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Moringa Oleifera: Phytochemistry, pharmacology

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Abstract

The retrospective research on the *Moringa Oleifera* at the molecular level are reviewed in this study. The family Moringaceae includes roughly thirteen different species of moringa trees. The most well-known species of moringa is *Moringa Oleifera* Lam are used in traditional medicine to treat a variety of illnesses. Many tropical and subtropical nations support the growth of the *Moringa Oleifera* Lam. tree. Commercial cultivation occurs in regions including South and Central America, Africa, India, Hawaii, Mexico, and Asia. *M. oleifera*'s seeds, leaves, roots, and flowers are frequently employed in traditional medicine, while the immature pods, leaves, and seed are utilised as food ingredients for human consumption. *M. oleifera* leaf extracts are essential for animal safety investigations and antioxidant activities. No negative impacts on humans have been reported thus far. Studies utilising powdered *M. oleifera* leaf preparations have shown anti-dyslipidemic and anti-diabetic effects. Leaf extracts and powders were used on animals to confirm these actions. Alkaloids, flavonoids, polyphenols, phenolic acids, and phenolic acids are the compounds responsible for the effects. This study's objective was to examine *M. oleifera* as a potential miracle tree and place more emphasis on its applications. Therefore, it is necessary to research the standardised *M. oleifera* leaf extracts that have a wide variety of applications. Future research would use this study's findings as a backdrop. They also have antitumor, antipyretic, anti-inflammatory, antiulcer, antispasmodic, diuretic, antihypertensive, cholesterol-lowering, antioxidant, antidiabetic, hepatoprotective, antibacterial, and antifungal properties.

Keywords: Polyphenols; Alkaloids; Antifungal; Anticancer; Antihypertensive; Antidiabetic.

1. Introduction

Numerous tropical and subtropical nations are home to the *Moringa Oleifera* Lam. tree. Commercial cultivation occurs in regions including South and Central America, Africa, India, Hawaii, Mexico, and Asia. On the basis of ground root taste preparations, it was given the name "horseradish" tree. It was also given the name "drumstick tree" due to the look of its immature seed pods, and the name "ben oil" tree because of the oils that are obtained from its seeds. Some regions consume the immature seed pods, but because fresh leaves have a high nutritional content, they are frequently utilised as a staple diet[1].

The tree or shrub *Moringa Oleifera*, which is a member of the Moringacae family and is native to the Indian subcontinent, has spread naturally to tropical and subtropical regions around the world. It is a deciduous tree or shrub with a mature height of about 12 metres and is a fast-growing, drought-resistant plant. They are as follows: *Moringa arborea, Moringa borziana, Moringa concanensis, Moringa drouhardii, Moringa hildebrandtii, Moringa longituba, Moringa ovalifolia, Moringa peregrina, Moringa pygmaea, Moringa arivae, Moringa ruspolian,* and *Moringa stenoprtala*[1-2].

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Figure 1 Leaf of *Moringa Oleifera*

Humanity has used medicinal plants for their therapeutic benefits ever since the dawn of civilization. For thousands of years, nature has served as a source for therapeutic substances, and an astounding number of contemporary medications have been identified from natural sources. The utilisation of the drugs in conventional medicine formed the basis for many of these isolations. With nearly 80% of the world's population relying mostly on traditional medicines for their primary health care (Owolabi et al., 2007), the plant-based, traditional medicine systems continue to play a crucial role in healthcare. According to Okigbo et al. (2008), medicinal plants are those that naturally have active components that can be utilised to treat illness or lessen discomfort. The antioxidant, antibacterial, and antipyretic actions of plants may serve as the foundation for their therapeutic qualities. The Rig Veda (4500-1600 BC) and Atharva Veda are two examples of ancient scriptures that reference the usage of various plants as medicines. More than 700 herbs are mentioned in the texts on ayurvedic medicine, including Charaka Samhita and Susruta Samhita (Jain, 1968). The World Health Organisation (WHO, 1977) defined "a medicinal plant" as any plant that has chemicals that can be utilised therapeutically in one or more of its organs. The word "herbal drug" refers to the part or components of a plant (leaves, flowers, seeds, roots, barks, stems, etc.) used in the preparation of medications. Numerous such medications derived from plants or plant products and their morphological, pharmacological, or pharmacognostic characteristics have been described by the Indian ayurveda system.[2] A species of indigenous medicinal Indian herb known as moringa (*Moringa Oleifera* Lam.) has gained popularity in tropical and subtropical nations. one more Horseradish tree, Mulangay, and other names for the plant Moringa Drumstick tree, Sajna, Kelor, Saijihan, Mlonge, Benzolive Marango, too. Its scientific name is *Moringa Oleifera*. Kingdom division to become: the division of plants Magnoliphyta, Magnoliopsida as a class, Brassicales as an order Genus Moringa, Family Moringaceae, and Species M.oleifera.[1-2].

One of the plants in the Brassica order and a member of the Moringaceae family is the vegetable *Moringa Oleifera*.With 13 recognised species, the Moringaceae family consists of a single genus (Khawaja et al., 2010). The *Moringa Oleifera* tree is a diminutive native to the sub-Himalayan regions of North West India, and it is currently found natively in many areas of South America and the Islands. In addition to being a common vegetable in these areas, the Moringa is well-known and valued for its medicinal properties. Due to its extraordinary healing powers for a variety of disorders and even certain chronic conditions, it has gained the nickname "the miracle tree" among common people. Due to its numerous bioactive components, several studies were done to separate them from different regions of the plant[3].

Since the beginning of time, humans have depended on plants for survival no matter the region or era. For many centuries, different plants have been used all across the world as both nutritional supplements and conventional therapies for a wide range of illnesses. One of the oldest types of treatment for a variety of illnesses is herbal medicine, which has attracted a sizable following for obvious reasons such being affordable, accessible, and blending with people's everyday lives. The greatest place to get a range of medications, according to the WHO, is from herbal or medicinal plants. They were, are, and will continue to be advantageous in terms of human health, as well as social, cultural, religious, and environmental factors. The potential for medicinal plants is greatest.

Since all of the Moringa plant's parts are good sources of protein, vitamins, minerals, and carotenoids, it has been widely used for economic, nutritional, and therapeutic purposes around the world. The name *M. oleifera* Lam. (syn. Moringa

pterygosperma Gaerthn, Moringa moringa Millsp.) means "generic root" in the Dravidian language of India. Kelor, Marango, Moonga, Mlonge, Mulangay, Nébéday, Saijhan, and Sajna, as well as Benzolive, are further regional names. Horseradish tree, Drumstick tree, Never Die tree, West Indian Ben tree, or Radish tree are some of its English names. *M. oleifera*, which originally came from the sub-Himalayan region of India, has naturalised in a number of tropical and subtropical areas of the world, including the Middle East, Africa, the Americas, Asia, the Philippines, Cambodia, and the Caribbean islands[4]. One of the most amazing plants I have ever come across is the moringa tree. Although it may sound sensationalistic, the nutritional and therapeutic benefits of moringa have the ability to eradicate starvation and malnutrition as well as to prevent and treat a wide range of illnesses and ailments globally.1 The moringa plant is certainly a miracle and a gift from God for human nourishment and healing. It is challenging to know where to start when discussing the various benefits and unique qualities of this amazing plant[4-5].

Drumstick or *Moringa Oleifera* is another name for it.It is extensively distributed in the sub-Himalayan area and is widely planted throughout India. It is a very well-liked backyard tree that reaches a height of over 9 m 2.Its branches have sticky bark, and its delicate, white corky trunk is corky. Each leaf in a tripinnate compound has several tiny leaflets. The three winged seeds in the white blooms are dispersed by the wind 3. Flowers, delicate leaves, and pods can all be consumed as vegetables. Because the leaves are heavy in iron, expecting moms should strongly consider using them. Given the presence of all necessary amino acids, moringa can legitimately be referred to as a complete food for comprehensive nutrition[5].

2. Origin of *Moringa Oleifera*

One of the most frequently cultivated species of the Moringaceae family and a significant medicinal plant, *M. oleifera* is indigenous to the sub-Himalayan regions of India, Pakistan, Bangladesh, and Afghanistan. Ancient Romans, Greeks, and Egyptians used the quickly growing tree, also known as the Ben oil tree, horseradish tree, drumstick tree, benzolive tree, kelor, marango, mlonge, and moonga. Due to its extensive therapeutic benefits, it has been highly prized for ages. It is currently widely grown and has gone wild in many tropical areas[2].

2.1. Description

A short, slender, deciduous, perennial tree, *M. oleifera* grows to a height of about 10 m, is rather slender, and has branches that droop; the branches and stem are brittle, and the bark is corky; the leaves are feathery, pale green, compound, tripinnate, and have many small leaflets that are 1.3-2 cm long and 0.6-0.3 cm wide, with the lateral ones being somewhat elliptic and the terminal Flowers are fragrant, white or creamy-white, 2.5 cm in diameter, borne in sprays, and have five(5) stamens at the top of each flower. Pods are pendulous, brown, triangular, splitting lengthwise into three parts when dry, (30-120 cm long, 1.8 cm wide), and contain about 20 seeds embedded in the pith. The seeds are dark brown, the pod is nine (9) ribbed, and it tapers at both ends[2].

Figure 2 Fruits of *Moringa Oleifera*

2.2. Cultivation

Production and Cultivation There are two basic methods for growing *Moringa Oleifera*: seeding and cutting. Although vegetative propagation is popular in India, Indonesia, and some parts of West Africa 8, seeds are traditionally favoured in Sudan 8. When seeds are readily available and human labour is scarce, sowing needs the selection of the seeds, but

the ability to transplant seedlings permits flexibility in field planting even when it necessitates additional work and expense. Within two weeks, seeds will begin to sprout at a maximum depth of 2 cm. The seedlings can be transplanted when they are approximately 30 cm tall when sowing is planned in the nursery. Depending on the variety, there are between 3000 and 9000 seeds per kilogramme, with a germination rate of between 80% and 90% under ideal storage circumstances (3 °C, 5% to 8% moisture). However, if seeds are left at room temperature and high relative humidity, their viability declines, and after three months, their germination rate falls to 7.5%. 10. When seeds are hard to get by or when labour is not a constraint, cutting is recommended. 10. Ramachandran et al. There have been claims that plants grown from seeds yield fruits of lower quality, although Animashaun et al. In comparison to trees developed from cuttings, which have considerably shorter roots, trees grown from seeds are said to develop longer roots, which is advantageous for stabilisation and access to water.

Hard woodcuttings from adult trees that are planted during the rainy season with a third buried in the ground grow roots that are noticeable in size in a short period of time 13. If permitted to grow organically, the *Moringa Oleifera* tree can reach 3 metres in height in just three months and 12 metres in just a few years. Since the tree aggressively grows back after being cut, trimming or pollarding is sometimes used to encourage lateral branching and give the tree a bush-like appearance to make harvesting easier. However, as there are few literature data on the effective management of *Moringa Oleifera*, practical experiments are required 14. Seeds and leaves are components of the plant. Therefore, when planting *Moringa Oleifera* trees, the geographical distribution is planned to make it easier to carry out the necessary management and harvesting procedures.[3]. The design of a *Moringa Oleifera* plantation for leaf production can be as follows: Irrigation and fertilisation are required for (i) intensive production with spacing ranging from 10 cm 10 cm to 20 cm 20 cm, harvest occurring every 35 to 45 days; (ii) semiintensive production with spacing around 50 cm 100 cm, harvest occurring every 50 to 60 days; and (iii) integrating in an agroforestry system with spacing distance of 2-4 m between rows, harvest occurring every 60 days, fertilisation and irrigation not strictly necessary[2-3]. Cu;tivation Parameters shown in Fig.1.

Table 1 Cultavation parameters of *Moringa Oleifera*

Parameters	**Requirement/range**
Climate	Grow best in topical or subtropical.
Altitude	0-2000m.
Rainfall	Irrigation needed for leaf production if rainfall is less than 800mm.
Soil type	Loamy, sandy or sandy loam.
Soil pH	5-9.

2.3. Cultivation practice

Figure 3 Parts of *Moringa Oleifera* plant

The moringa plant can be grown as a perennial or annual plant. All pods are edible throughout the early stages of plant development, but as the plant matures, the pods become bitter and inedible. When cultivated perinially, moringa benefits less favourable growing environments by reducing erosion and stabilising agroforestry[10].

2.4. Nutrition

Malnutrition, particularly in young children and nursing moms, has been combated by using moringa trees. Particularly, three non-governmental organisations, Trees for Life, Church World Service, and Educational Concerns for Hunger Organisation, have pushed for the use of moringa as "natural nutrition for the tropics." According to reports, leaves can be consumed raw, roasted, or dried and stored for several months without losing any nutritional value. Because the moringa tree is in full leaf near the end of the dry season, when other foods are often sparse, the moringa tree seems particularly promise as a food source in the tropics.

There are now a lot of studies on the nutritional benefits of moringa, both in academic and lay literature. Anyone who has read about Moringa will be able to identify the frequently used descriptor.

Any readers who are familiar with the Moringa plant will be able to identify the oft-repeated claim made by the Trees for Life organisation many years ago that "ounce-for-ounce, Moringa leaves contain more Vitamin A than carrots, more calcium than milk, more iron than spinach, more Vitamin C than oranges, and more potassium than bananas," as well as the claim that the protein quality of Moringa leaves rivals that of milk and eggs. These readers will also be familiar with the oral histories that Lowell Fuglie collected in Senegal and other parts of West Africa, where he describes (and has extensively documented on film) innumerable cases of nutritional rescue that saves lives that are linked to Moringa. In fact, there appears to be little debate regarding the significant health benefits of moringa because its nutritional qualities are now so well documented[6].

In the tropics, where other food sources are often scarce near the end oIn particular for infants and nursing moms, moringa trees have been utilised to fight malnutrition.Particularly three nongovernmental organisations have promoted moringa as "natural nutrition for the tropics": Trees for Life, Church World Service, and Educational Concerns for Hunger Organisation. According to reports, leaves retain their nutritious content whether they are consumed raw, cooked, or dried and stored for many months without refrigeration. f the dry season, moringa is especially promising as a food source because the tree is in full leaf at that time. There are now a lot of studies on the nutritional benefits of moringa, both in academic and lay literature. Any readers who are familiar with moringa will be able to identify the often-repeated claim made by the Trees for Life organisation many years ago that "ounce-for-ounce,More calcium than milk, more iron than spinach, a nd more vitamin A than carrots are all found in moringa leaves. potassium than bananas, more Vitamin C than oranges, and that the protein quality of Comparable to milk and eggs are moringa leaves. These readers will also be familiar with the documented oral histories. in Senegal and throughout West Africa by Lowell Fuglie, who recounts[2-6].

3. Geographical Source

M. oleifera is a 10 m tall, quickly growing tree that is commonly grown throughout India's plains and has naturalised in tropical areas. Additionally, it is grown in north-eastern Pakistan, north-eastern Bangladesh, Sri Lanka, West Asia, the Arabian Peninsula, East and West Africa, all of the West Indies and southern Florida, in Central and South America from Mexico to Peru, as well as in Brazil and Paraguay. It is grown in yards and around hedges. It can grow in many sorts of soil but does best in the climates found in North and South India8. Up to 60 cm long, the leaves. 1.5 to 2 cm long are the blooms. Fertile filaments covered in pendulous, long fire hair pods that are 15 to 30 cm long.[3-5].

3.1.1. Taxonomical classifications

- Kingdom - Plantae
- Subkingdom - Tracheobionta
- Super division - Spermatophyta
- Division - Magnoliophyta
- Class - Magnoliosida
- Subclass - Dilleniidae
- Order - Capparales
- Family - Moringaceace
- Genus - MoringaAdans
- Species - *Moringa Oleifera*lam
- Synonyms - Moringa pterygosperma

3.1.2. Botanical Description

Synonyms

- Latin - *Moringa Oleifera*
- Sanskrit - Subhanjana
- Hindi - Saguna, Sainjna
- Gujarati - Suragavo
- Tamil - Morigkai
- Telugu - Mulaga, Munaga
- Malayalam –Murinna, Sigru
- Punjabi - Sainjna, Soanjna
- Unani - Sahajan
- Ayurvedic - Akshiva, Haritashaaka, Raktaka, Tikshnagandhaa
- Arabian - Rawag
- French - Moringe à graine ailée, Morungue
- Spanish - Ángela, Ben, Moringa
- Portuguese - Moringa, Moringueiro
- Chinese - La ken
- English - Drumstick tree, Horseradish tree, Ben tree
-

4. Morphology

A tiny, quickly-growing evergreen or deciduous tree, *Moringa Oleifera* often reaches heights of 10 to 12 metres. It has a feathery foliage with tripinnate leaves, a spreading, open crown of drooping, frail limbs, and thick, corky, whitish bark.[7]

4.1. Young leaves and shoots

Bipinnate or, more frequently, tripinnate leaves up to 45 cm long are placed alternately and spirally on the branches. The lateral leaflets are elliptic, while the terminal ones are obovate. The pinnae and pinnules are opposite, and the leaflets are 1.2 to 2.0 cm long and 0.6 to 1.0 cm wide. The lateral leaflets' petioles are 1.5 to 2.5 mm long, while those of the terminal ones are 3 to 6 mm long. The leaflets have whole (not toothed) borders, are rounded or blunt-pointed at the apex, and are short-pointed at the base. They are finely hairy, green, and nearly hairless on the upper surface, and paler and hairless beneath. The midveins have a reddish tint. The twigs are green and finely haired before turning brown.

4.2. Fruits, Flowers, and Seeds

Figure 4 Flowers of *Moringa oleifra*

On thin, hairy stalks, the fragrant, bisexual, yellowish-white flowers are produced in spreading or drooping panicles (clusters) that are 10–25 cm long. Individual flowers range in size from 0.7 to 1 cm long and 2 cm wide, with five uneven yellowish-white, thinly veined, spathulate petals, five stamens, five smaller sterile stamens (staminodes), and a pistil

made up of a 1-celled ovary and slender style [27, 30, 51]. Individual flowers are arranged in a basal cup (hypanthium) that is about 3 mm long. The fruits are three-sided, linear, pendulous pods with nine longitudinal ridges that are typically 20 to 50 cm long but can reach 1 m or more on rare occasions. They are also 2.0 to 2.5 cm wide. The pods, which can have up to 26 seeds apiece on average, are dark green while they are developing and require around 3 months to reach maturity [45]. When fully developed, they turn brown and crack open lengthwise along the three angles, releasing the triangular, dark-brown seeds. The seeds have three pale papery wings on the angles and have a diameter of around 1 cm. Different cultivars have different seed weights, ranging from 3,000 to 9,000 seeds per kilogramme.

4.3. Growth and development of *Moringa Oleifera*

On favorable sites, *M. oleifera* grows quickly, gaining 1 to 2 m in height every year for the first 3 to 4 years. How long trees typically survive is unknown. Nursery-grown seedlings in a Tanzanian experiment that was rainfed reached an average height of 4.1 m in the first year [38]. Trees rarely reach heights more than 10 to 12 metres, however, they can occasionally reach heights of up to 16 meters with stem diameters of up to 75 centimeters [46]. For trees grown from stem and branch cuttings, fruit production can start 6 to 8 months after planting [51]. During the first two years, fruit yields are often minimal, but beginning in the third year, a single tree can produce 600 to 1,600 fruits annually[7].

5. Phytochemistry

In the purest sense, phytochemicals are substances made by plants. However, the term is typically only used to describe substances that may affect a plant's flavour, texture, fragrance, or colour without having any effect on human health. A variety of rather rare compounds can be examined by looking at the phytochemicals of Moringa species. This plant family is particularly abundant in substances containing the sugar rhamnose as well as in the very uncommon substances glucosinolates and isothiocyanates (10,38). For instance, some Moringa preparations have been found to contain compounds that have been shown to have hypotensive, anticancer, and antibacterial activity. These compounds include 4-(4'-O-acetyl-L-rhamnopyranosyloxy)benzyl isothiocy-anate, 4-(-L-rhamnopyranosyloxy)benzyl isothiocy-anate, benzyl glucoside [6]. While the Moringa family has a variety of compounds that are somewhat unique, it is also abundant in vitamins, minerals, and other phytochemicals that are more widely known, such as the carotenoid[6].

In the purest sense, phytochemicals are substances made by plants. However, the term is typically only used to describe substances that may affect a plant's flavour, texture, fragrance, or colour without having any effect on human health. A variety of relatively distinct molecules can be examined by looking at the phytochemicals of Moringa species21. This plant family is particularly abundant in substances that include the sugar rhamnose as well as in the unusual substances glucosinolates and isothiocyanates. For instance, specific Moringa preparations' ingredients have been shown to have hypotensive, anticancer, and antibacterial activity. These ingredients include niazimicin, 4-(4'-O-acetyl-L-rhamnopyranosyloxy)benzyl isothiocy-anate, Pterygospermin, and 4-(L-rhamnopyranosyloxy)benzyl isothiocy-an both 4-(-L-rhamnopyranosyloxy)benzyl glucosinolate [6] and benzoyl isothiocyanate [5]. Although the Moringa family only contains a small number of these chemicals, it is also abundant in a variety of vitamins and minerals as well as other, more well-known phytochemicals like carotenoids (such -carotene or pro-vitamin A), are all present[5-7].

5.1.1. Vitamins

It has been estimated that *Moringa Oleifera* fresh leaves have between 11,300 and 23,000 IU of vitamin A. Vision, reproduction, embryonic growth and development, immunological competence, cell differentiation, cell proliferation and apoptosis, preservation of epithelial tissue, and brain function are only a few of the physiological processes in which vitamin A is essential[5-6]. Many underdeveloped nations still suffer from this shortage, which is thought to be the main cause of infant and mother death. Carotenoids with pro-vitamin A action are also abundant in fresh leaves of the Moringa oleifara plant.

A unique source of vitamin C is the *Moringa Oleifera* plant. About 200 mg/100 g are present in fresh leaves, which is more than orange. Since vitamin C affects the production and metabolism of numerous substances, including tyrosine, folic acid, and tryptophan, as well as the hydroxylation of glycine, proline, lysine, carnitine, and catecholamine, these quantities are of particular relevance. By making it easier for cholesterol to be converted into bile acids, it decreases blood cholesterol levels[5-7]. It also improves iron absorption in the stomach by changing ferric to ferrous state. Finally, it functions as an antioxidant, defending the body against the harmful effects of free radicals, poisons, and other contaminants. However, vitamin C is quickly oxidised since it is susceptible to heat and oxygen, which reduces its concentration in the *Moringa Oleifera* plant.

5.1.2. Polyphenols

The dried leaves of *Moringa Oleifera* are a fantastic source of polyphenols. They had concentrations between 1600 and 3400 mgTAE/100g of DW (or 2090 to 12,200 mgGAE/100g of DW). These quantities are higher than what is present in fruits and vegetables. Such a wide range of reported values may be explained by the varying environmental circumstances in the different origin nations, the harvesting season, the genetics of the plant, the drying method, the stage of leaf development, and the extractive method employed. Flavonoids and phenolic acids are the main polyphenols found in *Moringa Oleifera* leaves[5-8].

5.1.3. Phenolic acid

The naturally occurring hydroxybenzoic acid and hydroxycinnamic acid found in plants are the source of phenolic acids, a subgroup of phenolic chemicals. Because of their well-documented impacts on human health, phenolic acids found in food are a topic that is gaining more and more attention. These substances are specifically investigated for their proven anti-inflammatory, anti-mutagenic, antioxidant, and anti-cancer activities. Phenolic acids, which are particularly prevalent in fruit and vegetables, were also detected in significant quantities in the leaves of *Moringa Oleifera*. Gallic acid appears to be the most prevalent substance in dried leaves, with a concentration of about 1.034 mg/g of DW, despite the fact that Bajpai et al. only discovered barely measurable levels. The range of chlorogenic and caffeic acids in DW and ND is 0.018 to 0.489 mg/g and ND to 0.409 mg/g, respectively.

5.1.4. Alkaloids

Alkaloids are a class of chemical substances that exist in nature and primarily include basic nitrogen atoms. The amines that make up this nitrogen can be classified as primary amines (RNH2), secondary amines (R2NH), or tertiary amines (R3N). The majority of alkaloids also contain nitrogen, hydrogen, and oxygen. Due to their pharmacological characteristics, alkaloids are of great interest. These substances are known to exist in *Moringa Oleifera* leaves. Several of these substances, including N,L-rhamnopyranosyl vincosamide, 4-(L-rhamnopyranosyloxy) phenyl acetonitrile (niazirin), pyrrolemarumine 4′′-O-L-rhamnopyranoside, 4′-hydroxy phenylethanamide-L-rhamnopyranoside (marumoside A) and its 3-O.

5.1.5. Saponins

Genin or sapogenin, an aglycone generated from isoprenoids, is covalently joined to one or more sugar moieties in a group of natural chemicals known as saponins. Although certain saponins have hemolytic side effects, their anti-cancer capabilities are still being researched. Saponins can be found in abundance in *Moringa Oleifera* leaves.

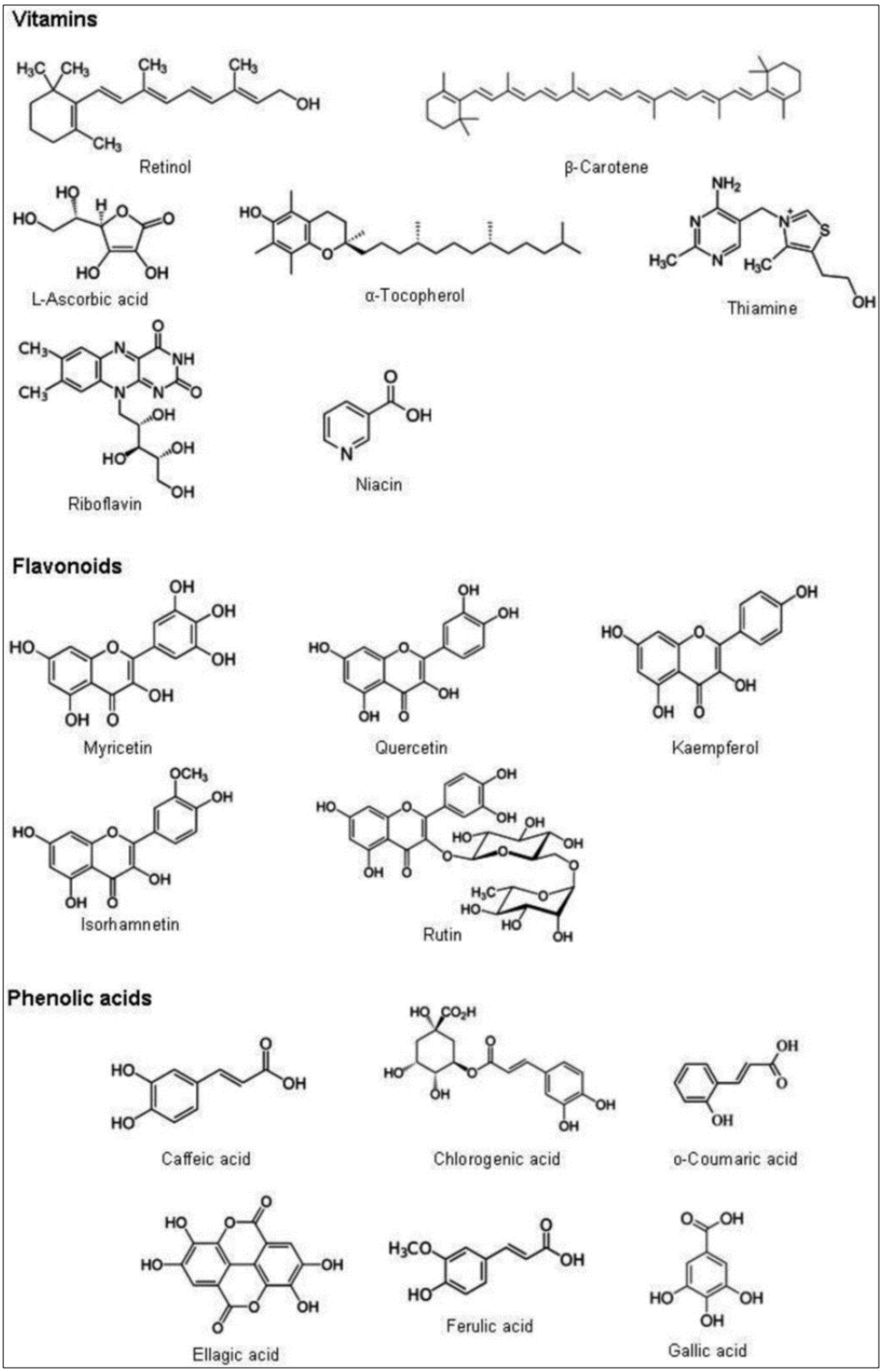

Figure 5 Strctures of phytochrmicals present in Moringa Oleifera.

5.2. Disease and treatment prevention

It is less well understood what advantages Moringa preparations (such as extracts, decoctions, poultices, creams, oils, emollients, salves, powders, and porridges) may have for the treatment or prevention of illness or infection when consumed or applied topically (116). Even while the oral history presented here is equally extensive, it has undergone far less rigorous scientific analysis[8-10]It is therefore important to study the assertions made and evaluate the quality of the evidence supporting the assertions that have been more thoroughly supported. This review encourages readers

to look at two recent publications that do a great job of contrasting the challenge of combining evidence from complementary and alternative medicine (such as traditional medicine. The burden of proof must be met in order to draw valid conclusions about the effectiveness of these conventional treatments based on evidence other than tribal wisdom, oral histories, and anecdotes. It is obvious that much more research is necessary, but it is also obvious that fundamental and applied researchers will find this to be a very lucrative area of study during the coming ten years.

Unluckily, a lot of these reports of effectiveness in people are not backed up by placebo-controlled, randomised clinical trials and haven't been written up in widely read publications. For instance, a study from over 25 years ago on the surface seems to prove that Moringa is an effective treatment for urinary tract infections, but it offers the reader no basis for comparison (no control patients). Therefore, to the extent that this is in opposition to Western medicine, moringa has not yet been and will not be welcomed for either its therapeutic or nutritional benefits by Western-trained medical professionals.

5.3. *Moringa Oleifera* for oral health

In urbanised nations, oral and dental health has significantly improved over the past century, but in poor nations like India, dental caries is still a significant clinical issue. Cavities, often known as tooth decay, are microbiological illnesses brought on by particular bacteria found in human mouths Herbal plants have been used for a very long time to enhance oral health, and their use as a source of antibacterial chemicals has been demonstrated to be quite successful. There are numerous studies on the antibacterial abilities of *Moringa Oleifera*. According to Veira et al. (2010), gramme positive and gramme negative bacteria are both sensitive to the aqueous and ethanolic extracts of *Moringa Oleifera* seeds at a concentration of 50 microL/dish. According to research by Jagan Rao et al. (2012), *Moringa Oleifera* leaves have antibacterial and anti-inflammatory properties on both gramme positive and gramme negative microorganisms. The *Moringa Oleifera* methanolic extract has inhibitory activities against oral pathogens and can be taken orally to treat dental caries. The presence of phenolic chemicals, particularly flavonoids, and the synergistic effects of aerial parts on these compounds are the main causes of *M. oleifera* methanolic extract's antibacterial action.

6. Pharmacological activity of *Moringa Oleifera*

6.1. Antimicrobial activiy

Microbiological Activity *Moringa Oleifera* leaves, roots, bark, and seeds have been shown to have antibacterial properties in vitro against bacteria, yeast, dermatophytes, and helminths by A. Cáceres et al. (1991). Pseudomonas aeruginosa and Staphylococcus aureus are prevented from growing by the aqueous extracts from the seeds and fresh leaf juice32. Other pathogenic Gram-positive and Gram-negative bacteria as well as Candida albicans were not shown to exhibit any action. Using the disc diffusion method, Doughari, J. H. et al. showed that M.O. leaf extracts for the treatment of infectious diseases were tested for their effectiveness against Salmonella typhi isolated from blood clot culture.

Moringa roots reportedly contain a lot of antimicrobial compounds and have antibacterial activity. These are said to contain pterygospermin, an active antibiotic principle with potent antibacterial and fungicidal properties. The antibacterial and fungicidal effects of 4-Lrhamnosyloxybenzyl isothiocyanate's presence are discovered to be caused by a comparable substance[2]

The bacteria Escherichia coli, Salmonella typhi, Pseudomonas aeruginosa, Enterobacter cloacae, Proteus vulgaris, Kocuria kristinae, Klebsiella aerogenes, Shigella, Bacillus cereus, Bacillus subtilis, Klebsiella pneumoniae, Geobacillus stearothermophilus, Streptococcus py Conclusion: MO may be a source for the treatment of many illnesses brought on by resistant microorganisms. We can draw the conclusion that MO might be a source for the treatment of many illnesses brought on by hardy microorganisms. Additionally, according to Singh et al., the plant's aqueous, ethanol, and methanol extracts showed a growth-inhibiting impact on the examined bacteria [78]. The ethanolic extract also reveals antibacterial activities against gram-positive, gram-negative, and acid-fast bacteria. Basidiobolus haptosporus, Basidiobolus ranarum, Trichophyton rubrum, and Trichophyton mentagrophytes are the pathogens that cause subcutaneous phycomycosis in both people and animals, according to Nwosu and Okafor. MO exhibits inhibitory action against Epstein-Barr virus early antigen activation.

In vitro research on the antibacterial properties of *Moringa Oleifera* leaves, roots, barks, and seeds against human pathogenic bacteria, yeast, dermatophytes, and helminthes. The growth of Pseudomonas aeruginosa and staphylococcus aureus was shown to be inhibited by the fresh leaf juice and the aqueous extract from the seeds using the disk-diffusion method, and it was also shown that extraction temperatures above 56°C hinder this activity. Four

other pathogenic gram-positive and gram-negative bacteria as well as Candida albicans were not shown to exhibit any action. No action was shown to be present by a dilution approach against six pathogenic dermatophytes. Salmonella enteritidis, Staphylococcus aureus, Vibrio cholera, Escherichia coli (isolated from the organism and the aquatic environment), and aqueous and ethanolic extracts of seeds from *Moringa Oleifera* were tested for their ability to inhibit the growth of bacteria. Aqueous and ethanolic extracts of moringa were found to have antibacterial activity (inhibition halo > 13mm) against S. aureus, V. cholera, and E. coli isolated from the white leg prawn, Litopenaeous vannmaei. E. coli isolated from Oreochrom isniloticus and tilapia fish were both susceptible to the ethanolic extract of *M. oleifera*[9].

6.2. Antifungal activity

Different plant parts, including the leaves and seeds, have been shown to exhibit antifungal properties against fungus like Trichophyton interdigitale, Aspergillus flavus, and Penicillium. niger, Aspergillus oryzae, and Aspergillus terreus, nidulans, Aspergillus F. solani and R. izoctonia Solani, Penicillium sclerotigenum, Cladosporium cladosporioides, Trichophyton rubrum, and Microsporum canis An ethanolic leaf extract showed antifungal efficacy. a variety of dermatophytes. Methanolic and MO leaf extracts in ethyl acetate were discovered to be powerful against both fungi. The present study's results According to the study, MO extract was effective against the test fungus. Both pathogens and solvents are required for the activity. MO extracts, according to Ganie et al, exhibit a possible antifungal impact on dermatophytic fungus like Gypsum microsporum. Consequently, MO is utilised in conventional medication to treat infectious infections and skin conditions[11-12].

6.3. Anticancer activity

The leaves of the moringa plant may have anticancer properties. O-Ethyl- 4-(□-Lrhamnosyloxy)benzyl carbamate 11 together with 4(□-L-rhamnosyloxy)-benzyl isothiocyanate 3 , niazimicin 4 and 3-O-(6′-O-oleoyl-□-D glucopyranosyl)-□-sitosterol 15 have been tested for their potential antitumor promoting activity using an in vitro assay which showed significant inhibitory effects on Epstein- Barr virus-early antigen36. It has been suggested that niazimicin is a powerful chemo preventive agent in chemical carcinogenesis. Additionally, the seed extracts have been shown to have positive effects on antioxidant parameters, cutaneous papillomagenesis in mice, and hepatic carcinogen metabolising enzymes. Neomycin and a seed ointment both effectively treated mice with Staphylococcus aureus pyodermia. Niaziminin, a thiocarbamate contained in the leaves of *M. oleifera*, has been discovered to prevent the activation of the Epstein-Barr virus caused by tumour promoters[11-12]. On the other hand, the naturally occurring 4-[(4′-O-acetyl--i-rhamnosyloxy) benzyl] 2 among the isothiocyanates strongly suppressed tumor-promoter driven Epstein-Barr virus activation, demonstrating that the isothiocyano group is a vital structural factor for activity 26. The inflammation caused by carrageenan in the mice's hind paw was reduced by the crude ethanol extract of dried seeds38. Additionally, the butanol, water, and hexane fractions of the crude ethanol extract of the dried seeds all reduced inflammation. The ethyl acetate fraction, on the other hand, increased inflammation and displayed toxicity. After the fraction was given orally to the mice, they perished. Additionally, the 12-0 tetradecanoylphorbol-13-acetate (TPA)-induced synthesis of Epstein-Barr virus-early antigen (EBV-EA) was suppressed by the crude ethanol extract, indicating that it has antitumor-promoting properties[5]. It has been discovered that moringa has the ability to treat various additional illnesses. It is well known that both a balance and the stimulation of Phase I and II drug metabolising enzymes signal a defence against chemical carcinogens (Singh et al., 2000). The hydroalcoholic *Moringa Oleifera* bifunctional inducer, inducing both Phase-I and Phase-II enzymes, was discovered by Bharali et al. in 2003. Gluthione-Stransferase (GST), cytochrome P450, and cytochrome b5 levels in the liver were said to have increased as a result. In a related study, Sharma et al. (2012) found that *Moringa Oleifera* had higher levels of cytochrome P450 and cytochrome b5.

Phase II detoxification enzymes such as NAD(P)H: quinone oxidoreductase 1 (NQO1), heme oxygenase 1 (HO1), and glutathione S-transferase (GST) are among the genes that are induced to be transcribed when Nrf2 is accumulated and translocated to the nucleus as a result of exposure to chemical or environmental stresses [87]. Since increased generation of inflammatory mediators and ROS has been linked to a variety of disorders, they are important targets for the treatment of ailments brought on by inflammation and oxidative stress [92]. Alternative medications are looked into because anti-inflammatory pharmaceuticals have potential health hazards. According to studies, MO seeds include compounds such nitriles, glycosidic glucosinolates, isothiocyanates, carbamates, and thiocarbamates, which have antioxidant and anti-inflammatory properties.

6.4. Antitumor activity

The effects of numerous isolates as anti-tumor promoters were revealed in a study to extract several bioactive compounds from *Moringa Oleifera* Lam. that was grown in the Philippines. One of these bioactive chemicals, niazimicin, was shown to have a role as an inhibitor against the two-stage mice tumorigenesis by Guevara et al. in 1999. A number of the test chemicals, especially anti-tumor promoters, were recommended by the in vitro screening results to be

effective. While papilloma-bearing mice incidence was reduced by 80% at 10 weeks and 17% at 20 weeks of promotion in the in vivo two-stage 50% delay in the promotion of tumours. Niazimicin was found to be an effective antitumor promoter in chemical carcinogenesis, according to this study's findings.

Folk medicine practitioners have acknowledged the utility of Moringa species in the treatment of tumours (Hartwell, 1971), and chemicals [1] and [2] have been shown to have anticancer potential (Fahey et al., 2004). According to recent studies (Guevara et al., 1999; Murakami et al., 1998), compound [1] and the corresponding compound [3] have emerged as the most potent inhibitors of phorbol ester (TPA)-induced Epstein-Barr virus initial activation of antigen in lymphoblastoid (Burkitt's lymphoma) cells. In one of these experiments (Murakami et al., 1998), compound [3] also suppressed tumour promotion in a mouse twostage DMBA (7, 12-Dimethylbenz(a)anthracene)-TPA (12-O-tetradecanoylphorbol-13-acetate) cancer model. After eating a drumstick, Bharali and colleagues (2003) observed that skin tumours were prevented.[3-8].

6.5. Antihypertensive activity

This plant is quite beneficial in treating cardiovascular problems due to its widespread combination of diuretic, lipid- and blood-pressure-lowering constituents56. Blood pressure is found to be stabilised by moringa leaf juice. Nitrile, mustard oil glycosides, and thiocarbamate glycosides have been isolated from Moringa leaves and were determined to be responsible for the blood pressure-lowering action, according to The Wealth of India, 1962. The majority of these substances are completely acetylated glycosides, which are extremely uncommon in nature and bear thiocarbamate, carbamate, or nitrile groups. Niazinin A, Niazinin B, Niazimicin, and Niazinin A B were isolated as four pure compounds using bioassay-guided fractionation of the active ethanol extract of Moringa leaves, and they demonstrated a blood pressure-lowering effect in rats through a possible mechanism. through the action of a calcium antagonist. Thiocarbamate and isothiocyanate glycosides, which are recognised to be the hypotensive principles58,59, have been isolated using activity-directed fractionation of the ethanol extract of *M. oleifera* pods. In the pods of *M. oleifera*, methyl phydroxybenzoate and -sitosterol have also demonstrated promising hypotensive action. Diuretic activity has been discovered in the roots, leaves, flowers, gum, and aqueous infusion of moringa seeds. These diuretic components are believed to complement the plant's general ability to reduce blood pressure[5-12]. Blood pressure is stabilised by MO leaf water.This plant is very helpful in treating cardiovascular disorders because it frequently contains diuretics along with lipid and hypotension-related components. According to Gilani, niazinin A, niazinin B, niazimisin and niacin A + B showed a hypotension effect in rats resulting from a calcium antagonist effect. Because of the diuretic nature of such compounds, this plant is likely to play a complementary role in the overall hypotension effect. MO fruit was found to reduce serum cholesterol, phospholipids, triglycerides, low density lipoprotein, very low density lipoprotein cholesterol phospholipid ratio to atherogenic index lipid and to decrease liver, heart and aorta lipid profile in hypercholesteremic rabbits and to increase fecal cholesterol excretion. Additionally, mice fed a high-fat diet showed significantly decreased serum cholesterol levels when given MO leaf extract.

6.6. Antidiabetic activity

A moringa leaf extract has been demonstrated to drop blood sugar levels within three hours of intake, albeit less successfully than the go-to hypoglycemic medication, glibenclamide. DM (Diabetes Mellitus) is a long-lasting metabolic condition. impaired glucose tolerance and hyperglycemia (Tiwari and Roa, 2002). The well-known benefits of *Moringa Oleifera* include pharmaceutical effects and is employed for the conventional diabetes mellitus treatment (Bhishagratna, 1991; Babu 2005; and Chaudhuri). The benefits of several medicinal plants on preventing diabetes for diabetes are acknowledged in several societies 2002's Grove and Altman. According to Ajit et al., 2003 that *Moringa Oleifera*'s hypoglycemic properties, coupled the production of N-benzyl thiocarbamates, N-benzyl carbamates, benzyl nitriles and a benzyl are found to cause insulin to be released. restraining behaviours (Francis et al., 2004). Abdull Razis, Ahmad Faizal MO has documented pharmacological effects, including are employed in the standard management of diabetes. Insulin-related issues are a feature of the condition known as diabetes. Insulin is produced by the pancreas and is then used by the body to utilise and store the fat and sugar that come from diet in healthy individuals. In people with diabetes, insulin sensitivity may be hampered in a few distinct ways. The pancreas may not produce any insulin at all in some people. The term "insulin resistance" refers to situations where the body does not respond to insulin as it should. Last but not least, diabetes can occasionally be distinguished by an insufficient amount of insulin produced by the pancreas. Like with any illness or condition, doctors and researchers are always looking for novel approaches to manage and treat diabetes. Diabetes symptoms have long been treated and managed with *M. oleifera*.

6.7. Antifirtility activity

At doses of 200 mg/kg and 400 mg/kg, respectively, the aqueous extract of root and bark demonstrated post-coital antifertility. Effect in rats, as well as late-pregnancy-induced foetal resorption. Researchers looked into the

progestational, antigestational, proestrogenic, and estrogenic effects of an aqueous extract of *Moringa Oleifera* roots. The traumatised uterus of ovariectomized rats did not exhibit a decidual response to oral doses of the extract up to 600 mg/kg. The extract's antifertility effect seems to result from a number of factors. . In 1987, A.O. Prakash and colleagues looked into the antifertility potential of an aqueous extract of *Moringa Oleifera* roots. Rats' pre- and post-implantation uterine histoarchitecture has been examined to determine the impact of an aqueous extract. In female reproductive organs of cyclic rats, S. Shukla et al. (1988) demonstrated anti-implantation activity from the aqueous extract of *Moringa Oleifera* as well as antifertility activity from the aqueous extract of the plant's roots. The uterine wet weight of rats with bilateral ovariectomies increased over time after extract administration by mouth. The activation of uterine histo-architecture facilitated this estrogenic activity. When the extract and estradiol dipropionate (EDP) were administered together, the uterine wet weight gradually decreased in comparison to the increase seen with EDP alone, and uterine histological structures were similarly inhibited. Using ovariectomized rats, S. Shukla et al. (1989) examined the antifertility effects of an aqueous extract of *Moringa Oleifera* roots on the genital tract in both the presence and absence of progesterone and estradiol dipropionate.

6.8. Antioxidant activity

Strong antioxidants are present in *Moringa Oleifera* leaves. This is due to the presence of natural antioxidant molecules such as phenolics, vitamin E, vitamin A, and vitamin C. flavonoids, too. Extracts that are aqueous, methanolic, and ethanolic of MO's leaves and roots display potent in vitro antioxidant. They are a rich source of antioxidant chemicals and may shield animals from diseases brought on by oxidative stress. Administration extract from MO leaves appears to stop oxidative harm brought on by a high-fat diet. Aqueous *M. oleifera* leaf extracts considerably boosted the activity of the enzymes superoxide dismutase, catalase, and glutathione S-transferase and lowered lipid peroxidation, according to studies with normal and diabetic rats [61]. According to some research, both healthy and diabetic people may be protected from oxidative damage by the extract's high phenolic and flavonoid content [61]. In addition, a study involving 60 postmenopausal women revealed that supplementing with *M. oleifera* leaf powder for three months significantly reduced the serum levels of malondialdehyde, which is produced by lipid peroxidation, and elevated levels of ascorbic acid, superoxide dismutase, and glutathione peroxidase, which are indicators of the plant's antioxidant property[8].

6.9. Anti-inflammatory activity

After being treated with extracts from the roots, stems, leaves, flowers, pods, and seeds of *M. oleifera*, anti-inflammatory action has been noted. *M. oleifera* root extract inhibited the growth of paw edema in a research with rats, producing outcomes comparable to those of phenylbutazone, a non-steroidal anti-inflammatory medication having analgesic and antipyretic characteristics. Additionally, via altering Th1/Th2 cytokines, the butanol extract of *M. oleifera* seeds prevented guinea pigs from developing bronchospasms and airway inflammation caused by acetylcholine[8-13]. Additionally, *M. oleifera* dried seed powder significantly increased forced vital capacity, forced expiratory volume, and peak expiratory flow without causing any negative side effects in a clinical investigation with patients with mild to moderate asthma. The anti-inflammatory activities of *M. oleifera* may be due to a variety of bioactive substances, including quercetin, which inhibits the activation of NF-B, a crucial step in breaking the cycle of inflammation.

6.10. Gastroprotective activity

As a safe and efficient ulcer treatment, MO leaf extract may include active compounds that have gastroprotective and mucus-enhancing properties. The phytocomponents flavonoids, tannins, terpenoids, sterols, alkaloids, and phenols, which have been shown to be present in the leaves extract of MO, may be responsible for the gastroprotection provided by MO extract. These phytochemicals have beneficial impacts on gastroprotective and anti-ulcer characteristics. It is well documented that chronic stomach ulcers brought on by acetic acid have improved dramatically in mice given Mo leaf extract.

6.11. Hypercholsterolemic activity

After giving a crude extract of *M. oleifera* leaves to rats on a high-fat diet, Ghasi et al. noticed a hypocholesterolemic activity that resulted in a decrease of up to 14% in serum cholesterol levels. Consuming fruit from *M. oleifera* is also efficient in lowering serum levels of very-low-density lipoprotein, low-density lipoprotein, and high-density lipoprotein [54]. *M. oleifera* leaf extract has also been shown to lessen the development of atherosclerotic plaques in addition to these benefits.

Few investigations have been conducted on people, although some studies have shown that *M. oleifera* may be useful in treating hyperglycemia and dyslipidemia (Table 5). For instance, in research with 46 people with type-2 diabetes, 8 g of *M. oleifera* leaf was administered daily.

7. Discussion

The *Moringa Oleifera* plant is widely available in India; its wild source is uncommon, but it is widely grown there. Its entire structure, including the leaf, fruit, seed, and stem, is beneficial for treating a variety of illnesses. The leaves of *Moringa Oleifera* and other plant organs display a variety of pharmacological and physiological actions. The anti-diabetic (anti-hyperglycemic), antioxidant, chemoprotective, and anti-dyslipidemic effects of *M. oleifera* were studied in animal studies using hydroalcohol, alcohol (methanol or ethanol), and aqueous extracts of the plant's leaves and other organs. Human studies used powdered leaf preparations. It is a tree with numerous uses that may either be processed into another form for use in different locations or consumed as food. The standardized *M. oleifera* leaf extracts that have a wide variety of applications need to be studied. Future investigations would use this research as a foundation.

8. Conclusion

In conclusion, it has been demonstrated in multiple instances that the *Moringa Oleifera* tree has a wide spectrum of therapeutic and medical characteristics. For instance, this paper examines the Moringa's general nutritional contents and its anti-fibrotic, anti-inflammatory, anti-microbial, and anti- properties. Additional research into the Moringa plant's components and method of action may offer amazing potential for creating pharmaceutical drugs. Due to its pharmacological and medicinal characteristics, moringa is a well-known herb. Beyond meeting basic needs, it contains numerous bio-active components that promote extra health advantages. Due to its high nutritional bioavailability and therapeutic qualities, it helps with a variety of illnesses, including diabetes, high blood pressure, cancer, and disease prevention through antioxidant activity, including heart attack, obesity, Parkinson's disease, and Alzheimer's disease. The hypercholesterolemia that caused a rise in body weight, total cholesterol, triglycerides, and a decrease in HDL values is controlled by moringa extracts. It shows a marked decline in the concentrations of liver biomarkers and glucose.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Ng CX, Affendi MM, Chong PP, Lee SH. The potential of plant-derived extracts and compounds to augment anticancer effects of chemotherapeutic drugs. Nutrition and Cancer. 2022 Aug 13, 74(9):3058-76. Al-Dabbas MM, Ahmad RA, Ajo RY, Abulaila KH, Akash MU, Al-Ismail KH. Chemical composition and oil components in seeds of Moringa peregrina (Forssk) Fiori. Crop Res. 2010, 40(1):2.

[2] Dixit S, Tripathi A, Kumar P. Medicinal properties of *Moringa Oleifera*: A review. International Journal of education and Science research review. 2016 Apr, 3(2):173-85.

[3] Razis AA, Ibrahim MD, Kntayya SB. Health benefits of *Moringa Oleifera*. Asian pac J cancer prev. 2014 Jan 1, 15(20):8571-6.

[4] Sujatha BK, Patel P. *Moringa Oleifera*–nature's gold. Imperial Journal of Interdisciplinary Research. 2017, 3(5):1175-9.

[5] Singh U, Dwivedi C, Kulsum U, Verma N, Saraf S, Pradhan DK. Phytochemistry and medicinal uses of *Moringa Oleifera*: an overview. Journal of Drug Delivery and Therapeutics. 2017 Nov 15, 7(6):104-16.

[6] Fahey JW. *Moringa Oleifera*: a review of the medical evidence for its nutritional, therapeutic, and prophylactic properties. Part 1. Trees for life Journal. 2005 Dec 1, 1(5):1-5.

[7] Parrotta JA. *Moringa Oleifera*. Enzyklopädie der Holzgewächse: Handbuch und Atlas der Dendrologie. 2004 Jul 13:1-8.

[8] Ercan K, Gecesefa OF, Taysi ME, Ali Ali OA, Taysi S. *Moringa Oleifera*: a review of its occurrence, pharmacological importance and oxidative stress. Mini Reviews in Medicinal Chemistry. 2021 Feb 1, 21(3):380-96.

[9] Brilhante RS, Sales JA, Pereira VS, Castelo DD, de Aguiar Cordeiro R, de Souza Sampaio CM, Paiva MD, Dos Santos JB, Sidrim JJ, Rocha MF. Research advances on the multiple uses of *Moringa Oleifera*: A sustainable alternative for socially neglected population. Asian Pacific journal of tropical medicine. 2017 Jul 1, 10(7):621-30.

[10] Bashir KA, Waziri AF, Musa DD. *Moringa Oleifera*, a potential miracle tree, a review. IOSR J. Pharm. Biol. Sci. 2016, 11:25-30.

[11] Kumar GK, Ramamurthy S, Ulaganathan A, Varghese S, Praveen AA, Saranya V. *Moringa Oleifera* Mouthwash Reinforced with Silver Nanoparticles–Preparation, Characterization and its Efficacy Against Oral Aerobic Microorganisms–In Vitro Study. Biomedical and Pharmacology Journal. 2022 Dec 20, 15(4):2051-9.

[12] Ugwoke CE, Eze KA, Tchimene KM, Anze SP. Pharmacognostic evaluation and antimicrobial studies on *Moringa Oleifera* Lam.(moringaceae). International Journal of Pharmaceutical Sciences and Research. 2017, 8(1):88.