perennial crop (Bosch, 2017) it is a deciduous tree, can reach up to 7 to 12 meters in height (Foidl *et al.*, 2001) [7]. The bark is cork with whitish-grey in color and the stem is fragile with hanging branches, leaves are bipinnate with pale green in color (Pandey *et al.*, 2011). Leaves are 4-6 pairs of pinnae and 6.5 – 60 cm long and oval-shaped to obovate leaflets (Bosch, 2017). Flowers generally 1-1.5 cm and 2 cm broad (niphm.gov.in), flowers are bisexual, surrounded by 5 ununiform thin veined petals with yellowish-white color, and the fruits of drumstick are 10- 50 cm long capsules (Bosch, 2017). Fruits are drooping, which contains globular, dark brown seeds having approx. 1cm in diameter (niphm.gov.in).

Table 1

Languages	Common names
Latin	Moringa oleifera
Sanskrit	Subhanjana
Hindi	Saguna, Sainjana
Punjabi	Sainjana, Soanjana
Bengali	Sojne danta
Gujarati	Suragavo
Marathi	Shevga
Tamil	Morigkai
Telugu	Mulaga, Munaga
Malayalam	Muringa, Sigru
Unani	Sahajan
Arabian	Rawag
French	Bèn ailé, Benzolive
Spanish	Árbol del ben, Ben
Portuguese	Moringuiero, Muringa
Chinese	La Ken
English	Drumstick tree, Horseradish tree, Ben tree

Moringa oleifera leaves rich in carotenoids, terpenoids, tannins, essential amino acids, flavonoids, fibers, and sugars, apart from that ascorbic acid, cardiac glycosides and saponins also identified in moringa leaves (Okumu *et al.*, 2016) [29]. Drumstick mainly grows for its nutritious value, its fully grow pods, flowers and leaves use for consumption apart from that leave's extraction use for lactating mother's augment breast milk. Moreover, it is used for antimicrobial, anti-inflammatory, antioxidant, antidiabetic properties (Gopalakrishnan *et al.*, 2016). Pods, flowers, and leaves have amino acids by 30%, 31%, and 44%. In addition,

46.78 % fiber and 20.66% protein contain by immature pods (Sánchez-Machado *et al.*, 2010) [4]. M. oleifera leaves accommodate crude fat by 2.23%, crude protein by 27.51%, moisture content by 76.53%, crude fiber b 19.25%, ash content by 7.13%, calorific value as 1296.00 kJ/g (305.62 cal/g), and carbohydrate content as 43.88% (Oduro *et al.*, 2008) [28]. all parts of moringa plant (roots, leaf, and bark) used as treatment or preventions against 300 complications (diseases, disorders) (National Institutes of Health-NIH, 2018).

Table 2

Part of Tree	Nutritive Properties	References
Leaves	Moringa leaves contain fat, fiber, proteins, and minerals like Mg, Ca, K, Fe, P, Cu, and S. Vitamins like Vitamin-A (Beta-carotene), choline Vitamin B, vitamin B ₁ , ascorbic acid, riboflavin, nicotinic acid and are present in leaves. Moreover, different amino acids like Arg, Phe, Thr, Leu, Ile, Trp, Met, Val are present. Phytochemicals like tannins, phenolics, sterols, alkaloids, saponins, terpenoids, and flavonoids like quercetin, isothiocyanates, isoquercitrin, kaemfericitin, and glycoside compounds are present.	Rockwood <i>et al.</i> , (2013); Mbika, (2012); Fuglie, (2005); Sallau <i>et al.</i> , (2012); Ijarotimi <i>et al.</i> , (2013); Jung, (2014); Choudhary <i>et al.</i> , (2013).
Root Bark	Alkaloids like morphine, moriginine, minerals like calcium, magnesium, and sodium.	Adeyemi and Elebiyo (2014); Monera and Maponga (2012)
Pods	Rich in carbohydrates, fiber, lipids, ash, non-structural, protein. Fatty acids like palmitic acid, oleic acid, and linoleic acid are also present.	Fuglie (2005)
Seeds	Contains Ben oil, an antibiotic that is pterygospermin, and fatty acids like behenic acid, Linoleic acid, Phytochemicals like tannins, phenolics, saponin, flavonoids, terpenoids, phytate, and lectins. In addition to, protein, fats, fiber, vitamins A, B, C proteins, minerals.	Rockwood <i>et al.</i> , (2013); Kasolo <i>et al.</i> , (2010); Thurber and Fahey (2010); Sotalangka <i>et al.</i> , (2013); Nair and Varalakshmi (2011).
Flowers	Flowers contain Calcium, K, and amino acid. It also contains nectars	Fuglie (2005); Sotalangka <i>et al.</i> , (2013)

Table 2: Various phytochemical properties in different parts of moringa: (Mishra *et al.*, 2020)

Plant parts	Phytochemical constituents
Roots	Benzylglucosinolate and 4-(a-L-rhamnopyranosyloxy)-benzylglucosinolate
Stem	octacosanic acid, 4-hydroxymellein, B-sitosterol, 8-sitosterol, and vanillin
Bark	4-(a-L-rhamnopyranosyloxy)-benzyl glucosinolate
Leaves	Niazirin, three mustard oil glycosides, 4-(4'-Oacetyl-a -L-rhamnosyloxy) benzyl] isothiocyanate, Glycoside niazirin, <u>niaziminin A and B</u>
Whole pods	Nitriles, thiocarbates, 0-(2'-hydroxy-3'-(2'-heptenyloxy)]-propylundecanoate, isothiocyanate, 0-ethyl-4-((a-1 rhamnosyloxy)-benzyl] carbamate, methyl-p-hydroxybenzoate and 8-sitosterol
Mature seeds	Crude fat, carbohydrate, cysteine, 4-(a-L-rhamnopyranosyloxy) benzyl glucosinolate, benzyl glucosinolate, moringyne, mono-palmitic, methionine, and di-oleic triglyceride, Crude protein
Whole gum exudates	L-arabinose, D-galactose, L-rhamnose, D-mannose, D-glucuronic acid and leucoanthocyanin
Mature flower	D-glucose, protein, ascorbic acid, polysaccharide and D-mannose

Table 3: The nutrient value of 100 gram per material plant in leaf powder, leaves, pods, and seeds of moringa:

Nutrients	Pods	Fresh leaf	Dry leaf	Leaf powders
Vitamin B1(mg)	0.05	0.06	2.02	2.64
Vitamin B2 (mg)	0.07	0.05	21.3	20.5
Vitamin B3 (mg)	0.2	0.8	7.6	8.2
Vitamin E (mg)	—	448	10.8	113
Magnesium (mg)	24	42	448	368
Iron (mg)	5.3	0.85	25.6	28.2
Calories (cal)	26	92	329	205
Carbohydrates (g)	3.7	12.5	41.2	38.2
Protein (g)	2.5	6.7	29.4	27.1
Fat (g)	0.1	1.7	5.2	2.3
Vitamin C(mg)	120	220	15.8	17.3
Calcium(mg)	30	440	2185	2003
Fiber (g)	4.8	0.9	12.5	19.2
Phosphorus (mg)	110	70	252	204

(L.J. Fuglie, 2005); (Olagbemide and Alikwe, 2014); (<http://www.moringaleafpowder.co.za/analysis.html>)

Table 4: Various value-added products of moringa. (Sandeep *et. al.*, 2018)

S. No.	Name of value-added products	Raw material used	Product in use of curing
1.	Moringa oil	Moringa seeds	Skin Allergies, Moisturizing, Softness to Skin
2.	Moringa Tea in Four Different Tastes	Moringa Leaves + mint or Ginger or lemon or Tulsi	Nourishing and Detoxifying Nutrient-rich Super-food, Reduce Body-weight
3.	Mogo Energy Bites	Moringa Leaves + Dry Ginger +Padam+Peanut+ Alfafa + Spirulina + Cardamom + Almond + Countrv Sugar	Energy Chocolate and Nutrient Supplement
4.	Moringa Energy Drops	Moringa Leaves	Concentrated Drops for General Health
5.	Moringa Kernel -Pepper Fry	Ghee+Moringa Seed Kernel +Pepper	General Health and Nutrient Supplement
6.	Moringa Bio-Booster	Various Parts of Moringa + Other Extracts	Plant Growth Promoter
7.	Moringa Honey	Moringa Flowers	Medicinal Use
8.	Moringa Idly Powder	Moringa Leaves + Redgram + Red Chili + Salt + Blackgram	General Health
9.	Moringa Gum Powder	Moringa tree Gum	Diuretic, Astringent, Fever, Dysentery, Asthma, Intestinal Cancer
10.	Moringa Leaf Powder	Moringa Leaves	Activating Role, Balancing Health, Cleansing Role in the Body (ABC)
11.	Moringa leaf tablets	Moringa Leaves	Vitality and Nutrient Sunnlement
12.	Mogo-Colostrums Organic Enern.v Bar	Colostrums + Alfafa Groundnut + Almond + Moringa Leaves + Dry Ginger Spirulina + Cardamom	energy C: chocolate with nutrient Supplement
13.	Bio Moringa Instant Soup	Moringa fresh pods	ABC Role Plus General Health
14.	Moringa Oil Cake	Moringa seeds	Water Purifier
15.	Moringa Wunder Mix	Moringa Leaves + cashew+A Tuber from Nature + Cardamom + Dry Ginger+ nutmeg	General Health and Vitality
16.	Moringa Chips	Tender moringa pods	General Health and Protein Supplement
17.	Moringa Dry Flowers	Moringa flowers	General Health
18.	Moringa Capsules	Moringa leaves	General Health

Review of literature

Nutritional content in moringa

Research conducted on the nutrients content in moringa and resulted that dried moringa leaves have more micro-nutrients that are 15 times more potassium than a banana, 9 times the protein of yogurt, 17 times calcium of milk, 25 times iron of spinach, and 10 times vitamin A of carrots (Mishra *et. al.*, 2020) Research revealed that different parts of moringa like flowers, leaves, and pods have a different chemical composition for example crude protein (28%), fiber (10.2%), moisture (5.4%), crude fat (3.4%), ash (8.5%) and carbohydrates (43%) in leaves and pods protein (17%), fiber (34.1%), moisture (5.2%), fat (0.5%), and carbohydrates (26%) respectively (Kshirsagar *et al.*, 2016). A study was conducted on nutritional properties and chemical arrangements of popcorn-based corresponding foods amplified with moringa's leaf flour. The study acknowledged that the blend containing brewed popcorn-moringa leaves contain essential amino acid and protein than weaning food like 'ogi' and cerelec (Kumari and Sindhu, 2017). In a research standardized assessed freshly etiolated leaves of the drumstick integrated into three recipes which are commonly consumed in India that is desi chana (*Cicer arietinum*), mung (*Phaseolus aureus*), kabuli chana (*Cicer arietinum*), and desi chana (*Cicer arietinum*). Each recipe on one serving (30 g raw weight of pulses) could include a highest of 20 g of fresh drumstick leaves. The overall range of all three recipes was found to be adequate with an overall combined score was 3.06-3.53. Every serving of moringa leaf recipe rich with micronutrients beta-carotene (3955 µg), iron (1.6mg), and ascorbic acid (46 mg) (Nambiar and Parnami (2008).

A study found that dry leaves of moringa contain more iron content than fresh leaves. They compared the fresh leaves of iron content with dried leaves powder which was prepared by various methods like sun drying, oven drying, and shadow dried and found that fresh leaves contained 0.085mg per 100g of iron and on other hand, sun-dried contains 21mg per 100g leaf powder, oven-dried contains 19mg per 100 g of leaves powder and shadow dried sample contained higher amount of iron than other two methods that was 24mg per 100g of leaf powder. Whereas the iron content of dried leaves powder made by various methods of dehydration was 19-24 mg per 100g of leaf powder which was 95-96 percent higher than fresh leaves. (Haniff and Chamberlain, 2013). Nutritional comparison of fresh and dry Drumstick leaves with common food per hundred grams. (Fuglie L. J. 1999).

Table 5

Nutrients	Common foods	Fresh leaves	Dry leaves
Vitamin A	1.8 mg carrots	6.8 mg	18.9 mg
Vitamin C	30 mg oranges	220 mg	17.3 mg
Calcium	120 mg milk	440 mg	2003 mg
Protein	3.1 g yogurt	6.7g	27.1g
Potassium	88 mg Bananas	259 mg	1324 mg

A study conducted in Africa -America on the food consumption in the male by 2 samples and founded that a higher percentage of boys aged between 14-16 years have consumed 62% carbonated beverages, and 62% sweetened juices 66% chips. It showed that children enable to get the (EAR) estimated average requirement for zinc (Kolahdooz *et al.*, 2015)^[17]. Apart from this, the moringa

chips enriched with 26.0% (sample 1) and 24.0% (sample 2) of the EAR for zinc for aged group 9-13 years old of children. In addition, for the age group 9-13 years old of children, moringa chips accommodated between 14.0% of sample 1 and 17.0% of sample 2 of the Estimated Average Requirement.

Various value-added products of Moringa

Moringa tea was prepared like green tea. The researcher is interested to prepare two variations as V₁T₁ and V₂T₂. The moringa leaf powder for two variants V₁T₁ and V₂T₂ were 14grams and 21grams respectively. The moringa tea was graced with 1 teaspoon of honey for twain Variations of 100ml tea (S Yegambal and A Swarnalatha, 2019) [36]. Researchers prepared the chocolate by using moringa powder, which requires milk, cocoa powder, and moringa powder. This product was also prepared in two distinct variations such as V₁C₁ (40gms) V₂C₂ (60gms) respectively (S Yegambal and A Swarnalatha, 2019) [36]. Researchers studied the Moringa's leaves and sweet potato's leaves and found that the crude fat content of drumstick was more than the sweet potato. It is considered dietary fat absorbs and retains flavor, a dietitian consisted Moringa leaves are considered to be more appetizer Oduro *et al.*, (2017). Researchers found the nutrient contents from Moringa paneer, Paneer with extract of Drumstick leaf of different concentration resulted that the moringa paneer has high nutrient content than normal paneer (Sachan, 2015). In A research it was reported that Herbal biscuits, biscuits assimilated with Moringa leaf powder @ 5% enhanced protein content by 14% (Alam *et al.*, 2015). Cakes were made by using moringa leaves and whole wheat flour with distinct quantities of Moringa leaf (2gram, 4gram, 6gram, 8gram, and 10gram). for the cake checked two parameters nutritional and sensory and found that crude fiber, moisture, crude protein, and total ash showed a greater while carbohydrate content and total fat decreased with enhancing the concentration of Drumstick (Chinma *et al.*, 2014). Fortified yogurt was prepared with Moringa leaves but the product was not rated as good as compared with the control with as regards sensory parameters and also it did not negatively affect the growth of bacteria (*lactobacillus rhamnosus*) GR-1 in yogurt (Hekmat *et al.*, 2015). The product made from moringa was Moringa muffin, which was rich in a high amount of beta carotene, protein, vitamin C, and fat. Apart from this mineral content was also high in Moringa muffin. Iron, Calcium, Potassium content was significantly higher in Moringa muffin than the controlled one. Moreover, phosphorus content was also higher (Srinivasamurthy *et al.*, 2017). In the locals of Tamil Nadu state the moringa's Dry stem powder use as an antidote to poisonous bites (Rajendran *et al.*, 2008). Researchers' studies on mineral contained by moringa leaves and found that the eight ounces of moringa leaves contain 1000mg calcium and dry leaves powder of moringa have more amount of calcium that was 4000mg which is very higher than milk, milk can give 300-400mg of calcium (Gopala Krishnan *et.*

al., 2016). Banana flour, drumstick flour, soy flour, mixed dry then butter oleo, sugar, full cream milk powder, water and then cooked until the dough is smooth, the dough is then printed and baked in an oven at 140°C for 40 minutes. The protein range in each piece (100g) was 7.06 – 7.97g and based on the requirement of nutritional food should contain 7.9-8.1g protein. Based on these requirements, F₁ formula that is banana flour (25%), soy flour (10%) and Moringa flour (10%), F₂ formula that is 15% banana flour, 15% soy flour, and 15% Moringa flour, and F₃ formula that is banana flour (20%), soy flour (20%), and Moringa flour (5%) meet the standards recommended by the Institute of Medicine. (Allen *et. al.*, 1995) [1]. In research of processing standardized the moringa-based soup by mix the other products like onion, tomato. In which researchers used the two processing techniques for example- pulping dehydrated and drying blending to prepare soup mixes. In the first method, by used a grinder make the pulp of different ingredients like tomato, moringa pods pulp, onion, and moringa leaves and dehydrated under drier at 70⁰ C for 7-8 hours. This dried pulp is powdered, blended, and sieved with other ingredients. On other hand, using another method that was drying- blended separately dried all ingredients like tomato, moringa leaves, onion, moringa pod pulp at 70⁰C for 4-8 hours, and blended along with other ingredients viz. cornflour, soya flour, and milk solid with distinct proportion. The base, moringa leaves, and moringa pulp were added to soup mixes by different proportions and found that admixture of 10 percent moringa leaves to powder and 35 percent moringa pulp powder gave superior result (Saranya and John, 2017). Health benefits of Moringa soup: (S Yegambal and A Swarnalatha, 2019) [36]

Table 6

Protect the healthy eyes	Prevent the growth of cancer cells
Stimulate the nervous systems	Control the blood sugar level in diabetes
Boost your immune system	Help to treat asthma
Keep the healthy bone	Prevent anemia in pregnant women
Help to prevent heart disease	Prevent constipation
Control the blood pressure Prevent hair loss	Increase breast milk secretion

A study conducted on blended Technology for beverages preparation by using moringa of 10-12 percent carrots, 50- 52 percent drumstick (juice extracted from leaves), and 38-40 percent Pineapple and for storage and increase shelf life used ambient condition for 8 weeks. This beverage contained 159.14 mg vitamin C, 2.9 g protein, and 1.02 mg iron per 100ml of juice. Carrot juice, pineapple juice, and Moringa juice was pasteurized for 30 mins at 62⁰ C (Yarely *et al.*, 2013)

Commercial health care products and benefits of Moringa

Table 7

Moringa capsule Moringa dried leaves	Energy and health supplements Can be used as a food fortification
Poonga monga moringa tea	Nourishing beverages
Zija smart mix health drink	Delicious powder <i>drink</i> blend filled with <i>Moringa oleifera</i> full of essential vitamins and minerals
Moringa pharm	Organic moringa leaf capsule
Moringa tea	Nourishing beverages
Moringa pod powder	Can be used as a food fortification
Miracle malunggay	100% pure <i>Moringa oleifera</i> leaf food supplementation
Pooga Monga health drink	Health drink mixture of pomegranate - moringa-aloe vera

Source: Singh, (2010)

A study assessed that when moringa pods stored in ambient storage then ascorbic acid reduction was higher (8.2%) than the pods stored under 14⁰ C temperature (5.5%) in local variety. Apart from this, in PKM-1 variety when oxygen concentration 3%, 4%, and 5% was estimated at 14⁰ C in 40 days it revealed the higher loss of ascorbic acid that was by 54.1%, 5.3%, and 5.9% respectively. So, the 14⁰ C of temperature treatment was best from both ambient and 14⁰ C temperature, 4% oxygen, and 5% carbon dioxide for enhancing the shelf life of moringa pods up to 40 days (Selvi and Varadharaju, 2016). Moringa tree gave an important product that is gum, when the tree is wounded then the bark exudes the gum a sticky-like substance, which is white in color but after some time turns into reddish-brown or brownish-black on exposure. Gum is used in dental caries, Gum mixed with sesame oil is used to relieve fevers, headaches, intestinal complaints, asthma, Dysentery. Also, use in Gum used in leather tanning and calico printing. (Omotesho *et. al.*, 2013) ^[16].

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