

Moringa oleifera : Nutritional and Medicinal Properties for preventive health care**A. Padma^{*}, A. Indhuleka, J. Janet and V. Ragavi**^{*}padmasokki@gmail.com

Department of Science and Humanities, Sri Krishna College of Engineering and Technology, Coimbatore – 641008, Tamil Nadu, India

Abstract

Moringa oleifera, commonly known as “drum stick” or the “horse radish” is cultivated all over the country as it can withstand both severe drought and mild frost conditions. It is a good source of protein, vitamins, fatty acids, micro-macro minerals and other essential phytochemicals. Due to its high nutritional content, the extract of leaves of *Moringa oleifera* is used to treat malnutrition and supplement breast milk in lactating mothers. Because of its medicinal value, it is also used as anti-inflammatory, anticancer, antioxidant, antidiabetic, cardiovascular hepatoprotective, anti-ulcer, antimicrobial agent. The pharmaceutical effects of *Moringa oleifera* makes it useful in therapeutic remedy in traditional medicinal system. Each part of the tree is useful in one form or another due to high nutritional and medicinal value. This paper reports the results of the study made on how these can help boosting the immunity level in individuals.

Key words: *Moringa oleifera*, enriched nutrient supplement, preventive medical care.

1. Introduction

The *Moringa* genus comprises of 14 species namely *Moringa arborea*; *Moringa longituba*; *Moringa borziana*, *Moringa pygmaea*; *Moringa hildebrandtii*; *Moringa drouhardii*; *Moringa longituba*; *Moringa peregrina*; *Moringa stenopetala*; *Moringa rivae*; *Moringa ruspoliana*; *Moringa Ovalifolia*; *Moringa Concanensis* and *Moringa oleifera* (Rani et al., 2018). The scientific details are listed below:

Scientific name: <i>Moringa oleifera</i>	Family: Moringaceae
--	---------------------

Order: Brassicales	Kingdom: Plantae
--------------------	------------------

From the Moringaceae family, *Moringa oleifera* is the commonly known, studied and used species (Anwar 2005; Olson 2011) and it is also the most commonly cultivated plant. It is extremely nutritious with a variety of uses and it is an effective remedy for malnutrition. *Moringa oleifera* is an indigenous of Indian subcontinent and but now has become naturalized in many tropics and subtropics regions worldwide. *Moringa oleifera* is referred to as “The Miracle Plant or Tree of Life” (Palada, 1996; Fuglie, 1999). There are several reasons why the issues and challenges of malnutrition and under nutrition still prevail and unresolved. Reasons are many including food insecurity, lack of access and affordability to modern the health care, lack of availability of nutritional food supplements to certain class of people (West *et al.*, 2006). One solution to resolve these issues is to find alternative and cost effective ways of producing nutritional food supplements. This could reduce the chances of people getting ill and thus reducing their expenses on medical treatments. The best choice for healthy and nutritional food is from fruits and vegetables. There are only few trees that grow in almost all climatic conditions, one such tree is *Moringa oleifera*. Almost all parts of moringa are used in diverse culinary ways (Chumark *et al.*, 2008, Iqbal *et al.*, 2006). This is used in different classes and society of people due to its nutritional value and medicinal properties (DanMalam *et al.*, 2001; Dahiru *et al.*, 2006).

Traditional healers and health consultants prescribe different parts of *Moringa oleifera* for treatment of skin diseases, respiratory illness, hypertension, diabetes, cancer treatment, ear and dental infections and have stimulated its use as a nutrient condensed food source (Anwar *et al.*, 2007; Fuglie, 1999). All parts of the tree are rich in nutritional content and also have medicinal value (Adewumi *et al.*, 2016). Leaves are used as forage, tree trunk is useful in making gums, flower nectar is beneficial for preparation in honey and seed powder for water purification (Fuglie, 1999).

Moringa oleifera leaf has been used as an alternative food source to combat malnutrition especially among children and infants (Anwar *et al.*, 2007). Almost all parts of this plant, namely leaves, flowers, seeds, pods, bark and roots, have enormous nutritional content and are in traditional medicine to treat numerous pathologies. They are part of regular cooking in most of the areas. As *Moringa oleifera* can survive in all climates - humid or dry hot, and can grow even in poor soils, it is found in all regions irrespective of the climatic condition. (Anwar *et al.*, 2007; Mainenti 2018). *Moringa oleifera*, a highly nutritious plant, helps to treat malnutrition in developing countries (Zongo 2013; Valdez-Solana *et al.*, 2015; Gopalakrishnan *et al.*, 2016; Debajyoti *et al.*, 2017). This study is to focus on medicinal potential of this unique plant and its potential as a nutritional and medicinal benefits. The applications and the challenges of the tree is shown in Fig 1.

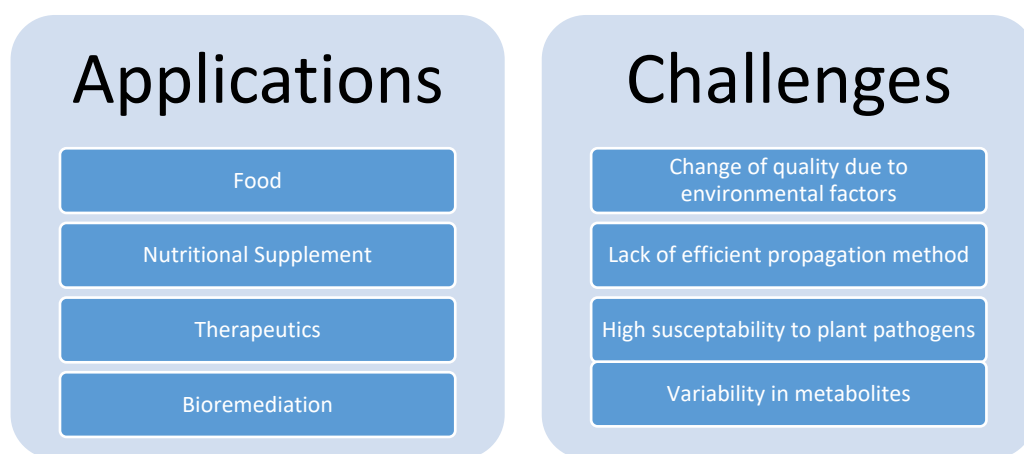


Fig 1: Applications and challenges of *Moringa oleifera*

2. Nutritional Properties of *Moringa Oleifera*

Moringa Oleifera tree is rich in a number of nutrients such as proteins, fibre, minerals, flavonoid content and essential phytochemicals present in its leaves, pods and seeds (Jongrungruangchok *et al.*, 2010, Moyo *et al.*, 2011) that play important role in human nutrition and cosmetic industry. *Moringa* is found to have higher level of nutrients compared to the costly counterparts. For instance, when compared to other plants, from 100 g of dry leafs of *Moringa oleifera* has 7 times more vitamin C than oranges, 10 times more vitamin A

than carrots, 17 times more calcium than milk, 9 times more protein than yoghurt, 15 times more potassium than bananas and 25 times more iron spinach (Oduro *et al.*, 2008; Rockwood 2013; Saini *et al.*, 2016) as shown in Fig 2. As *Moringa oleifera* is easily cultivable and cheaper supplement compared to other products, it becomes a sustainable remedy for malnutrition (Kasolo *et al.*, 2010).

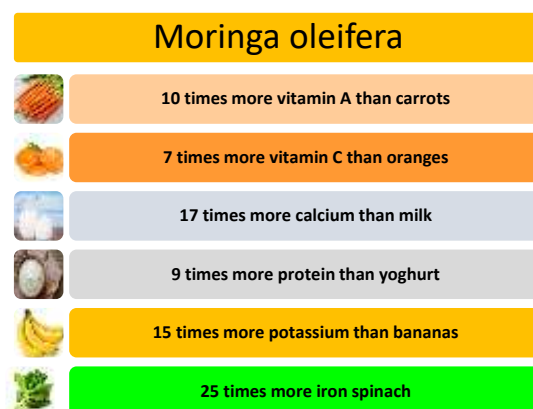


Fig 2: Comparison of nutrient value of *Moringa oleifera* with other food items

The nutrients present in different parts of Moringa have made it useful in treatment of various diseases. Due to rich iron content, more than the content in Spinach, Moringa powder are use in the treatment for anemia (Fuglie, 1995).

The bioactive flavonoids in the leaves of *Moringa oleifera* have excellent anti-viral and anti-estrogenic activities that makes it an appropriate for nutritional and pharmaceutical supplementation (Havsteen, 2002; Mian *et al.*, 2001 and Middleton *et al.*, 2000). The reported facts are supported by the reports of World Health Organization (WHO) which has studied the use of *Moringa oleifera* as a low cost supplement enhancer in the poorest countries around the world especially in countries suffering from malnutrition (WHO Readers). Earlier researchers have reported that moringa seed oil contains around 76% PUFA. PUFAs are linoleic acid and oleic acid that have the ability to control cholesterol. Hence moringa is an ideal substitute for olive oil (Lalas *et al.*, 2002).

2.1 The leaves

The leaves of *Moringa oleifera* are used in traditional food as vegetables in almost all parts of the world. It is consumed either in fresh or powder form, allowing conservation for use in the later period (Moyo 2011; Olson *et al.*, 2016). Studies show that nutritional value of *Moringa oleifera* does not reduce. The study on the nutrient content of these leaves showed that they are a valuable source of both macro-and micronutrients. In addition to these nutrients, they also have significant amounts of vitamins like beta-carotene of vitamin A, vitamin B such as folic acid, pyridoxine and nicotinic acid, vitamin C, D and E (Hekmat *et al.*, 2015, Mbikay, 2012). *Moringa oleifera* leaves are also rich in phytonutrients such as carotenoids, tocopherols and ascorbic acid (Saini *et al.*, 2014b, Saini *et al.*, 2014d). These nutrients when combined with a balanced diet may have immunosuppressive effects (DanMalam *et al.*, 2001). *Moringa* leaves also have low calorific value and can be used in the diet of the obese.



Fig 3: Moringa Leaves

In spite of several leaves consumed as food, studies have shown that *Moringa oleifera* leaves are extremely high in protein and iron. There may be slight variations in the nutritional value of *Moringa Oleifera* of different cultivar and source (Jongrungruangchok *et al.*, 2010, Teixeira *et al.*, 2014, Moyo *et al.*, 2011). Yang *et al.* (2006) has reported that among all species of *Moringa*, *Moringa oleifera* has the highest amount of β -carotene, ascorbic acid (Vitamin C), α -tocopherol (Vitamin E) and iron. Fresh leaves of *Moringa Oleifera* have been found to be good sources of carotenoids such as trans-lutein (approx. 37 mg/100 g), trans- β -

carotene (approx. 18 mg/100 g) and trans-zeaxanthin (approx. 6 mg/100 g) and high amounts of ascorbic acid (271 mg/100 g) and tocopherols (36.9 mg/100 g) (Saini *et al.*, 2014d).

Studies have showed that *Moringa oleifera* leaves contain significant amount of essential amino acid, alpha linoleic acid and a wide range of dietary antioxidants (Moyo *et al.*, 2011, Moyo *et al.*, 2012, Qwele *et al.*, 2013, Saini *et al.*, 2014d, Saini *et al.*, 2014e, Yang *et al.*, 2006). According to Yang *et al.* (2006), *Moringa oleifera* leaves have significantly higher antioxidant contents when compared to fruits such as strawberries that are known for high antioxidant contents. (Saini *et al.*, 2014b, Saini *et al.*, 2014d). Other studies have showed that *Moringa Oleifera* plant improve meat quality in terms of chemical composition, colour and lipid stability (Qwele *et al.*, 2013, Nkukwana *et al.*, 2014a, Nkukwana *et al.*, 2014b, Nkukwana *et al.*, 2014c).

Experimental studies have proved that leaves of *Moringa oleifera* contain a high amount of polyunsaturated fatty acids and low saturated fatty acids content (Moyo 2011). Studies have proved that these fatty acids in the leaves along with diuretic and lipid help in maintenance of cardiovascular health (Anwar *et al.*, 2007). The blood pressure lowering properties of leaves and pods also aids good cardiovascular health. Phytosterols from *Moringa oleifera* increase estrogen production that enhance the activity of the mammary glands ducts (Gopalakrishnan 2016). It is found that adding fresh or dried leaves to the feed of milk cows increased milk production by 43 and 65% respectively (Bhargave 2015). *Moringa oleifera* can also help lactating mothers produce more milk and help to treat malnutrition in young children. Studies carried out on mice by adding *Moringa oleifera* in doses of 0.042 mg/g of body weight resulted in increased milk production. The presence of antioxidants and flavonoids enhances the nutritional value of the foods/snacks with *Moringa oleifera*. (Ellis 2011; Jung 2016). Studies were carried out on animals with cerebrovascular diseases by adding *Moringa oleifera* in their daily feed and found to have promoted memory, learning and cognitive

functions (Vauzour et al. 2008). Due to high iron content, *Moringa Oleifera* can overcome iron deficiency and modulate the expression of iron-responsive genes better than conventional iron supplements and leaves can be a potential source of dietary folate. (Saini *et al.*, 2014b).

Moringa leaves have antioxidants (260 mg/ 100 g) along with polyphenol contents (260 mg / 100 g), quercetin (100 mg/ 100 g)), Kaempferol (34 mg/ 100 g) and B- catotene (34 mg/ 100g). A complete list of nutrients available in leaves (Fresh & Dry), leaf powder, seeds and pods are shown in Table 1 (Fuglie L.J,1999). It is noted that nutrient content is more in dry leaves than in fresh ones.

Table 1. The Nutritional analysis of Fresh and Dry leaf powder, seeds and pods per 100 g of edible portion.

Nutrients	Fresh leaves	Dry leaves	Leaf powder	Seed	Pods
Calories (cal)	92	329	205	–	26
Protein (g)	6.7	29.4	27.1	35.97 ± 0.19	2.5
Fat (g)	1.7	5.2	1.9	35.21 ± 0.01	0.1
Carbohydrate (g)	12.5	41.2	38.2	8.67 ± 0.12	3.
Fibre (g)	0.9	12.5	19.2	2.87 ± 0.03	4.8
Vitamin B1 (mg)	0.06	2.02	2.64	0.05	0.05
Vitamin B2 (mg)	0.05	21.3	20.5	0.06	0.07
Vitamin B3 (mg)	0.8	7.6	8.2	0.2	0.2
Vitamin C (mg)	220	15.8	17.3	4.5 ± 0.17	120
Vitamin E (mg)	448	10.8	113	751.67 ± 4.41	–
Calcium (mg)	440	2185	2003	45	30
Magnesium (mg)	42	448	368	635 ± 8.66	24
Phosphorus (mg)	70	252	204	75	110
Potassium (mg)	259	1236	1324	–	256
Copper (mg)	0.07	0.49	0.57	5.20 ± 0.15	3.1
Iron (mg)	0.85	25.6	28.2	–	5.3

Sulphur (mg)	—	—	870	0.05	137
---------------------	---	---	-----	------	-----

Studies have demonstrated that regular consumption of *Moringa oleifera* leaf tea changes blood circulating neutrophils and helps in ease of stress (Drue *et al.*, 2018). Previous studies fed mouse with acute lung inflammation with dried *Moringa* leaves tea and showed that mice that had decreased lung inflammation marked by alterations in cytokine production, leukocyte migration, and neutrophil apoptosis (McKnight *et al.*, 2014). It is proved by the animal study carried out on Swiss albino mice that ethanolic extract of *Moringa* leaves has anti-anxiety effect (Bhat 2014).

2.2 The Flowers

Moringa oleifera flowers are consumed directly as part of the diet, but also to make infusions which have hypocholesterolemic properties (Gopalakrishnan *et al.*, 2016). The flowers can also be a cause of nectar and are used to produce honey and in transepidermal water loss letting to increase hydration (Ali *et al.* 2013a, b, c) (2). A methanol extract of *Moringa oleifera* flowers is proved to have anti-cancer properties by inhibiting growth of PC3 cells in a dose-dependent manner, while not affecting the feasibility of normal cells (Inbathamizh 2013). Several researchers have reported on the medicinal value of *Moringa oleifera* flower, especially their anti-microbial and anti –tumour properties (Fahey (2005, 2017), (Divya *et al.*, (2019), (Delaveau Boiteau 1980; Hameed *et al.*, 1998; Faizi *et al.*, 1998; Fuglie 1999, Guiger *et al.*, 2016; Gopalakrishnan *et al.*, 2016)

Moringa flowers are found to have significant amount of amino acids and substantial quantity of calcium and potassium. Due to this reason, it is prescribed for lactating mothers as nutrient supplement. The flowers also produce good honey and honey clarifier (Jahn, 1984).

Moringa flowers contained both sucrose and D- glucose and it is mostly used in treatment of tumors. The flower juice of *Moringa peregrine* is useful for urinary problems (Moustafa AA, et al., 2020).



Fig 4: Moringa Flowers

Recent studies on laboratory rats have shown that extracts from the moringa flower can be used to reduce inflammation and muscle spasms. Owed to the diuretic effects of moringa flower extract, it is use to help the body heal after an injury or illness.

Moringa oleifera flowers have sufficient amount of vitamin A to boost the immune system and protect vision. As the flowers are rich in calcium, they are used to strengthen bones. Its high vitamin C content helps to reduce. (Adewumi, 2016) Moringa flower contains sucrose, D- glucose, nine amino acids, alkaloid, wax, calcium and potassium. The antibiotic property of pterogospem in present in Moringa flower is highly effective in the treatment of cholera. They are also noted for their quercetin, flavonoid with hepatoprotective activity.

The flowers were believed to be beneficial and effective for helping to let go of traumatic memories that obstructed the mind, guilt, emotional wounds and phobias. *Moringa oleifera* flowers are said to encourage positive thinking and to renew the view on life, bringing light to the spirit (Warrier 2010).

2.3 The Pod

Pods of *Moringa oleifera* have β -carotene and vitamin A and C support in the induction of antioxidant and anti-inflammatory profiles (Bharali *et al.*, 2003; Praengam *et al.*, 2014). They act as potent inhibitors on the formation of reactive oxygen intermediates, a pre-requisite for tumorigenesis (Gupta *et al.*, 2010; Kraiphet *et al.*, 2018).



Fig 5: Moringa Pods

The pods are highly nutritious containing all the essential amino- acids (Ramachandran *et al.*, 1980, Makkar *et al.*, 1996). Pods of Moringa contain high amount of Ca, Mg, K, Mn, P, Zn, Na, Cu, and Fe (Aslam *et al.*, 2005).

2.4 The seed

Seeds, collected from pods, can be eaten raw or cooked. *Moringa oleifera* seed oil or Behen/Ben oil is produced through the cold pressing of its seeds. *Moringa oleifera* oil has several uses such as cooking oil, preparation of biodiesel, as lubricant and in the cosmetic industry (Rashid *et al.*, 2008). The oil contains behenic acid, which has more resistance to oxidative degradation compared to other vegetable oils. The constituents of Ben oil is oleic acid (up to 76%), palmitic (6.54%), stearic (6%), behenic (7%), and arachidic (4%) (Anwar 2005). It is used in preparation of cosmetic cream because of its nourishing, moisturizing, antioxidant and protective properties. It is also a good skin cleansing product (Nadeem and Imran 2016).

Moringa oleifera seeds help reducing the blood glucose level and its anti-diabetic activity is proved by carrying out several studies on rats by treating with 50 or 100 mg of Moringa

oleifera seeds powder/kg body weight for 4 weeks (Al-Malki and El Rabey, 2015). It also showed that ingestion led to an increase in antioxidant enzymes and compound contents such as glucomoringin, phenols, and flavonoids. This study also demonstrated the significant improvement in the kidney function. Treatment with *Moringa oleifera* seeds also changed oxidative stress in relation to its anti-inflammatory activity. Histopathological observations showed mild or less infiltration of lymphocytes, angiogenesis and synovial lining thickening. Seeds also have applications in industries. Seed powder has the capability to purify water and remove heavy metals and organic compounds (Sharma *et al.*, 2006) through low molecular weight cationic proteins arbitrated precipitation (Kansal and Kumari 2014). A significant reduction of 80–99.5% in the turbidity of the water and 90–99.99% of bacterial reduction was observed (Bhargave 2015; Lea 2014). The left over paste after the oil extraction has the same flocculation properties (Lea 2010).

The seeds of *Moringa* were found to increase immunity. Due to the present pandemic situation, these seeds were widely used and given especially to people who are isolated in home to increase the immunity in their body (Moustafa AA *et al.*, 2020).



Fig 6: *Moringa* Seeds

Moringa seed oil is rich in unsaturated fatty acids like oleic acids and is more stable against oxidative rancidity and ensures low risks of coronary diseases. Seed oil from *Moringa* contains high amount of tocopherol (Vitamin E) indicates the higher level of antioxidant activity.

The seeds were considered notifying and were believed to renew the spirit and strengthen the body, as well as the mind and emotions (Warrier 2010).

3. Medicinal Properties

In traditional medicine, a paste made of leaves is applied externally in wounds (Siddhuraju and Becker 2003). Aqueous leaves extract increased human dermal fibroblasts proliferation and lead to faster wound healing (Muhammad *et al.*, 2013). *Moringa oleifera* leaf extract with addition of ethyl acetate, in low concentration (12.5-50 µg/ml), exhibited in vitro effect in skin healing (Gothai *et al.*, 2016). A hydro alcoholic extract of *Moringa oleifera* leaves used in a cream showed anti-aging characteristics due to phenolic compounds (Baldisserotto *et al.*, 2018). Application of such cream is found to reduce sebum production and in transepidermal water loss permitting to increase hydration. (Ali *et al.*, 2013a, b, c).

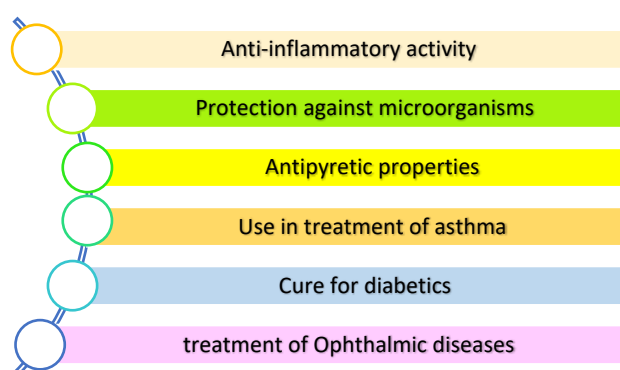


Fig 7 Medicinal value of *Moringa oleifera*

3.1 Anti-inflammatory activity

Moringa plant parts have substantial anti-inflammatory activity. The root extract exhibits anti-inflammatory activity in carrageenan induced rat paw oedema (Ezeamuzie *et al.*, 1996; Khare *et al.*, 1997). As the seeds of *Moringa oleifera* contains n-butanol, it shows anti-inflammatory activity against ovalbumin-induced airway inflammation. This is confirmed as result of studies on guinea pigs. Treatment with *Moringa oleifera* seeds also altered oxidative stress in relation to its anti-inflammatory activity. Histopathological observations showed mild or less infiltration of lymphocytes, angiogenesis and synovial lining thickening

(Mahajan *et al.*, 2009). The anti-inflammatory activity of *Moringa oleifera* bioactive compounds could cure inflammation related chronic diseases (Muangnoi *et al.*, 2011). Due to the anti-inflammatory activity of Moringa plant, it has beneficial effects on asthma, pain, and other resultant symptoms.

3.2 Protection against microorganisms

Antimicrobial components of *Moringa oleifera* have been proved to be inhibitory against several microorganisms. Research studies have shown that aqueous extracts of *Moringa oleifera* was found to be inhibitory against many pathogenic bacteria, including *Staphylococcus aureus*, *Bacillus subtilis*, *Escherichia coli*, and *Pseudomonas aeruginosa* and *Mycobacterium phlei* and *B. subtilis* and the growth of fungi *Basidiobolus haptosporus* and *Basidiobolus ranarums* (Saadabi and Abu Zaid, 2011, Eilert *et al.*, 1981, Nwosu and Okafor, 1995).

Study conducted on antimicrobial activity of seed extracts against bacteria (*Pasturella multocida*, *E. coli*, *B. subtilis* and *S. aureus*) and fungi (*Fusarium solani* and *Rhizopus solani*) showed that *P. multocida* and *B. subtilis* were the most sensitive strains. *Moringa oleifera* flower and leaves are also capable of scheming parasitic worms. (Bhattacharya *et al.*, 1982).

3.3 Antipyretic properties

Due to anti-inflammatory action of *Moringa* bioactive constituents, the antipyretic activity can be hypothesized. A study carried out on rats to assess antipyretic effect of ethanol, petroleum ether, solvent ether and ethyl acetate extracts of *Moringa oleifera* seeds using yeast induced hyperpyrexia method. Paracetamol was used as control in the study. Ethanol and ethyl acetate extracts of seeds showed significant antipyretic activity (Hukkeri *et al.*, 2006). . From all above observations, it can be concluded that the seeds possess promising antarthritic property (Mahajan *et al.*, 2009).

3.4 Use in treatment of asthma

Moringa plant alkaloid relaxes bronchioles and hence are used in the treatment of asthma (Kirtikar and Basu, 1975). The seed kernels of *Moringa oleifera* significantly decrease in the severity of asthma symptoms and also improves the respiratory functions (Agrawal and Mehta, 2008).

3.5 Significance in cure for diabetics

Several medicinal plants have been valued for their potential as therapeutic agent for diabetes. *Moringa oleifera* is also an important component in this category. As a mechanistic model for antidiabetic activity of moringa, it has been shown that dark chocolate polyphenols and other polyphenols are responsible for hypoglycemic activity. (Grassi *et al.*, 2005)

3.6 Use in treatment of ophthalmic diseases

Moringa oleifera leaves and pods are rich source of vitamin A. This helps in preventing night blindness and eye problems in children. The leaves of moringa enhance vitamin A nutrition and slow down the growth of cataract (Pullakhandam and Failla, 2007).

Conclusion

The study on nutrients present in *Moringa* has demonstrated its medicinal properties. These properties make it a promising plant for cure of various diseases such as malnutrition, ophthalmic diseases, asthma and related inflammatory diseases etc. Almost each and every part of the tree is edible consisting of larger amount of proteins, vitamins and carbohydrates compared to other nutritional products. There are number of food preparation which can be made from a single tree using various parts. *Moringa* is popularly referred as Miracle Tree having many benefits and can be grown at large scale without much of water and good soil requirements.

Acknowledgements

This study was carried out as part of the project (TIDE SEED/ TITE/2019/77) financially supported by Department of Science and Technology. Authors wish to acknowledge

Department of Science and Technology for their financial support extended for the project and management of Sri Krishna College of Engineering and Technology for the support extended to carry out the project in the campus.

References

- Adewuni T, Oyeyinka, Samson A. Oyeyinka (2016). Moringa *Oleifera* as a food fortificant: Recent trends and prospects. J jssas.2016.
- Agrawal B, Mehta A (2008). Antiasthmatic activity of Moringa *Oleifera* Lam: A clinical study. Indian J. Pharmacol. 40: 28-31.
- Ali A, Akhtar N, Khan MS, Khan MT, Ullah A, Shah MI (2013a) Effect of Moringa *oleifera* on undesirable skin sebum secretions of sebaceous glands observed during winter season in humans. Biomed Res 24:8571–8576
- Ali A, Akhtar N, Khan MS, Khan MT, Ullah A, Shah MI (2013a) Effect of Moringa *oleifera* on undesirable skin sebum secretions of sebaceous glands observed during winter season in humans. Biomed Res 24:8571–8576
- Ali A, Akhtar N, Khan MS, Rasool F, Iqbal FM, Khan MT, Din MU, Elahi E (2013b) Moisturizing effect of cream containing Moringa *oleifera* (Sohajana) leaf extract by biophysical techniques: in vivo evaluation. J Med Plants Res7:386–391
- Ali A, Akhtar N, Mumtaz AM, Khan MS, Iqbal FM, Zaidi S (2013c) In vivo skin irritation potential of a cream containing Moringa *oleifera* leaf extract. African J Pharm Pharmacol 7:289–293
- Ali A, Akhtar N, Khan MS, Rasool F, Iqbal FM, Khan MT, Din MU, Elahi E (2013b) Moisturizing effect of cream containing Moringa *oleifera* (Sohajana) leaf extract by biophysical techniques: in vivo evaluation. J Med Plants Res 7:386–391
- Ali A, Akhtar N, Mumtaz AM, Khan MS, Iqbal FM, Zaidi S (2013c) In vivo skin irritation potential of a cream containing Moringa *oleifera* leaf extract. African J Pharm Pharmacol 7:289–293
- Al-Malki AL, El Rabey HA (2015) The antidiabetic effect of low doses of Moringa *oleifera* Lam. seeds on streptozotocin induced diabetes and diabetic nephropathy in male rats. Bio Med Res Int ID381040:1–13.
- Anwar F, Ashraf M, Bhanger MI (2005) Interprovenance variation in the composition of Moringa *oleifera* oil seeds from Pakistan. J Am Oil Chem Soc 82:45–51
- Anwar F, Latif S, Ashraf M, Gilani AH (2007). Moringa *Oleifera*: a food plant with multiple medicinal uses. Phytother. Res. 21:17-25.
- Aslam M, Anwar F, Nadeem R, Rashid U, Kazi TG, Nadeem M (2005). Mineral composition of Moringa *Oleifera* leaves and pods from different regions of Punjab, Pakistan, Asian J. Plant Sci., 4: 417-421.
- Baldisserotto A, Buso P, Radice M, Dissette V, Lampronti I, Gambari R, Manfredini S, Vertuani S (2018) Moringa *oleifera* leaf extracts as multifunctional ingredients for “Natural and Organic” sunscreens and photoprotective preparations. Mol (Basel, Switzerland) 23(3):664

- Bharali R, Tabassum J, Azad MR (2003) Chemomodulatory effect of *Moringa oleifera*, Lam, on hepatic carcinogen metabolising enzymes, antioxidant parameters and skin papillomagenesis in mice. *Asian Pac J Cancer Prev APJCP* 4:131–139
- Bhargave A, Pandey I, Nama KS, Pandey M (2015) *Moringa oleifera* Lam. Sanjana (horseradish tree)—a miracle food plant with multipurpose uses in Rajasthan- India- an overview. *Int J Pure Appl Biosci* 3: 237–248
- Bhat SKJA (2014) (2014) Antianxiety effect of ethanolic extract of leaves of *Moringa oleifera* in Swiss albino mice. *Arch Med Health Sci* 2:5–7
- Bhattacharya SB, Das AK, Banerji N (1982). Chemical investigations on the gum exudate from sajna (*Moringa Oleifera*). *Carbohydr. Res.* 102:253-262).
- Chumark, P., Khunawat, P., Sanvarinda, Y., Phornchirasilp, S., Morales, P.N., Phivthong-ngam, L., Ratanachamnong, P., Srisawat, S., Pongrapeeporn, K. S. (2008) Thein vitro and ex vivo antioxidant properties, hypolipidaemic and antiatherosclerotic activities of the water extract of *Moringa oleifera* Lam. leaves. *J. of Ethnopharmacology.*, 116: 439-446.
- Dahiru, D.; Obnubiyi, J. A.; Umaru, H.A (2006). Phytochemical screening and antiulcerogenic effect of *Moringa*. *African Journal of Traditional, Complimentary and Alternatives Medicines*. 2006, 3, 3, 70-57
- DanMalam, H., Abubakar, Z., Katsayal, U., (2001). Pharmacognosistic studies on the leaves of *Moringa Oleifera* Nig J. Nat. Prod. Med., 5: 45-49.
- Debajyoti D, Dipsundar S, Dinesh B, Chandreyee R, Sanatan R, Jayram H (2017) *Moringa olifera* (shigru): a miracle tree for its nutritional, ethnomedicinal and therapeutic importance. *Int J Dev Res—IJDR* 07(11):16823–16827
- Delaveau P, Boiteau P (1980) oil of pharmacological, cosmetic and dietetic interest: VI-Oils of *Moringa oleifera* Lam and *Moringa drouhardii* Jumelle. *Plantes Méd Phytothér* 14(10):29–33
- Divya KG, Rubeena M, Andalil R, Erni B, Sundaramoorthy B, Thatipelli S, Koppala Narayana Sunil Kumar KNS, Shakila R (2019) Identity profile of *Moringa oleifera* Lam. Flower *Int J Bot Stud* 4(4):90–99
- Drue GEHS, Minor RC (2018) *Moringa oleifera* tea alters neutrophil but not lymphocyte levels in blood of acutely stressed mice. *Madridge J Immunol* 2:43–48
- Eilert U, Wolters B, Nahrstedt A (1981). The antibiotic principle of seeds of *Moringa Oleifera* and *Moringa stenopetala*. *Planta Med.* 42: 55-61.
- Ellis WO, Oduro I, Owusu D (2011) Development of crackers from cassava and sweetpotato flours using *Moringa oleifera* and *Ipomoea batatas* leaves as fortificant. *Am J Food Nutr* 1:114–122
- Ezeamuzie IC, Ambakederemo AW, Shode FO, Ekwebelem SC (1996)
- Ezeamuzie IC, Ambakederemo AW, Shode FO, Ekwebelem SC (1996). Antiinflammatory Effects of *Moringa Oleifera*. Root Extract. *Pharm. Biol.* 34: 207-212.

- Fahey J (2005) *Moringa oleifera*: a review of the medical evidence for its nutritional, therapeutic, and prophylactic properties. Part 1. *Trees Life J* 1(5):1–15.
- Fahey J (2017) *Moringa oleifera*: a review of the medical potential. *Acta Hort* 1158:209–224
- Fahey J W (2005). *Moringa Oleifera*: A review of the medical evidence for its nutritional, therapeutic and prophylactic properties. Part 1. *Trees life J*. 1: 5.
- Faizi S, Siddiqui, BS, Saleem R, Aftab K, Shaheen F, Gilani AH (1998) Bioactive compounds from the leaves and pods of *Moringa oleifera*. *New trends in natural products chemistry* 175–183
- Fuglie LJ (1999) *The miracle tree: moringa oleifera, natural nutrition for the tropics*. Church World Service, Dakar, Senegal, pp 68
- Fuglie, L., (1999). *The Miracle Tree: Moringa oleifera : Natural nutrition for the Tropics*. Church World Services. Dakar, pg 172.
- Gopalakrishnan L, Doriya K, Kumar DS (2016) *Moringa oleifera*: a review on nutritive importance and its medicinal application. *Food Sci Human Wellness* 5:49–56
- Gothai S, Arulselvan P, Tan WS, Fakurazi S (2016) Wound healing properties of ethyl acetate fraction of *Moringa oleifera* in normal human dermal fibroblasts. *J Intercult Ethnopharmacol* 5:1–6
- Grass D, Lippi C, Necozone S, Desideri G, Ferri C (2005). Short-term administration of dark chocolate is followed by a significant increase in insulin sensitivity and a decrease in blood pressure in healthy persons. *Am. J. Clin. Nutr.* 81: 611-614.
- Guiguer L, Barbalho SM, Bueno P, Mendes CG, Oshiiwa M, Menezes ML, Marinelli PS, Santos PC, Santos MC, Leticia Maria Salzedas LM, Nicolau CC, Otoboni AM (2016) Consumption of *Moringa oleifera* flour and its effects on the biochemical profile and intestinal motility in an animal model. *Int J Phytomed* 8 (3):427–434.
- Gupta SC, Kim JH, Prasad S, Aggarwal BB (2010) Regulation of survival, proliferation, invasion, angiogenesis, and metastasis of tumor cells through modulation of inflammatory pathways by nutraceuticals. *Cancer Metastasis Rev* 29(3):405–434
- Hameed-Un-Nisa L, Shehnaz D, Faizi S (1998) Measurement of sympatholytic activity of *Moringa oleifera*. *New Trends in Natural Products Chemistry* [6th International Symposium on Natural Products Chemistry]. Harwood Amsterdam, pp 269–277
- Havsteen, B.H. (2002). The biochemistry and medical significance of the flavonoids. *Pharmacol.* 96: 67-202.
- Hekmat, S., Morgan, k., Soltani, M., Gough, R (2015). Sensory evaluation of locally- grown fruit purees and inulin fibre on ptpbiotic yogurt in mwanza, Tanzania and the microbial analysis of probiotic yogurt fortified with *Moringa Oleifera*. *J. Health popul. Nutr.* 33: 60-67.
- Hukkeri VI, Nagathan CV, Karadi RV, Patil BS (2006). Antipyretic and wound healing activities of *Moringa Oleifera* Lam. In rats. *Ind. J. Pharm. Sci.* 68: 124-126.
- Inbathamizh L, Padmini E (2013) Evaluation of growth inhibitory potential of *Moringa oleifera* flowers on PC3 cell lines. *Asian J Pharm Clin Res* 6:60–64

- Iqbal, S., Bhanger, M.I., (2006). Effect of season and production location on antioxidant activity of *Moringa oleifera* leaves grown in Pakistan. J. of Food Comp. and Anal. 19: 544-551.
- Jahn, S.A., (1984). Effectiveness of traditional flocculants as primary coagulants and coagulants aids for the treatment of tropical raw water with more than a thousand fold fluctuation in turbidity. J. Water supply. 6: 8-10.,
- Jongrungruangchok, S., Bunrathep, S., Songsak, T., (2010). Nutrients and minerals content of eleven different samples of *Moringa oleifera* cultivated in Thailand J. Health Res., 24; 123-127
- Jung KI (2016) Quality Characteristics of muffins added with *Moringa* (*Moringa oleifera* Lam.) leaf powder. J Korean Soc Food Sci Nutr 45:872–879
- Kansal SK, Kumari A (2014) Potential of *M. oleifera* for the treatment of water and wastewater. Chem Rev 114:4993–5010
- Kasolo, J.N., Bimenya, G.S., Ojok, L., Ochieng, J., Ogwal-okeng., (2010). Phytochemicals and uses of *Moringa oleifera* leaves in Ugandan rural communities. J. Med. Plants Res., 4: 753-757.
- Khare GC, Singh V, Gupta PC (1997). A New Leucoanthocyanin from *Moringa Oleifera* Gum. J. Ind. Chem. Soc. 74: 247-248.
- Kirtikar KR, Basu BD (1975). Indian Medicinal Plants. In: Singh B. and M.P. Singh (eds) Dehradun, 676-683.
- Kraiphet S, Butryee C, Rungsipipat A, Budda S, Rattanapinyopitak K, Tuntipopipat S (2018) Apoptosis induced by *Moringa oleifera* Lam. pod in mouse colon carcinoma model. Comp Clin Pathol 27:21–30
- Lalas, S., Tsaknis, J., (2002). Extraction and identification of natural antioxidant from the seeds of the *Moringa oleifera* tree variety of Malawi. JAOSC. 79: 677-683.
- Lea M (2014) Bioremediation of turbid surface water using seed extract from the *Moringa oleifera* Lam (Drumstick) tree. Curr Protoc Microbiol 33:1G.2.1–8.
- Lea M (2010) Bioremediation of turbid surface water using seed extract from *Moringa oleifera* Lam (drumstick) tree. Curr Protoc Microbiol 33:1G.2.18.
- M. Mbikay, M., (2012). Therapeutic potential of *Moringa oleifera* leaves in chronic hyperglycemia and dyslipidemia: a review Front. Pharmacol, 3 : 1-12.
- Mahajan SG, Banerjee A, Chauhan BF, Padh H, Nivsarkar M. Mehta AA (2009). Inhibitory effect of n- butanol fraction of *Moringa Oleifera* Lam. Seeds on ovalbumin- induced airway inflammation in a guinea pig model of asthma. Int J. Toxicol. 28: 519-527.
- Mahmood KT, Mugal T, Haq IU (2010) *Moringa oleifera* : a natural gift-a review. J Pharm Sci Res 1:775–781
- Mainenti D (2018) *Moringa oleifera*: a prolific herbal research front. Inf Sci Bibliometr DIS803:1–4

- Makkar, H.P.S.; Becker, K. (1996). Nutritional value and whole and ethanol antinutritional components of extracted *Moringa Oleifera* leaves. *Animal Feed Science Technology*. 63, 211-228.
- Middleton Jr., E., Kandaswami, C., Theoharides, T.C (2000). The effects of plantflavonoids on mammalian cells: implications for inflammation, heart disease and cancer. *Pharmacological Reviews.*, 52, 673-751.
- Miean, H. K, Mohamed, S. (2001) Flavonoid (Myricetin, Quercetin, Kaempferol, Luteolin and Apigenin) Content of Edible Topical Plants. *J. Agri. Food Chem* 49, 3106-3112.
- Moharram FA, Marzouk MS, EI-Toumy SA, Ahmed AA, Aboutabl EA (2003). Polyphenols of *Melaleuca quinquenervia* leaves- pharmacological studies of grandinin. *Phytother. Res.* 17: 767-773.
- Moustafa AA, Mansour SR (2020). *Moringa peregrine* a Natural Medicine for Increasing Immunity Defense against the COVID-19. *J. Medicinal & Aromatic Plants*. 9: 358.
- Moyo, B., Masika, P., Hugo, A., Muchenje. V., (2011). Nutritional characterization (Moringa *Oleifera* Lam) leaves. *Afr.J. Biotechnol.* 10. 12925-12933.
- Moyo, B., Oyedemi, S., Masika, P., Hugo, A., Muchenje. V., (2012). Polyphenolic content and antioxidant properties of Moringa *Oleifera* leaf extracts and enzymatic activity of liver from goats supplemented with Moringa *Oleifera* / sunflower seed cake, *Meat Sci.* 91. 441-447.
- Muangnoi C, Chingsuwanrote P, Praengamthanachoti P, Svasti S, Tuntipopipat S (2011). Moringa *Oleifera* pod inhibits inflammatory mediator production by lipopolysaccharide-stimulated RAW 264.7 murine macrophage cell lines. *Inflammation*.
- Mughal MHS, Ali G, Srivastava PS, Iqbal M (1999). Improvement of drumstick (*Moringa pterygosperma* Gaertn.) A unique source of food and medicine through tissue culture. *Hamdard Med.* 42:37-42.
- Muhammad AA, Pauzi NA, Arulselvan P, Abas F, Fakurazi S (2013) In vitro wound healing potential and identification of bioactive compounds from Moringa *oleifera* Lam. *Bio Med Res Int* 2013 (ID974580): 1–10.
- Nadeem M, Imran M (2016) Promising features of Moringa *oleifera* oil: recent updates and perspectives. *Lipids Health Dis* 15:212
- Nkukwana, T., Muchenje. V., Masika, P., Hoffman. L., Dzama. K., (2014a). The effect of Moringa *Oleifera* leaf meal supplemented on tibia strength, morphology and inorganic content of broiler chickens. *S. Afr. J. Anim. Sci.* 44, 228-239.
- Nkukwana, T., Muchenje. V., Masika, P., Hoffman. L., Dzama. K., Descalzo, A., (2014b). Fatty acid composition and oxidative stability of breast meat from broiler chicken supplemented with Moringa *Oleifera* leaf meal over a period of refrigeration. *Food Chem.* 142, 255-261.
- Nkukwana, T., Muchenje. V., Pieterse, E., Masika, P., Mabusela, T., Hoffman. L., Dzama. K., (2014c). Effect of Moringa *Oleifera* leaf meal on growth performance, apparent digestibility, digestive organ size and carcass yield in broiler chickens. *Livestock Sci.* 161. 139-146.
- Nwosu MO, Okafor JL (1995). Preliminary studies of the antifungal activities of some medicinal plants against *Basidiobolus* and some other pathogenic fungi. *Mycoses* 38: 191-195.

- Odoro I, Ellis WO, Owusu D (2008) Nutritional potential of two leafy vegetables: *Moringa oleifera* and *Ipomoea batatas* leaves. *Sci Res Essay* 3:57–60
- Olson ME, Sankaran RP, Fahey JW, Grusak MA, Odee D, Nouman W (2016) Leaf protein and mineral concentrations across the “Miracle Tree” genus *Moringa*. *PLoS ONE* 11(7):1–17.
- Praengam K, Muangnoi C, Dawilai S, Awatchanawong M, Tuntipopipat S (2014) Digested *Moringa oleifera* boiled pod exhibits anti-inflammatory activity in Caco-2 cells. *J Herbs Spices Med Plants* 21(2):148–160.
- Olson MEFJ (2011) *Moringa oleifera*: un árbol multiusos par las zonas tropicales secas. *Rev Mexicana Biodivers* 82:1071–1082
- Palada M.C., (1996). *Moringa (Moringa oleifera Lam.): a versatile tree crop with horticultural potential in the subtropical United States*. *HortScience*. 31:794–797
- Pullakhandam R, Failla ML (2007). Micellarization and intestinal cell uptake of beta-carotene and lutein from drumstick (*Moringa Oleifera*) leaves. *J. Med. Food* 10:252–257.
- Qwele, K., Hugo, A., Oyedemi, S., Moyo, B., Masika, P., Muchenje, V., (2013). Chemical composition, fatty acid content and antioxidant potential of meat from goats supplemented with *Moringa (Moringa Oleifera)* leaves, sunflower cake and grass hay. *Meat Sci.* 93. 455–462.
- Ramachandran, C; Peter, K.V. and Gopalakrishnan, P.K. (1980). Drumstick (*Moringa Oleifera*) multipurpose Indian Vegetable. *Economic Botany*, 34. 276–283.
- Rani A, Husain K, Kumolosasi E (2018) *Moringa* genus: a review of phytochemistry and pharmacology. *Front Pharmacol* 9(108): 1–26.
- Rashid U, Anwar F, Moser BR, Knothe G (2008) *Moringa oleifera* oil: a possible source of biodiesel. *Bioresour Technol* 99:8175–8179.
- Rockwood, J.I., Anderson, B.G., Casamatta D. A., (2013). Potential uses of *Moringa oleifera* and an examination of antibiotic efficacy conferred by *M. oleifera* seed and leaf extracts using crude extraction techniques available to underserved indigenous populations. *Int. J. Phytotherapy Res.*, 3: 61–71.
- Saadabi AM, Abu ZAI (2011). An in vitro antimicrobial activity of *Moringa Oleifera* L. Seed extracts against different groups of microorganisms. *Asian J. Basic Appl. Sci.* 5: 129–134.
- Saini RK, Sivanesan I, Keum YS (2016) Phytochemicals of *Moringa oleifera*: a review of their nutritional, therapeutic and industrial significance. *3Biotech* 6(203):1–14
- Saini, R., Shetty, N., Prakash, M., Giridhar. P., (2014d). Effect of dehydration methods on retention of carotenoids, tocopherols, ascorbic acid and antioxidant activity in *Moringa oleifera* leaves and preparation of a RTE product. *J. Food Sci. Technol.*, 51, 2176–2182.
- Saini, R., Prashanth, K.H., Shetty, N., Giridhar. P., (2014b). Elicitors, SA and MJ enhance carotenoids and tocopherol biosynthesis and expression of antioxidant related genes in *Moringa oleifera* Lam. *Leaves Acta Physiol. Plant.*, 36. 2695–2704.
- Saini, R.K., Shetty, N.P., Giridhar. P., (2014e). Carotenoid content in vegetative and reproductive parts of commercially grown *Moringa oleifera* Lam. cultivars from India by LC–APCI–MS. *Eur. Food Res. Technol.*, 238; 971–978.

Sharma P, Kumari P, Srivastava MM, Srivastava S (2006) Removal of cadmium from aqueous system by shelled *Moringa oleifera* Lam seed powder. *Bioresour Technol* 97:299–305

Siddhuraju P, Becker K (2003) Antioxidant properties of various solvent extracts of total phenolic constituents from three different agroclimatic origins of drumstick tree (*Moringa oleifera* Lam) leaves. *J Agric Food Chem* 51(8):2144–2155

Teixeira, E., Carvalho, M., Neves, V., Silva, M., Arantes-Pereira, L, (2014). Chemical characteristics and fractionation of proteins from *Moringa oleifera* Lam. *Leaves Food Chem.*, 147; 51-54

Valdez-Solana MA, Mejía-García VY, Téllez-Valencia A, GarcíaArenas G, Salas-Pacheco JS, Alba- Romero JJ ,Sierra- Campos E (2015) Nutritional content and elemental and phytochemical analyses of *Moringa oleifera* grown in Mexico. *J Chem*.

Vauzour D, Vafeiadou K, Rodriguez-Mateos A, Rendeiro C, Spencer JP (2008) The neuro protective potential of flavonoids: a multiplicity of effects. *Genes Nutr* 3(4):115–126.

Warrier PK, Nambiar VPK, Ramankutty C (2010) *Indian Medicinal Plants, A Compendium of 500 species*, vol 4. Univerties Pres. Kottakal, India, pp 303–306

West KP, Jr., Caballero B, Black RE. (2006). *International Public Health: Diseases, Programs, Systems, and Policies*. Jones and Barlett Publishers; Sudbury, Massachusetts. 187 – 272.

Yang, R., Chang, L., Hsu, C., Weng, B., Palada, M., Chadha, M., Levasseur, V., (2006). Nutritional and functional properties of *Moringa* Leaves from germplasm, to plant, to food, to health *Moringa and Other Highly Nutritious Plant Resources: Strategies, Standards and Markets for a Better Impact on Nutrition in Africa*, American Chemical Society, Washington, D.C., Accra, Ghana 1-9.

Zongo UZL, Savadogo A, Traoré AS (2013). Nutritional and clinical rehabilitation of severely malnourished children with *Moringa oleifera* Lam. Leaf powder in Ouagadougou (Burkina Faso). *Food Nutr Sci* 4:991–997