East African Scholars Journal of Agriculture and Life Sciences
Abbreviated Key Title: East African Scholars J Agri Life Sci
ISSN 2617-4472 (Print) | ISSN 2617-7277 (Online)
Published By East African Scholars Publisher, Kenya

Volume-6 | Issue-7 | Jul-2023 | DOI:10.36349/easjals.2023.v06i07.01

OPEN ACCESS

Review Article

Moringa (*Moringa oleifera* Lam): A Review on its Importance Worldwide

Bibata Ali Outani[1, 2], Haougui Adamou[1*], Ali Mahamadou[2], Patrick Delmas[3]

[1]Institut National de Recherche Agronomique du Niger (INRAN), F4PM+W5W, Zone Insustrielle Z II, Niamey, Niger
[2]Université de Diffa, 8H7V+692, Diffa, Niger
[3]Réseau des Chambres d'Agriculture du Niger (RECA), Niger

Article History
Received: 18.05.2023
Accepted: 25.06.2023
Published: 04.07.2023

Journal homepage:
http://www.easpublisher.com

Quick Response Code

Abstract: Moringa is a plant whose cultivation began in Asia but has spread widely throughout the world. It is fast growing and drought tolerant. The uses of moringa are multiple and multiform. It is used in human and animal food and also is a medicinal plant that has antimicrobial activities and treats several types of diseases. In addition to this, it has other environmental and industrial uses that make it very important. This paper highlights its origin and geographical distribution, bio-ecology, chemical composition, uses, and pests that affect it.

Keywords: Moringa (*Moringa oleifera*), biology, composition, use, pests.

Origin and geographical distribution

Moringa (*Moringa oleifera*) is a plant native to the sub-Himalayan regions of northern India and Pakistan. It has been introduced to all tropical and subtropical regions and has naturalized in many African countries (Bosch, 2004; Vélez-Gavilán, 2017). It is widely cultivated in Ethiopia, the Pacific Islands, Florida, Sudan, the Caribbean, the Philippines, West Africa, South Africa, Asia and Latin America. It is therefore very popular and has several names around the world. The generic name comes from the Tamil name *morunga* (Olson, 2010).

Global moringa production was estimated at 46,000,000 tons in 2017, up from 32,000,000 t in the previous year or an increase of 43.75% (Nils-Gerrit, 2020). India is the world's largest producer of moringa with an annual production of 1.1 to 1.3 million tons of tender fruit on an area of 38,000 hectares (Rachana *et al*., 2020).

Systematic position and botanical description

Moringa belongs to the family Moringaceae, the genus *Moringa* and species *Moringa oleifera* Lam (Synonym: *Moringa pterygosperma* Gaertn (1791). It is a diploid plant with 2n chromosomes = 28 which has a good aptitude for polyploidy (Ramachandran *et al*., 1980). Thus it has been possible to create tetraploid individuals that have superior agronomic characteristics and higher biomass yield than diploids, and could represent excellent forage feedstocks for improved biomass and nutrition (Zhang *et al*., 2020).

The genus *Moringa* comprises 13 species of more or less different origin (Table I). But according to Bosch (2004), some of them are endemic to the Horn of Africa. These species are widely cultivated in Asia and Africa for their multiple uses. But *Moringa oleifera* and *Moringa stenopetala* are the most cultivated species (Gandji *et al*., 2018; Eyassu and Teketayb, 2020).

Moringa oleifera is a shrub that can reach 10 m high with opposite, tripinnate and deciduous leaves. This means that the old leaves turn yellow and fall off at the foot of the tree. Each leaf is up to 50 cm long, often up to about 90 cm long (Orwa *et al*., 2000 ; Bosch, 2004).

The white flowers are very numerous at the end of the branches and are bisexual. They have 5 sepals and 5 petals of unequal size, yellowish white. The ovary is carried by a very short peduncle and has a

***Corresponding Author:** Haougui Adamou
Institut National de Recherche Agronomique du Niger (INRAN), F4PM+W5W, Zone Insustrielle Z II, Niamey, Niger

compartment lined with 3 parietal placentas carrying numerous ovules (Letouzey, 1982).

Table I: Moringa species and origin

Species	**Area of origin**
Moringa arborea Verdc.	Kenya
Moringa Rivae Chiov.	Kenya et Ethiopia
Moringa stenopetala Cufod.	Kenya et Ethiopia
Moringa borziana Mettei.	Kenya et Somalia
Moringa longituba Engl.	Kenya et Somalia
Moringa pigmeae Verdc.	Somalia
Moringa ruspoliana Engl.	Kenya, Ethiopia et Somalia
Moringa ovalifolia Dinter and A. Berger	Namibia et Angola
Moringa drouhardii Jum.,	Madagascar
Moringa hildebrandtii Engl.	Madagascar
Moringa perigrina Forssk.	Saudi Arabia, Red Sea and Dead Sea
Moringa concanesis Dalzel et A. Gibson	Sub-Himalayan regions of the Indian sub-continent
Moringa oleifera Lam.	Sub-Himalayan regions of the Indian sub-continent
Source : Olsen (2002)	

The fruits are elongated 3-valved capsules, 10-50 cm long, with 9 ribs, brown at maturity, and containing numerous seeds (Bosh, 2004). In some varieties, the fruits can be up to 120 cm long. These capsules are pointed with a triangular cross section. They contain oily black seeds of one centimeter in diameter in a typical three-winged seed coat. The unripe green pods are fleshy but become fibrous and greyish when ripe and remain attached to the tree. The seeds are globular with 1 to 1.5 cm in diameter. The bark is smooth and is light gray in color that becomes darker with age. The branches and shoots are few but the crown is wide. The takes the shape of an umbrella. *Moringa oleifera* has a mostly deep root system (Bosch, op. cit).

Bio-ecology

Moringa tolerates a wide range of environmental conditions. It grows best between 25 and 35^{o} C, but tolerates temperatures around 48^{o} C. It does not tolerate frost (Adamou, 2015).

It produces new shoots quickly from the trunk after cutting (Orwa *et al*., 2009).

It is a drought resistant tree that is also fast growing (Hocking, 1993). It grows well in areas receiving annual rainfall of 250 to 1500 mm with an average altitude between 0 and 600 m. But it can adapt to altitudes up to 1200 m in the tropics or even higher. Indeed, Bosch (2004) reported that in Zimbabwe, a naturalized stand at 2000 m altitude has adapted well to the environmental conditions. *Moringa oleifera* adapts to a wide range of soils (well-drained clay to silty clay). It prefers neutral to slightly acidic pH soils (Patricio and Palada, 2017 ; Vélez-Gavilán, 2017). However, it tolerates a soil pH of 5 to 9 (Palada and Chang, 2003).

In the tropics, it blooms permanently. It is a highly allogamous plant and its pollination is provided by bees, the most involved of which are the so-called carpenter bees of the species *Xylocopa latipes*, *X. pubescens* or *Xylocopa* and *Amegilla* (Jyothi *et al*., 1990; Orwa *et al*., 2009; Krieg *et al*., 2017). Some birds such as *Nectaria zeylanica* and *N. asiatica* are also mentioned among the active pollinators (Orwa *et al*., 2009) while Bhattacharya and Mandal (2004) reported that insects belonging to the orders Thysanoptera, Hymenoptera, Lepidoptera, and Coleoptera are required for proper pollination.

M. oleifera can also reproduce vegetatively (Csurhes and Navie, 2016) and in vitro propagation has been tested with promising results (Förster *et al*., 2013; Avila-Treviño *et al*., 2017).

In India, trees shed their leaves in December-January, then regrow in February-March. Flowering can occur twice a year or even year-round depending on seasonal temperature and rainfall conditions. Fruiting occurs between April and June, but can also extend throughout the year under regular irrigation conditions (ICFRE, 1995).

The plant obtained from seeds has a longevity of 20 years while this parameter is 10 to 15 years for trees obtained from cuttings (Godino *et al*., 2017). But Olsoen (2017) reports that in temperate regions some varieties can be grown for a single season.

Pollen viability is greater than 88%. *M. oleifera* seeds have almost no dormancy and lose viability only two years after harvest (Csurhes and Navie, 2016).

Chemical composition of moringa

Recent analyses have shown that mature moringa seeds contain 38-54% edible oil with a high level of unsaturated fatty acids with oleic acid being the most abundant. It contains saturated fatty acids such as palmitic, lauric, stearic, linoleic and linolenic acids. The main sterols in *M. oleifera* seed oil are β-sitosterol, campesterol, stigmasterol and Δ5, avenasterol (Özcan, 2020).

M. oleifera leaves are high in protein (22.99-29.36%), low in fat (4.03-9.51%), fiber (6.00-9.60%) and ash (8.05-10.38%). The vitamin C content of fresh leaves varies between 187.96 and 278.50 mg/100 g) while the calcium level is between 1.322 and 2.645%, phosphorus from 0.152 and 0.304 g/100 g, and potassium from 1.317 of 2.025 g/100 g (Sulltana, 2020). Xavier (2018) noted that moringa is very rich in minerals (calcium, potassium, iron, magnesium), vitamins A, C, E, very good quality proteins (containing the 9 essential amino acids) and antioxidants.

The green leaves of moringa contain carbohydrates (9.1 g), dietary fiber, fat, and protein. The same study showed that they are also rich in vitamins such as vitamin A, thiamine (B1), riboflavin (B2), niacin (B3), pantothenic acids (B5), vitamin B6, folic acid (B9), vitamin C as well as minerals such as calcium, iron, magnesium, manganese, phosphorus, potassium, sodium and zinc. They are also rich in essential amino acids: Threonine, Valine, Methionine, Leucine, Isoleucine Phenylalanine, Histidine, Lysine and Arginine (Mukunzi *et al*., 2011; Mune, 2016; Abass *et al*., 2018; Kumar, 2018; González-Burgos, 2021; Sarr *et al*., 2015). The table II shows the nutrient composition of moringa organs.

Table II: The nutrient composition of leaves, leaf powder, seeds and pods

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	2.3	38.67 ± 0.03	0.1
Carbohydrate (g)	12.5	41.2	38.2	8.67 ± 0.12	3.7
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	–	259
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

Source: Gopalakrishnan *et al*., (2016)

Usage

Moringa oleifera was already used by the ancient Egyptians, Romans and Greeks in human food and medicine. Today, it is part of traditional diets in many countries in the Southeast Asian regions (Senthilkumar *et al*., 2018).

The leaves, flowers, fruits, and roots are used as vegetables in many lands (Morton, 1991; Kumssa *et al*., 2017; Hanaa and Gamal, 2013).

The leaves, a good source of vitamin C and minerals, are used to feed livestock. Filipino women consume moringa leaves mixed with chicken or shellfish soups to improve their taste. They are also eaten with the pods at different stages of maturity as vegetables. The soft pods are cooked or marinated and used in culinary preparations. The fresh pods, after being roasted, also make an appetizing dish. The seeds are also eaten after being fried and taste similar to peanuts (Özcan, 2020).

The seed oil contains all the fatty acids contained in olive oil (Lalas and Tsaknis, 2002). In Egypt, the oil obtained from moringa seeds has been used as edible oil in the Red Sea region (Hanaa and Gamal, 2013). *Moringa oleifera* is an important food that has received much attention as a natural food for children in the tropics (Anwar *et al*., 2007). The seed cake remaining after oil extraction can be used as fertilizer. The seed oil can be used as a biofuel (Rashid *et al*., 2008).

Moringa can be used as a natural non-toxic polypeptide for settling mineral and organic particles in drinking water purification, for cleaning vegetable oils, or for settling fibers in the juice and beer industries (Zaku *et al*., 2015). In some cases, the seeds are used as primary coagulants in wastewater treatment (Ndabigengesere and Subba-Narasiah, 2010).

In medicine, all the organs of the plant have also been used for centuries. Studies have revealed its antimicrobial, anti-inflammatory, antioxidant, anti-

ulcer, anti-diabetic and anti-cancer properties (Al-Asmari *et al*., 2015 ; Anthanont *et al*., 2016). It is also known to boost the immune system and treat HIV-related symptoms (Xavier, 2018). It can help to prevent certain chronic diseases such as cancer and cardiovascular diseases (Sy *et al*., 2018).

The leaves are taken as a purgative. Applied in poultice they heal wounds and headaches. They are used against hemorrhoids, fevers, sore throat, bronchitis, eye and ear infections, scurvy and catarrh. The juice of the leaves is believed to control glucose levels and cure glandular swelling (Morton, 1991; Fuglie, 1999). Aqueous extracts of *M. oleifera* leaves have been shown to be effective in the control of *Biomphalaria glabrata*, a species of snail that is the alternate host of *Schistosomia mansoni*, the parasite responsible for intestinal *schistosomiasis* in humans (Cláudio *et al*., 2014). Work conducted by Caceres *et al*., (2016) showed that raw juice from moringa leaf has antibacterial activity against *Enterococcus faecalis* among different strains tested, including *Bacillus cereus*, *Staphylococcus aureus*, *Esherichia coli* and *Candida albicans*, *Candida utilis* (Anand, 2016). El-Awady *et al*., (2015) also reported the comparative antibacterial activity of *M. peregrina* and *M. oleifera* leaf extracts. They note that methanol and ethanol extracts of *M. oleifera* have more pronounced activity against *E. coli, S. aureus, Enterococcus* sp, *Aeromonas hydrophila,* and *P. aeruginosa* than *M. peregrina.*

The effect of *Moringa oleifera* leaves, roots, bark and seeds were studied in vitro against bacteria, yeasts, dermatophytes and helminths pathogenic to humans. Fresh leaf juice and aqueous extracts of the seeds have been shown to inhibit the growth of *Pseudomonas aeruginosa* and *Staphylococcus aureus* (Zubair, 2020).

In some cases, traditional practitioners advise the use of moringa products in the treatment of high blood pressure and associated cardiovascular diseases (Iwara *et al*., 2014). The work of Al-Asmari (2015) revealed that *Moringa oleifera* leaf and bark extracts collected from the Saudi Arabian region possess anticancer activity that can be used to develop new drugs for the treatment of breast and colorectal cancers. The same is true of those of Jung *et al*., (2014) who worked on the soluble extracts of the leaves.

The boiled bark fights against kidney stones. It is used to treat eye diseases, delirious patients and prevents enlargement of the spleen and formation of tubercular glands in the neck. It is used to destroy tumors and to heal ulcers. The bark of the root relieves earache and toothache. It is used as an analgesic and has anti-tubercular activity (Siddhuraju and Becker, 2003).

The gum from the trunk is also used against dental caries. Mixed with sesame oil, it relieves headaches, fevers, intestinal diseases, dysentery, asthma and sometimes syphilis and rheumatism (Fuglie, 2001). Moringa has been well known for centuries for the antiseptic properties of its sap for external use (Milla *et al*., 2021).

The flowers and seeds are used as stimulants, aphrodisiacs, abortifacients and cholagogues. They treat inflammations, muscular diseases, hysteria, tumors and hypertrophy of the spleen. Their use lowers cholesterol, phospholipids, triglycerides and decreases the lipid profile of the liver, heart and increases the excretion of fecal cholesterol (Siddhuraju and Becker, 2003; Lalas and Tsaknis, 2002). Moringa has antioxidant properties due to its content of bioflavonoids, carotenoids, vitamins C and E, and selenium (Chen, 2022).

In livestock feeding, *Moringa oleifera* could be used as a feed substitute in laying hens to improve egg quality and laying rate (Adouko *et al*., 2021).

In plant protection, moringa extracts accelerate plant growth, strengthen and improve plant resistance to pests and diseases (Hussain *et al*., 2013). It has also been demonstrated the nematicidal activity of ethyl acetate extracts of *Moringa oleifera* leaves against eggs and larvae of *Haemonchus contortus* and *Nacobbus aberrans*, nematodes of agricultural importance (Páez-León *et al*., 2022).

Marketing of moringa

Worldwide, moringa is sold in two main forms: leaf powder and seed oil.

The leaf powder is used as a dietary supplement and is one of the botanical products used as a green superfood. The main markets for the dietary supplements are the United States, followed by Western Europe and Japan.

Moringa oil is used in cosmetics along with several other oils. The main importer of the oil is the European Union, but the quantities involved are not available as they are buried in the overall exports of all cosmetic vegetable oils.

The market for moringa-based products is expected to grow with the increasing demand for natural cosmetics and organic health products from the United States and Canada (https://agriexchange.apeda.gov.in/Weekly_eReport/Moringa_Report.pdf.). The global market for these products is estimated at 5.5 billions (DUS) in 2018. It is projected to grow by nearly 9% by 2025. In developing countries too, demand for these products is growing as is the case in such countries as India, China and Brazil (Maharshi, 2020).

Diseases and pests of moringa

Moringa was considered a plant resistant to most pests and diseases. But given its wide distribution worldwide, several ennemies are now known, some more important than others (Mridha and Barakah, 2017). The most common diseases are root rot caused by *Diplodia* sp, twig canker due to *Fusarium pallidoroseum*, and fruit rot whose causal agent is *Cochliobolus hawaiiensis* (Mandokhot *et al*., 1994; Rajangam *et al*., 2001; Patricio and Palada, 2017; Carbungco *et al*., 2017). Six other minor disease-causing fungi were found on fruit by Mridha and Barakah (2015) in Saudi Arabia. These are *Aspergillus niger*, *A. flavus*, *Alternaria alternata*, *Fusarium oxysporum*, *Macrophomina phaseolina*, and *Rhizopus stolonifer*. Previously, Zhao *et al*., (2012) identified an endophytic species of *Nigrospora* in moringa roots for the first time. Another disease causing elliptical or elongated spots with reddish-brown margins has been encountered. It is caused by *Drechslera hawaiiensis* (Rajangam *et al*., 2001). In South India, a microscopic fungus, *Leveillula taurica* (powdery mildew), has been catalogued as responsible for severe damage to papaya and moringa nurseries (Ullasa and Rawal, 1984). Root rot (*Armilaria* sp) affects roots under high soil moisture conditions (Ramasubramania *et al*., 2016) while anthracnose (*Colletotrichum chlorophyti*) has been found on moringa leaves (ZhiYing *et al*., 2017; Gatan, 2020). Several other fungal diseases have been reported. These include *Cercospora* spp, *Septoria lycopersici* and *Alternaria solani* (Muller and Rebelo, 2011).

In Mexico, moringa is also attacked by plant pests such as Mistletoe (*Phoradendron quadrangulare*) of the Viscaceae family and *Dendrophthoe falcata* (Moreno-Ramírez *et al*., 2018; Thriveni *et al*., 2010).

Moringa pests fall into two categories: defoliators and carpophagous. In India, various defoliator caterpillars are reported. These include the budworm, *Noordia moringae* and the mealybugs, *Diaspidotus* sp. and *Ceroplastodes cajani*, which inflict serious damage on plants (Fuglie, 2001). Black aphid (*Aphis craccivora*), borer (*Diaxenopsis apomecynoides*) and fruit fly *Gitonia* sp. are also mentioned as important pests in the Indian subcontinent (Zaku *et al*., 2015). In a survey conducted in Burkina Faso, Dao *et al*., (2016) identified 5 pests on moringa. These were the snail (*Cepaea sylvatica*), three insects (*Euproctis pasteopa*, *Noorda blitealis*, *Scoliopteryx libatrix*) and a mite (*Tetranychus urticae*). Another mite species (*Tetranychus neocaledonicus*) was reported by Ojiako *et al*., (2011) as a pest of moringa. Under irregular irrigation, *Macrotermes* spp and *Microtermes* spp termites plague the plots and destroy the plants, especially at the roots, shoots and twigs (Saint Sauveur and Broin, 2010). In some plantations in India, the bark caterpillar (*Indarbela tetraonis*) digs zig-zag galleries that weaken the attacked plant. A study conducted in northern Nigeria by Yusuf and Yusif (2014) revealed the existence of *Ulopeza phaeothoracica* as a defoliator of *M. oleifera* and that it could be a concern for growers there.

Another study in the same country showed that *Zonocerus variegatus* is a pest of Moringa (Akanbi *et al*., 2007). In Burkina Faso, Dao *et al*., (2020) found the same locust feeding on Moringa leaves. Pillai *et al*., (1979) identified *Helopeltis antonii*, as a pest of moringa while Verma and Khurana (1974), four years earlier, recorded *Inderbela tetraonis* as a new pest of moringa grown in India.

In Niger, moringa is attacked by two main enemies, two pests (*Noorda blitealis and Tetranychus urticae*) and a disease caused by *Lasiodiplodia theobromae* (Haougui *et al*., 2013). The moringa caterpillar has been known in the country for a long time but was only identified in 2011 as *Noorda blitalis* by Ratnadass *et al*., (2011). It has been observed in all moringa production areas of the country. It can cause yield losses of 100% during a season: it devours all the new leaves that form. It is more severe in the rainy season than in the rainy season and does not spare any of the two most planted varieties (Halilou, 2022). Nematological analyses by Haougui *et al*., (2017) in the peri-urban area of Niamey revealed the presence of 11 genera of plant-parasitic nematodes in the rhizosphere of *Moringa oleifera* among which the most frequent and abundant were *Meloidogyne* spp, *Helicotylenchus* spp and *Hoplolaimus* spp.

CONCLUSION

Moringa is one of the most useful tropical trees. The relative ease with which it propagates (sexual and asexual reproduction) and its low demand for nutrients and water make it easy to produce and manage. The introduction of this plant into a plot that has a biodiverse environment can be beneficial to both the farm owner and the environment. Therefore, any moringa improvement program must take into account diseases and pests to avoid damage to the plantations and the economic losses they inflict on the crop.

Acknowledgements

We would like to thank the University of Diffa and the PROLAC project for funding our thesis work. We would also like to thank the Director General of INRAN for allowing us to register for our thesis.

REFERENCES

- Abbas, R. K., Elsharbasy, F. S., & Fadlelmula, A. A. (2018). Nutritional Values of Moringa oleifera, Total Protein, Amino Acid, Vitamins, Minerals, Carbohydrates, Total Fat and Crude Fiber, under the Semi-Arid Conditions of Sudan. *J Microb*

Biochem Technol, 10, 56-58. doi: 10.4172/1948-5948.1000396

- Adamou, I. (2015). Techniques de production des cultures irriguées (Moringa). Ministère de l'Agriculture du Niger/GIZ/PROMAP. https://duddal.org/files/original /6175a 372d 26145 442862 c782d1fa8898a3b77df3.pdf.
- Adouko, S. J., Guedegbe, O. A. U. G., Ohouko, O. H. F., Soha, S. A. S., Youssao, A. K. I. & Dougnon, T. J. (2021). Effets de *Moringa oleifera* substitué au tourteau de soja chez des poules pondeuses. *Livestock Research for Rural Development*, 33(1). http://www.lrrd.org/lrrd33/1/adouk3309.html
- Akanbi, W. B., Adebayo, T. A., Togum, O.A., Adeyeye, A. S., & Olaniran, O. A. (2007). The use of compost extract as foliar spray nutrient source and botanical insecticide in T. elfairia occidentalis. *World Journal of Agricultural Sciences*, 3(5), 642-652.
- Al-Asmari, A. K., Albalawi, S. M., Athar, M. T., Khan, A. Q., Al-Shahrani, H., & Islam, M. (2015). *Moringa oleifera* as an anti-cancer agent against breast and colorectal cancer cell lines. *PLoS One*, 10(8): e0135814. DOI: doi.org/10.1371/journal.pone.0135814.
- Anand, K., Tiloke, C., Phulukdaree, A., Ranjan, B., Chuturgoon, A., Singh, S., & Gengan, R. M. (2016). Biosynthesis of palladium nanoparticles by using Moringa oleifera flower extract and their catalytic and biological properties. *Journal of Photochemistry and Photobiology B: Biology*, 165, 87-95. https://doi.org/10.1016/j.jphotobiol.2016.09.039.
- Anthanont, P., Lumlerdkij, N., Akarasereenont, P., Vannasaeng, S., & Sriwijitkamol, A. (2016). *Moringa oleifera* leaf increases insulin secretion after single dose administration : a preliminary study in healthy subjects. *J Med Ass of Thailand*, 99(3), 308-313.
- Anwar, F., Latif, S., Ashraf, M., & Gilani, A. H. (2007). *Moringa oleifera*: a food plant with multiple bio-chemical and medicinal uses- a review. *Phytother Res*, 21, 17-25.
- Avila-Treviño, J. J. A., Muñoz-Alemán M., Pérez-Molphe-Balch, E., Rodríguez-Sahagún A., & Morales-Domínguez, J. F. (2017). In vitro propagation from bud and apex explants of Moringa oleifera and evaluation of the genetic stability with RAMP marker. *South African Journal of Botany*, 108, 149-156.
- Bhattacharya, A., & Mandal, S. (2004). Pollination, pollen germination and stigma receptivity in *Moringa oleifera* Lamk. *Grana*, 43(1), 48–56. DOI:10.1080/00173134.2004.11877463
- Bosch, C. H. (2004). Moringa oleifera Lam. In: Grubben, G. J. H. & Denton, O. A. (Éds). PROTA 2 : Vegetables/Légumes. [CD-Rom]. PROTA, Wageningen, Pays Bas.
- Caceres, A., Cebreva, O., Morales, O., Miollinedo, P., & Mendia, P. (1991). Pharmacological Properties of Moringa oleifera: Prelilminary Screening for Antimicrobial Activity. *Journal of Ethnopharmacology*, 33, 213-216. http://dx.doi.org/ 10.1 016/ 0378-8741(91)90078-R.
- Carbungco, E. S., Pedroche, N. B., Panes, V. A., & De la Cruz, T. E. (2017). Identification and characterization of endophytic fungi associated with the leaves of Moringa oleifera Lam. *Acta Hortic*, 1158, 373–380 10.17660/ActaHortic.2017.1158.42.
- Chen, G. (2022). Les bienfaits du Moringa: les antioxydants. Another tree, mars 2022. https://anothertree.com/moringa/les-bienfaits-du-moringa-les-antioxydants/
- Cláudio, A. A. R., Lidiane, P. A., Luanna, R. S. S., Patrícia, C. B. S., Luana, C. B. B. C., Daniela, M. A. F. N., Monica, C. P. A. A., Ana-Maria M. A. M., Thiago H. N., Emmanuel V. P., & Patrícia, M. G. P. (2014). Assessment of toxicity of Moringa oleifera flower extract to Biomphalaria glabrata, Schistosoma mansoni and Artemia salina. *Chemosphere*, 132, 188-192. https://doi.org/10.1016/j.chemosphere.2015.03.041.
- Csurhes, S., & Navie, S. (2016). Queensland, Australia: Department of Agriculture and Fisheries, Biosecurity Queensland. 22 pp.
- Dao, C. E. M., Sanou, J., & Pare, S. (2016). Maraichage urbain et semi-urbain de Moringa oleifera Lam. Par des associations de femmes au Burkina Faso: contraintes et opportunités. Vertigo-la Revue Electronique des Sciences de l'Environnement, 16(1), 1-20. https://doi.org/10.4000/vertigo.17225
- El-Awady, M. A., Hassan, M. M., Abdel-Hameed, E. S. S., & Gaber, A. (2015). Comparison of the antimicrobial activities of the leaves-crude extracts of Moringa peregrina and Moringa oleifera in Saudi Arabia. *Int J Curr Microbiol App Sci*, 4, 1–9.
- Eyassu, S., & Teketayb, D. (2020). Introduction and expansion of Moringa oleifera Lam. in Botswana: Current status and potential for commercialization. *South African Journal of Botany*, (129), 471-479.
- Förster, N., Mewis, I., & Ulrichs, C. (2013). *Moringa Oleifera*_Establishment and Multiplication of Different Ecotypes In Vitro. *Gesunde Pflanzen*, 65, 21–31. https://doi.org/10.1007/s10343-013-0291-8
- Fuglie, L. I. (1999). The Miracle Tree: *Moringa oleifera*: Natural Nutrition for the Tropics. Church World Service, Dakar. 68 p.
- Fuglie, L. J. (2001). Introduction to the Multiple Uses of Moringa. In: Fuglie, L. J., Ed., The Miracle Tree: The Multiple Attributes of Moringa, CTA, Wageningen, CWS, Dakar, 7-10, 177 p.

- Gandji, K., Chadare, F.J., Idohou, R., Salako, V. K., Assogbadjo, A. E., & Glélé-Kakaï, R. L. (2018). Status and utilisation of Moringa oleifera Lam: a review. *African Crop Science Journal*, 26(1), 137-156.
- Gatan, M. G. (2020). Diseases of Moringa and their Management. Available at SSRN: https://ssrn.com/abstract=3582292 or http://dx.doi.org/10.2139/ssrn.3582292
- Godino, M., Arias, C., & Izquierdo, M. I. (2017). Moringa oleifera: potential areas of cultivation on the Iberian Peninsula. *Acta Hortic*, 1158, 405-412.
- González-Burgos, E., Ureña-Vacas, I., Sánchez, M., & Gómez-Serranillos, M. P. (2021). Nutritional Value of Moringa oleifera Lam. Leaf Powder Extracts and Their Neuroprotective Effects via Antioxidative and Mitochondrial Regulation. *Nutrients*, 13(7), 1-15. https://doi.org/10.3390/nu13072203
- Halilou, M. S. (2022). Bioécologie et gestion intégrée des populations de N. blitealis Walker, chenille défoliatrice du Moringa au Niger. Thèse de Doctorat: Université Abdou Moumouni de Niamey, Entomolgie Appliquée, Niamey (Niger).
- Hanaa, H. A. E. B., & Gamal, E. B. (2013). Healthy Benefit of Microalgal Bioactive Substances. *Journal of Fisheries and Aquatic Science*, 22(4). DOI:10.1080/10498850.2011654381
- Haougui, A., Basso, A., & Mossi, M. I. (2017). Plant-parasitic nematodes communities associated to Moringa (*Moringa oleifera* Lam., Moringaceae) western Niger. *Journal of Phytopathology and Pest Management*, 4(1), 28-37.
- Haougui, A., Basso, A., Mbaye, N., Koura, A., & Delmas, P. (2013). Une nouvelle maladie sur le moringa au Niger. https://reca-niger.org/spip.php?article829
- Hocking, D. (1993). Trees for Drylands. Oxford & IBH Publishing Co. New Delhi.
- Hussain, M., Farooq, M., Basra, S. M. A., & Lee, D. J. (2013). Application of Moringa Allelopathy in Crop Sciences. In: Cheema, Z., Farooq, M., Wahid, A. (eds) Allelopathy. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-30595-5_20
- ICFRE. (1995). Moringa oleifera. Dehra Dun, India: Indian Council of Forestry Research and Education.
- Iwara, I., Igile G., Ogar, I., Mboso, O., Ujong, U., Eyong, E., & Ebong, P. (2014). Anti-Lipidemic Effect of Combined Leaf Extracts of Moringa oleifera and Peristrophe bicalyculata in Alloxan-Induced Diabetic Rats. *Pharmacology & Pharmacy*, 5, 340-348. doi: 10.4236/pp.2014.54041.
- Jung, I. (2014). Soluble extract from Moringa oleifera leaves with a new anticancer activity. *PloS one*, 9(4), e95492. doi: 10.1371/journal.pone.0095492 PMID: 24748376; PubMed Central PMCID: PMC3991666
- Jyothi, P. V., Atlura, J. B., Reddi, C. S. 1990. Pollination ecology of Moringa oleifera (Moringaceae). Proceedings of the Indian Academy of Sciences, Plant Sciences, 100(1), 33-42.
- Krieg J., Goetze D., Porembski S., Arnold P., Linsenmair K. E., Stein K. (2017). Floral and reproductive biology of Moringa oleifera (Moringaceae) in Burkina Faso, West Africa. Acta Horticulturae, (No.1158), 63-69. http://www.actahort.org/books/1158/1158_8.htm doi: 10.17660/actahortic.2017.1158.8
- Kumar, H.d. (2018). Management of Nutritional and Health Needs of Malnourished and Vegetarian People in India. Advances in Experimental Medicine and Biology, book series (AEMB,volume 546).
- Kumssa, D.B., EJM, J., Young, S.D., Odee, D.W., Ander, E.L., Broadley, M.R. (2017). Variation in the mineral element concentration of Moringa oleifera Lam. and M. stenopetala (Bak. f.) Cuf.: Role in human nutrition. PLoS ONE 12(4): e0175503. https://doi.org/10.1371/journal.pone.0175503
- Gopalakrishnan, L., Kruthi, D., Devarai, S. K. (2016). *Moringa oleifera*: A review on nutritive importance and its medicinal application. Food Science and Human Wellness, 5 : 49-56.
- Lalas, S. and Tsaknis, J. (2002). Extraction and Identification of Natural Antioxidant from the Seeds of the *Moringa oleifera* Tree Variety of Malawi. Journal of the American Oil Chemists' Society, 79 (7) : 677-683.
- Letouzey, R. **(**1982). Manuel de botanique forestière. Afrique tropicale. Tome 1 : botanique générale. Tome 2A : familles (1ère partie). Tome 2B : familles (2è partie). Nogent-sur-Marne : GERDAT-CTFT, 864 p.
- Maharshi, D.P. (2020). Moringa in 2030 : Transforming the World *for The People, Planet and Prosperity*. https://dpmaharshi.medium.com/moringa-in-2030-transforming-the-world-for-the-people-planet-prosperity-e7ef926f7a8c
- Mandokhot, A. M., Fugro, P. A. and Gonkhalekar, S. B. 1994. A new disease of Moringa oleifera in India. Indian Phytopathology, 1994 47 4 443
- Milla, P.G., Peñalver R. and Nieto G. 2021. Health Benefits of Uses and Applications of *Moringa oleifera* in Bakery Products. Plants, 10, 318. https://doi.org/10.3390/plants10020 318
- Moreno-Ramírez, Y.D.R., Torres-Castillo, J.A., Mora-Olivo, A., Torres-Acosta, R.I. (2018). First Report of the Mistletoe Phoradendron quadrangulare (Viscaceae) on *Moringa oleifera* (Moringaceae) in Mexico. Plant Dis. 2018. [CrossRef] [PubMed] 57.

- Morton, J.F. (1991). The horseradish tree, *Moringa pterygosperma* (Moringaceae)—a boon to arid lands ? Econ Bot. 1991 ; 45(3):318–33.
- Mridha, M.A.U., and Al-Barakah, F.N. (2015). Report on the association of fungi with the fruits of Moringa oleifera Lam. a highly valued medicinal plant. Paper presented at : First International Symposium on Moringa (Manila, Philippines : ISHS).
- Mridha, M.A.U., and Barakah, F.N. (2017). Diseases and pests of moringa : a mini review. Acta Hortic. 1158, 117-124 DOI: 10.17660/ ActaHortic. 2017. 1158.14 https://doi.org/10.17660/ActaHortic.2017.1158.14
- Mukunzi, D., Nsor-Atindana, J., Zhang, X.M., Gahungu, A., Karangwa, E., Mukamurezi, G., Al-Domi, H., Will-Ogbonna, P.I.L., Ogbonna, P.C., and Arief, N.J. (2011). "Comparison of Volatile Profile of *Moringa oleifera* Leaves from Rwanda and China Using HS-SPM," Pakistan Journal of Nutrition, 10 (7) : 602-608. http://dx.doi.org/10.3923/pjn.2011.602.608
- Muller, I. and Rebelo, C. (2011). Moringa : The current market and future potential. An EcoPlanet Group Study. http://ecoplanetgroup.net/moringa-market-review-0.
- Mune M. M.A., Nyobe E.C., BassogogC.B. and Minka S.R. 2016. A comparison on the nutritional quality of proteins from *Moringa oleifera* leaves and seeds, Cogent Food & Agriculture, 2:1, 1213618, DOI: 10.1080/23311932.2016.1213618
- Ndabigengesere, A., and Subba-Narasiah, K. (2010). Use of Moringa Oleifera Seeds as a Primary Coagulant in Wastewater Treatment. Environmental Technology, 19 (8) : 789-800. https://doi.org/10.1080/09593331908616735
- Nils-Gerrit, W. (2020). Estimated production of moringa worldwide from 2012 to 2017. https://www.statista.com/statistics/813229/global-moringa-production/
- Ojiako, F.O., Dikuru, N.C., and Cemenyonu, A. (2011). Critical issues in Investment, Production and Marketing of Moringa oleifera as an Industrial Agricultural raw material in Nigeria. J. Agric. Res. & Dev. 10(2) : 39-56.
- Olson, M.E. (2017). Moringa frequently asked questions. Acta Hortic. 1158. ISHS 2017. DOI 10.17660/ActaHortic.2017.1158.4
- Orwa, C., Mutua, A., Kindt, R.; Jamnadass, R., Anthony, S. (2009). Agroforestree Database: a tree reference and selection guide version 4.0. World Agroforestry Centre, Kenya
- Özcan, M.M. (2020). Moringa spp: Composition and bioactive properties. South African Journal of Botany, 129 : 25-31.
- Páez-León, S.Y., Carrillo-Morales, M., Gómez-Rodríguez, O., López-Guillén, G., Castañeda-Ramírez, G.S., Hernández-Núñez, E., Wong-Villarreal, A., and Aguilar-Marcelino L. (2022). Nematicidal activity of leaf extract of Moringa oleifera Lam. against Haemonchus contortus and Nacobbus aberrans. Journal of Helminthology , Volume 96 , https://doi.org/10.1017/S0022149X22000025.
- Palada, M.C., and Chang L.C. (2003). Suggested Cultural Practices for Moringa. Asian Vegetable Research and Development Center ; P.O. Box 42, Shanhua ; Taiwan 741 ; ROC. 5 p.
- Patricio, H.G. and Palada, M.C. (2012). Adaptability and horticultural characterization of Moringa accessions under Central Philippines conditions. SEAVEG2012 Regional Symposium, 24-26 January 2012.
- Patricio, H.G., and Palada, M.C. (2017). Adaptability and horticultural characterization of different moringa accessions in Central Philippines. Acta Hortic. 1158, 45–54 10.17660/ActaHortic.2017.1158.6.
- Pillai, K.S., Saradamma, K., and Nair, M.R.G.K. (1979). Helopeltis antonii Sign. as a pest of Moringa oleifera. Curr. Sci. 49 (7), 288–289.
- Rachana, K. B., Jagginavar, S. B., and Prakash, H. T. (2020). Studies on Biology of Drumstick Leaf Eating Caterpillar, *Noorda blitealis*, Walker. Int J Curr Microbiol App Sci, 9(8), 623-630.
- Rajangam, J., Azahakia-Manavalan, R.S., Thangaraj, T., Vijayakumar, A., and Muthukrishan, N. (2001). Status of production and utilisation of moringa in southern India. Paper presented at: International Conference on Development Potential for Moringa Products (Dar Es Salaam, Tanzania).
- Ramachandran, C., Peter, K.V. and Gopalakrishnan ,P.K. (1980). Drumstick (*Moringa oleifera*): A multipurpose Indian vegetable. Econ Bot 34, 276–283 (1980). https://doi.org/10.1007/BF02858648
- Ramachandran, C., Peter K.V., and Gopalakrishnan, P.K. (1980). Drumstick (Moringa oleifera) : a multipurpose Indian vegetable. Econ Bot., 34 :276-83. http://dx.doi.org/10.1007/BF02858648
- Ramasubramania, R.R., Sreenivasulu, M., Vaishnavi, S., Navyasri, D.M., Samatha, G., and Geethalakshmi, S. (2016). *Moringa Oleifera*-An Overview », RA Journal of Applied Research, 2 (9) : 620-624.
- Rashid, U., Anwar, F., Moser, R., Knother, G. (2008). *Moringa oleifera* oil: a possible source of biodiesel. Bioresource Technology 99, 8175–8179
- Ratnadass, A., Zakari-Moussa, O., Salha, H., Minet J., et S.A.A. (2011). *Noorda blitealis* Walker, un ravageur majeur du Moringa au Niger (Lepidoptera, Crambidae). Bulletin de la Société entomologique de France, 116 (4) : 401-404.
- Saint-Sauveur, A., and Broin, M. (2010). Growing and processing moringa leaves. Moringa Association of Ghana Moringanews. ISBN : 978-92-9081-452-8. CTA No.1585 : 1 -68

http://www.publications.cta.int/publications/publication/1585/

- Sarr, S.O., Fall, A.D., Gueye, R., Diop, A., Diatta, K., Diop, N., Ndiaye, B., Diop, Y.M. (2015). Etude de l'activité antioxydante des extraits des feuilles de Vitex doniana (Verbenaceae). Int. J. Biol. Chem. Sci., 9(3): 1263-1269. DOI: http://dx.doi.org/10.4314/ijbcs.v9i3.11.
- Senthilkumar, A., Karuvantevida, N., Rastrelli, L., Kurup, S.S., Cheruth, A.J. (2018). Traditional Uses, Pharmacological Efficacy, and Phytochemistry of *Moringa peregrina* (Forssk.) Fiori. -A Review. Front Pharmacol. 11;9:465. doi: 10.3389/fphar.2018.00465. PMID : 29867473 ; PMCID : PMC5958191.
- 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. *Journal of Agricultural and Food Chemistry*, 51, 2144-2155.
- Sultana, S. (2020). Nutritional and functional properties of Moringa oleifera. Metabolism Open, 8, 1-6. doi: 10.1016/j.metop.2020.100061
- Sy, N. A., Fall, A. D., Ndiaye, M., Ndiaye, K., Gueye, R.S., Bassene, E., Dieye, A. M., & Sy, G. Y. (2018). Evaluation de l'activité antioxydante des feuilles de Moringa oleifera Lam. (Moringaceae) du Sénégal. *Int J Biol Chem Sci*, 12(4), 1816-1823.
- Thriveni, M. C., Shivamurthy, G. R., Amruthesh, K. N., Vijay, C. R., & Kavitha, G. R. (2010). Mistletoes and their hosts in Karnataka. *J Am Sci*, 6, 827–835.
- Ullasa, B. A., & Rawal, R. D. (1984). Papaver rheoeas and Moringa oleifera, two new hosts of papaya powdery mildew. *Curr Sci*, 53(14), 754–755.
- Vélez-Gavilán, J. (2017). *Moringa oleifera* (horse radish tree). https://www.cabi.org/isc/datasheet/34868#REF-DDB-181053.
- Verma, A. N., & Khurana, A. D. (1974). New host records of *Inderbela tetraonis* Moore (Lepidoptera: metarbelidae). *Haryana Agric Univ J Res*, 4(3), 253–254.
- Xavier, J. (2018). Les bienfaits du moringa. https://www.doctissimo.fr/nutrition/sante-dans-l-assiette/secrets-des-aliments-sante/bienfaits-moringa
- Yusuf, S. R., & Yusif, D. I. (2014). Severe damage of Moringa oleifera Lam. leaves by *Ulopeza Phaeothoracica* Hampson (Lepidoptera: Crambidae) in Ungogo Local Government Area, Kano State, Nigeria: a short communication. *Bayero J Pure Appl Sci*, 7(1), 127–130 http://dx.doi.org/10.4314/bajopas.v7i1.23.
- Zaku, S. G., Emmanuel, S., Tukur, A. A., & Kabir, A. (2015). Moringa oleifera: an underutilized tree in Nigeria with amazing versatility: A review. *African Journal of Food Science*, 9(9), 456-461. DOI:10.5897/AJFS2015.1346
- Zhang, J., Pian, R., Yang, E., Zhou, W., Hi, Q., & Chen, X. (2020). In vitro induction and characterisation of tetraploid drumstick tree (Moringa oleifera Lam.). Open Life Sciences, 15 : 840-847.
- Zhao, J. H., Zhang, Y. L., Wang, L. W., Wang, J. Y., & Zhang, C. L. (2012). Bioactive secondary metabolites from Nigrospora sp. LLGLM003, an endophytic fungus of the medicinal plant *Moringa oleifera* Lam. *World J Microbiol Biotechnol*, 28(5), 2107-2112.
- ZhiYing, C., Zeng, Y. H., Xiong, B., Liu, Y. X., Yang Y., Long, J. M., ZhenHua, Y., Han G., & HaiQuan, L. (2017). Isolation and identification of pathogens causing pod rot of Moringa oleifera, *Journal of Southern Agriculture*, 47(9), 1517-1521.
- Zubair, M. (2020). Antimicrobial and Anti-Biofilm Activities of *Citrus sinensis* and Moringa oleifera Against the Pathogenic Pseudomonas aeruginosa and Staphylococcus aureus. Cureus. 28;12(12):e12337. doi: 10.7759/cureus.12337. PMID : 33520533; PMCID: PMC7839279.

Cite This Article: Bibata Ali Outani, Haougui Adamou, Ali Mahamadou, Patrick Delmas (2023). Moringa (*Moringa oleifera* Lam): a Review on its Importance Worldwide. *East African Scholars J Agri Life Sci*, *6*(7), 112-120.