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# Overview on *Moringa oleifera*: The most nutritious nature's gift to mankind

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**Abstract**
*Moringa oleifera* is referred by many names such as "Miracle tree", "Super food", "Nature's medicine cabinet" for its multipurpose uses and its Medicinal and Pharmacological activities. Every part of the *M. oleifera* tree is nutritious. The majority of the research articles reviewed showed that *M. oleifera* leaves and other parts have very dense nutritional values, with the highest number of carbohydrates, antioxidants, amino acids, proteins, phytochemicals, β-carotene & rich in vitamins A, B, C, D, E and K. Apart from vitamins, the plant is also very rich in mineral content and contains calcium, iron, potassium, magnesium, manganese and zinc. Malnutrition is a major problem across the world. This tree has a great potential to treat the people suffering from malnutrition and micronutrient deficiencies. The usage of this plant parts are for fortifying various formulations is a great initiative and it can be applied in the food industry as a functional food ingredient. It is very useful for the rural communities; especially for farmers as it has potential for local value addition and employment. This comprehensive review focuses on the functional nutrients of *M. oleifera* with their respective health benefits, fortification into various formulations and its significant potential to address malnutrition.

**Keywords:** *Moringa oleifera*, miracle tree, super food, medicinal, pharmacological, nutritional, malnutrition, employment, fortification

## Introduction
In current world, the people's dependency on the chemical drugs is increasing day by day and there are several problems or disadvantages and side effects on the human body due to consumption of these chemicals. So, to overcome this type of disadvantages and problems we need to reduce the use of chemical drugs and increase use of plant-based products for a healthy and better life. There are many medicinal plants but recently the '*Moringa oleifera'* plant has been in limelight because of an unrealized potential to solve many problems related to the body [1].
*M. oleifera* belongs to *Moringaceae* family [2]. With its immense nutritional, pharmacological, medicinal and commercial properties the *M. oleifera* is referred to as "Superfood" and also referred to as "Miracle tree". According to Ayurveda, *M. oleifera* has a great potential to cure more than 300 diseases [3, 5].

## Geographical Source
*M. oleifera* tree (see fig.1) native to India, it has been introduced and widely distributed in many places and parts of Bangladesh, Pakistan, Afghanistan, Srilanka, South and Central America, West Asia, Europe countries Africa, Brazil, South East Asia and many other countries. In India the southern states and northern east states are major consumers of *M. oleifera.* India is the main supplier of *M.oleifera* worldwide, accounting for around 80% of global demand [2, 6, 9].

**Fig 1:** *M. oleifera* Tree

**Synonyms** [9, 15]

*M. oleifera* has different synonyms according to different languages

- Ayurvedic: Haritashaaka tikshnagandhaa, Raktaka, Akshiva
- Sanskrit: Danshamula, Shobhanjana, Sigru-shobhanjan, Chaksushya
- Unani: Sahajan
- English: Drumstick tree, West indian ben, Mother's best friend
- French: Ben oleifera, Benzolive, Arbreradis du cheval, Bois nephretique
- Latin: *M. oleifera*
- Nepali: Sitachini
- Hindi: Shajmah, Mungaara, Segra, Shajna
- Gujarati: Saragavo, Midho-saragavo, Seyla
- Tamil: Morunga, Murungai, Murunkak-kai
- Oriya: Munigha, Sajina
- Telugu: Mulaga, Munaga, Sajana, Tella-munaga
- Malayalam: Sigru, *Moringa*, Muringa, Murinna, Morunna
- Bengalese: Munga ara, Sajna, Sojna, Sujana
- Kannada: Nugga egipa, Nugge, Noogay, Nuggi mara
- Marathi: Sujna, Shevga, Shivga
- Rajasthani: Lal sahinjano
- Punjabi: Sainjna, Soanjna
- Urdu: Sahajna
- Konkani: Maising, Moring

**Historical Background**

*M. oleifera* is first described in 'Shushruta Sanhita' (Ayurvedic literature written in the first century AD) as 'Shigon'**.** It is also described in siddha and unani medicine systems. In siddha medicines, these drumstick seeds are used as a sexual virility drug for treating erectile dysfunction in men and also in women for prolonging sexual activity (They possess a compound called 'Pterygospermin' [4, 16]**.**

In ancient India, The history of *M. oleifera* dates back to 150 B.C, historical proofs reveal that ancient kings and queens used *M. oleifera* leaves and fruit in their diet to maintain mental alertness and healthy skin. In India Ancient brave Mauryan warriors of India were fed with *M. oleifera* leaf extract on the warfront. The elixir drinks were believed to add them extra energy and relieve them of the stress and pain incurred during the war. These brave soldiers were the ones who defeated 'Alexander' the great [17]**.**

**Nutritional Properties**

*M. oleifera* is a powerhouse of nutrients. Each part of *M. oleifera viz*. leaves (see fig.2), roots, bark, pods (see fig.3), flowers and seed contain high food supplements. The *M. oleifera* is source of carbohydrates, fibres, minerals, vitamins, amino acids, antioxidants, phytochemicals, proteins and many other nutrients. *M. oleifera* is source of minerals like zinc, calcium, sulphur, copper, potassium, magnesium, phosphorus, manganese, chromium and iron. Vitamins like β-carotene, vitamin A, vitamin B such as thiamine(B1),riboflavin(B2),folic acid, pyridoxine(B6), nicotinic acid(B3), biotin(B7), and cyanocobalamin (B12), vitamin C, vitamin D, vitamin E and vitamin K [1, 16, 18, 20].

It consists phytochemicals such as tannin, sterols, terpenoids, flavonoids, saponins, anthraquinones, alkaloids, phenolic acids, and reducing sugar present along with anti-cancerous agents like glucosinolates, isothiocyanates, glycoside compounds and glycerol-1-9-octadecanoate(18).It contains many essential amino acids such as arginine, histidine, leucine, isoleucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine and non-essential amino acids like alanine, aspartate, cysteine, glutamate, glycine, proline, serine and tyrosine [7]. antioxidants like carotenoids, quercetin, oxalic acid, kaempferol, β-sitosterol, caffeoulqunic acid, gallic acid, egallic acid, chlorogenic acid**,** ferulic acid, and zeatin [7, 21, 22]. Quercetin is considered as an inhibitor for cancer cell growth within the human body [8]. A research shows that immature pods contain around 46.78% fibre and around 20.66% protein content. Pods have 30% of amino acid content, the leaves have 44% and flowers have 31%. The immature pods, leaves and flowers showed similar amounts of fatty acids like palmitic, linolenic, linoleic and oleic acids & also contain PUFA [8, 23]. Omega 3 and 6 fatty acids are also present in *M. oleifera* [1]. It contains an 'aphytosterol' compound which helps to increase of milk production in breastfeeding mothers [24].

**Fig 2:** Drumstick/Pods

**Fig 3:** *M. oleifera* Leaves

**Comparison with other Food** [9, 23, 25, 26]

In Fact, *M. oleifera* can provide more nutrients than other food So, it is also referred as 'Human's Superfood'. The comparison of *M. oleifera* with other food is mentioned in Table 1.

**Table 1:** Comparison of 100 grams edible portion with *M. oleifera* dried leaves

| Nutrients | Dried leaves |
|---|---|
| Vitamin A | Ten times(10X) of carrots and thirteen times(13X) of spinach |
| Vitamin C | Seven times (7X) of oranges |
| Vitamin B | Four times(4X) of pork meat |
| Vitamin B2 | Fifty times (50X) of sarones |
| Vitamin B3 | Fifty times (50X) of peanut |
| Vitamin E | Six times (6X) of rapeseeds oil |
| Calcium | Seventeen times(17X) of milk |
| Magnesium | Thirty-six times(36X) of egg |
| Potassium | Sixty-three times(63X) of milk and three times (3X) of banana |
| Iron | Twenty-five times(25X) of spinach |
| Protein | Nine times (9X) of yoghurt/milk |
| Poly phenol | Eight times(8X) of red wine |
| Amino Acid | Two times(2X) of black vinegar |
| R-amino Acid | Thirty times(30X) of brown rice and four times (4X) of GABA tea |
| Chlorophyll | Four times (4X) of wheat grass |

**Recommended Daily Allowance (RDA) of various nutrients** [21]

According to the RDA limits provided of nutrients along with its daily intake and how much percentage of RDA should ideally be consumed by children's and parents has been depicted in Table 2.

**Table 2:** Recommended Daily Allowance (RDA) of various nutrients

| Nutrients | %RDA | | Daily intake |
|---|---|---|---|
| | Child | Parent | |
| Protein | 21 | 42 | Supplied to a nursing mother and a 1-3-year-old child by *M. oleifera* leaf powder.<br>6 tablespoons per day for a nursing mother;<br>1 tablespoon 3 times per day for a 1-3 year old child |
| Calcium | 84 | 125 | |
| Magnesium | 54 | 61 | |
| Potassium | 22 | 41 | |
| Iron | 94 | 71 | |
| Vitamin A | 143 | 272 | |
| Vitamin C | 9 | 22 | |

**Chemical Constituents of *M. oleifera*** [27]

Chemical constituents are basically chemicals which produced by plants and refer to only those chemicals which may have impact on health, smell & colour of plant. Examination on moringa species provides opportunity in plant family being rich in compounds having simple sugar, rhamnose and glucosinolates and isothiocyanates. Some components of moringa have been reported to have hypertensive, anticancer and antibacterial activity which include (1) 4-(4'-O-acetyl-α-L-rhamnopyranosyloxy) benzyl isothiocyanate, (2) 4-(α-L-rhamnopyranosyloxy) benzyl isothiocyanate, (3) niazimicin, (4) Pterygospermin, (5) benzyl isothiocyanate and (6) 4-(α-L-rhamnopyranosyloxy) benzyl glucosinolate (see fig.4).

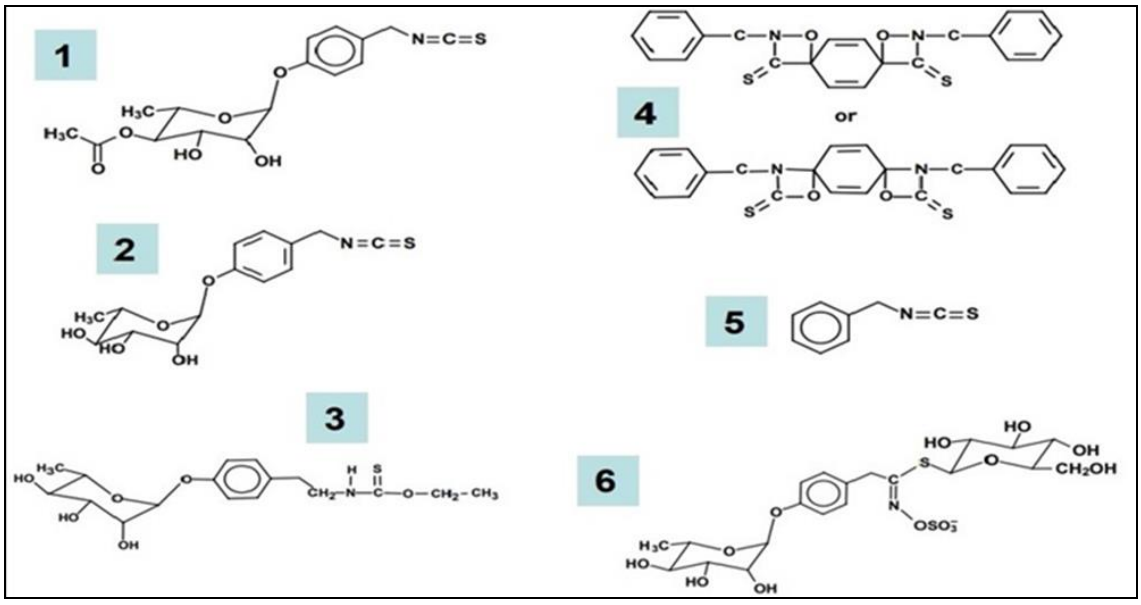


**Fig 4:** Chemical constituents present in M. oletfera; (1) 4-(4'-0-acetyl-a-Lrhamnop-yTanosyloxy) benzyl isothiocyanate, (2) 4-(u-L-rluunnopyranosyloxy) benzyl isothiocy-anate, (3) niazhnicin, (4) Pterygospennin, (5) benzyl isothiocyanate and (6) 4-(u-L-rhamnopyranosyloxy) benzyl glucosinolate

**Medicinal uses and Pharmacological Activities**

Various parts of *M. oleifera* such as leaves, pods, seeds, flowers, roots are very useful for the treatment of various diseases such as anemia, eye and ear infections, anxiety, hysteria, liver problems, arthritis, asthma, bronchitis, purification of blood, tuberculosis, digestive disorders, diarrhoea, rheumatism, paralysis, diseases due to vitamin deficiencies, prostate disorders, cardiac disorders, insomnia, crohn's disease, alzheimer's disease, venomous bites, malaria, hyperglycemia, hypoglycemia, dyslipidemia, blackheads, semen deficiency and many more diseases cure by *M. oleifera* [1, 3, 12, 18, 19, 25, 29].

*M. oleifera* also contains anti-diabetic, anti-cancer, analgesics, anti-inflammatory, anti- hypertensive, anti-microbial, anti-pyretic, anti-tumor, anti-ulcer, anti-epileptic, anti-arthritic, antiseptic, anti-fungal, hepatoprotective, neuroprotective, diuretic, cholesterol lowering etc. activities [3, 9, 12, 20, 26, 30].

In some countries the *M. oleifera* was given to the infants and breast-feeding mothers for constant supply of nutrients and to increase woman's milk production. That's why *M. oleifera* is referred to as ''mother's best friend'' [22, 24].

Due to its higher nutritional value, it is recommended for the malnutrition and nutritional deficiencies. Countries like Senegal, Benin, Philippines, Zimbabwe, and Haiti are now using *M. oleifera* to combat malnutrition. *M. oleifera* was also promoted by WHO as an alternative to imported food source to treat malnutrition [5, 6, 12, 24, 31].

*M. oleifera* seeds (see fig.5) act as a natural coagulant. *M. oleifera* seed powder can be used for water purification, replacing dangerous, antibacterial, expensive chemicals such as aluminium sulphate, arsenic from the aqueous system for the canal and industrial wastewater treatments as an alternative sustainable friendly matter in third world countries [19]. Latin America, Africa and Asia use seed powder for cleaning dirty water. This action can remove bacteria contained in water up to 90-99% [26].

*M. oleifera* tree is recognized by the national institutes of health as the ''Botanical of the year'' in 2007 and praised again in 2011 and 2012.By its nutritional value we can say that this plant has saved more lives in 3rd world countries [12]. In India it was named the 'plant of the year' in 2008 by the National institute of health and family care [18].

**Fig 5:** *M. oleifera* seeds

***M. oleifera* in Indian Context**

Various parts of the *M. oleifera* tree *viz*. roots, bark, leaves, pods, flowers and fruits are used in human consumption. In India *M. oleifera* is consumed by different methods according to the region, in southern states of India it is used to prepare 'Sambar' and also fried. In West bengal it is made into a variety of 'Curry' dishes by mixing with coconut, poppy seeds and mustard or boiling, also used to prepare 'Kormas and Dals' etc. In Maharashtra people made 'Aamatee' by using Pods of *M. oleifera*. In some regions the pods and flowers are gathered and cleansed to be cook with Besan to make 'Pakoras' [9, 31]. In Bihar and Orissa, the tender pods garnished with mustard seed paste are cooked like beans and consumed with rice called 'Panibhaat'. Mature pods are used to prepare soups and stews. Vegetable called 'Sanjana tarkari' is prepared from fresh young leaves is commonly recommended as a special food supplement for pregnant women, lactating mothers, in patients suffering from osteoporosis and bone fracture. In northern India mainly in Punjabi, Sindhi and Multani communities prepare flowers as a delicacy after boiling/frying with curd [31]. Generally Indian people consume *M. oleifera* powder in form of tablets and capsules.

***M. oleifera* in World Context**

Different countries use various formulations of *M. oleifera*. In Senegal, an infusion of leaf juice is consumed to control glucose levels in diabetes. In Bahamas and Jamaica, men drink leaf decoction to build up blood and relieve inside dryness. In Philippines, eating leaves is believed to increase a woman's milk production and is sometimes prescribed for anemia. In Haiti, an infusion made from flowers is taken against colds. In Puerto Rico, an infusion of the flowers is used as eyewash and a decoction from the flowers has been used to treat hysteria [25]. In Africa 25g of *M. oleifera* powder is given to pregnant women daily to improve prenatal nutrition [31].

**Need for Formulations/Fortification of *M. oleifera* [13, 18, 23, 32]**

According to the study, the children refuse to take *M. oleifera* due to its slightly bitter taste. So, to overcome this type of problem we need to do fortification of *M. oleifera* by making different type of formulations. So, *M. oleifera* if adapted in various formulations into Noodles, Chocolates, Cookies, Soup, Cake, Bread. The leaves can be also processed into tea. Such type of formulations with fortifications makes it easy for people to consume the *M. oleifera.*

**Future Prospects**

The above mentioned pharmacological and traditional uses of *M. oleifera* and its higher nutrition value prove it to be a better nutraceutical [9]. India is the largest producer of *M. oleifera*, with an annual production of 1.1 to 1.3 million tons of pods from an area of 38000 hectares [32]. According to UNICEF, one in three malnourished children in the world is Indian. It is estimated that reducing malnutrition could add some 3% to India's GDP [33]. So, by the using *M. oleifera* India could easily fight against the problems of malnutrition, hunger, poverty, diseases by local and cost-effective manner, India can utilize its full benefits. So future prospective, *M. oleifera* can be included in routine diet to get its maximum benefits and to avoid several disease as well as malnutrition [21, 34]. The poor and develop countries should promote planting and use of *M. oleifera* instead of waiting for bounties of food relief from the rich west. substantial foreign exchange could be earned by exporting product of *M. oleifera* instead spending foreign exchange on imports *M. oleifera* [28]. Due to the multipurpose use of *M. oleifera*, it can be the best option for rural poor, smallholder farmers and marginalized community for livelihood

improvement. It can be intercropped with many other vegetables and has potentially to increase rural income by generating employment, self-sustainability, and alleviate poverty. The crop proves more profitable with minimum investment even within a small land in a short span of time. Therefore the crop can be a blessing to the rural community [18].

## Conclusion & Recommendations

*M. oleifera* is rightly said to be a "Miracle tree". It has multipurpose use for humankind and a dense nutritional profile as compared to many other popular health foods. *M. oleifera* possesses broad spectrum of Nutritional, Medicinal and Pharmacological activities. *M. oleifera* contains 96 Nutrients, 46 Anti-oxidants, 20 Amino acids, 36 Anti-inflammatory agents which are enough for a healthy and better life.

With its rich nutritional and medicinal properties, many countries use it as nutritional supplements to save millions of lives in poor and developing countries where malnutrition is prevalent. Bio-fortification has been introduced to overcome the nutritional problem. By making children consumption friendly formulations, children can easily consume *M. oleifera* indirectly leading to more wholesome nutrition in their diet.

It is still an underutilized crop in most of countries, governments and health agencies should make an effort towards educating populance, particularly the vulnerable ones, on the values of *M. oleifera* as a source of medicine and nutrition, by training them on the best methods of preparing the products to get optimum benefits.

More research must be carried out on *M. oleifera* especially in current Scenario. In India, where the malnutrition level is high, incorporation of *M. oleifera* into various formulations like bakery products, easy to cook products and also add *M. oleifera* as a food ingredient in 'Mid-day meal' is a great initiative idea. By making children consumption friendly formulations, children can easily consume *M. oleifera* indirectly leading to more wholesome nutrition in their diet. Not only India but all the countries which suffer from malnutrition can easily tackle malnutrition and micronutrient deficiencies by incorporating and encouraging *M. oleifera* based formulations and food ingredients in daily food.

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