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A REVIEW ON THERAPEUTIC AND POTENTIAL BENEFITS OF *MORINGA OLEIFERA*

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Abstract:

Moringa oleifera, commonly known as the Miracle tree because of its nutritional and therapeutic properties, is a member of the Moringaceae family. The same species is known as the horseradish tree, drumstick tree, or ben oil tree. It is widely cultivated throughout India found in the tropical and subtropical zones of the world globe. Medicines, functional food preparations, water filtration, and biodiesel generation are all possible applications of Moringa oleifera. *Drumstick tree contains various bioactive constituents like flavonoids, glucosinolates, phenolic acid, terpenes, alkaloids, sterols, saponins and tannins etc.* Moringa oleifera *has various biological activities which comprise antidiabetic, anticancer, antioxidant, antimicrobial, anti-inflammatory, antifertility, hepatoprotective, antiviral, anticonvulsant, anti-trypanosomal, antileishmanial, antihyperlipidemic, hypocholesterolaemic, antispasmodic, antihypertension, antispasmodic, analgesic and antipyretic effect. Each part of the horseradish tree shows nutritive value; hence it is significant for nutritional and commercial purpose. Minerals, vitamins, and other phytochemicals are abundant in these plants. It contains vitamins A, C, B1, B2, B3, E as well as minerals such as Calcium, Magnesium, Phosphorous, Potassium, Copper, Iron and Sulphur all of which are essential for human growth and development. Due to the presence of vitamins and minerals,* Moringa oleifera *is widely used in the treatment of malnutrition. By use of drying and freezing technique, we can store nutrients from the leaves of* Moringa *for a longer period of time. Apart from its nutritional and therapeutic properties, the horseradish tree has a plethora of other noteworthy qualities, making it ideal for aesthetics, agriculture, and industrial applications. Horseradish tree has a lot of potential for purifying domestic water supplies as well as treating agricultural, commercial, and municipal wastewater. Seeds of* Moringa oleifera *plays a vital role in water treatment.*

Keywords: *Moringa oleifera, Moringa peregrine, bioactive components, biological activities*

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INTRODUCTION:

Moringa oleifera is a kind of Moringa popularly known as "The Miracle Tree," "Horseradish-tree," "Drumstick-tree," or "Ben oil tree" because it has great nutritional and Medicinal significance. Around 33 species were belonging to the Moringaceae family. Between them the thirteen species are best recognized and found globally, M. arborea, M. borziana, M. concanensis, M. drouhardi, M. hildebrandtii, M. longituba, M. oleifera, M. ovalifolia, M. peregrina, M. rivae, M. ruspoliana, M. stenopetala. Moringa oleifera is the most common of the 13 species that is highest cultivated in tropical and semitropical plant over an area of a domain as it has a notable variety of curative usage with great nutritive significance [1]. The overwhelming awareness of the horseradish tree is due to its versatile usage and its capacity to guarantee good harvests where other crops are inept to do so, in many nations maximum people are in danger of dietary insufficiencies. Moringa oleifera has various biological activities which comprise antidiabetic, anticancer, antioxidant, antimicrobial, anti-inflammatory, analgesic, antipyretic, antifertility, hepatoprotective, antiviral, anticonvulsant, anti-trypanosomal, antileishmanial, antispasmodic, antihyperlipidemic, hypocholesterolemic and antihypertension effect [2]. In various nations, many scientists described that entire portion of horseradish tree such as leaves, fruits, immature pods, and flowers are beneficial and because of that they are incorporated into the food for human intake [3].

Taxonomic Classification:

Kingdom	**Plantae**
Subkingdom	Tracheobionta
Super division	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Dilleniidae
Order	Capparales
Family	Moringaceae
Genus	*Moringa*
Species	*oleifera*

Distribution:

The horseradish tree grows up to 1,400 metres above sea level on alluvial soil or along riverbeds and rivers in the Himalayan ranges of South Asia, from north-eastern Pakistan (33°N, 73°E) to northern West Bengal State in India and north-eastern Bangladesh [4].

Morphology: Moringa oleifera is a tiny, fast-growing perennial plant. A deciduous tree that can reach a height of 10 to 12 meters is known as an evergreen. It has a drooping crown, delicate, breakable offshoots, feathery leaves, and dense, feathery foliage, as well as corky, white bark [4].

Leaves: Leaves of Moringa oleifera are usually found as bipinnate or tripinnate with nearby 45 cm enlarge and they are arranged alternately and spirally on the twigs. Leaflets of Moringa oleifera are around 1.2 to 2.0 cm lengthy and 0.6 to 1.0 cm widespread, the leaflets on the sides and those at the end of their leaves are elliptic, outer ends respectively; the lateral leaflets petioles are 1.5 to 2.5 mm elongated, those of terminal ones 3 to 6 mm elongated. The leaflets are bushy, green, and practically hairless, with full margins and short-pointed bases and pointed tips. The twigs are finely bushy and green in appearance [5]. Hyperglycemia, asthma, influenza, heart disease, dyslipidemia, malaria, syphilis, diarrhoea, pneumonia, scurvy, burns, headaches, bronchitis, skin disorders, diseases of the eyes and ears, and other conditions are treated with horseradish tree leaves. It also decreases blood pressure and cholesterol levels, as well as acting as a neuroprotector [6]. In 2009, as per Japanese research, Leaves serve as a strong drain for the uptake and consumption of carbon dioxide. The assimilation proportion of carbon dioxide from the horseradish tree is 20 times greater than that of vegetation in general. Moringa has seven times the vitamin C of bananas, ten times the vitamin A of carrots, and seventeen times the vitamin A of oranges, as well as four times the calcium of milk, nine times the protein of yoghurt, fifteen times the potassium of bananas, and twenty-five times the iron of spinach [7].

Flowers: Moringa oleifera blooms are scented, bisexual, yellowish-white flowers grown on slender, hairy stalks in disseminated or axillary bunches that are 10–25 cm long. Individual flowers are 0.7 to 1 cm long and 2 cm wide, with five unequal yellowish-white spathulate petals, five stamens with five smaller sterile stamens, and a pistil consisting of a 1-celled ovary and slender style set in a 3 mm elongated basal cup [4].

Seeds: Seeds of Moringa oleifera have a diameter of around 1 cm, with 3 white papery wings at the corners. Seed weights per kilogram range from 3,000 to 9,000 seeds vary between varieties. Around 15000 to 21000 seeds per year can be produced by each tree. Seeds contain many phytochemicals, antioxidants such as vitamin C, β-carotene, alpha and β-carotene, γ-tocopherol, β-sitosterol, phenolic compounds, vitamin

A, quercetin, and kaempferol, as well as flavonoids and anthocyanins, as well as glucosinolates, alkaloids, and isothiocyanates. Mature seeds of Moringa oleifera are rich in oil, comprising 22 to 40% crude fat [7].

Roots: Roots of the horseradish tree show anti-ulcer, anti-inflammatory and cardiac stimulant action. Seedlings grow a bloated, tuberous, white taproot with a pungent characteristic smell. Trees that have been produced from seeds have a deep, stout taproot and a system of thick, tuberous lateral roots that spread widely [3].

Bark and Wood: Moringa oleifera has whitish-grey bark that is dense, fuzzy, fissured, warty, or corky as it ages. When the bark is wounded, it produces a white gum that when exposed to sunlight turns reddish-brown or brownish-black. Moringa oleifera has a squashy, light wood with a density of 0.5 to 0.7 g/cm3 [7].

Pods: Pod husks of Moringa oleifera contain alkaloids, tannins, flavonoids, triterpenoids, cardiac glycosides and diterpenoids. Extract of husks suggests probable antimicrobial activity against some Enterococcus faecalis, bacteria like Staphylococcus epidermidis, bacteria like Klebsiella pneumonia and Salmonella typhimurium. Pods of Moringa also treating problems associated with liver, diarrhoea, spleen and joint pain [8].

Nutritive Properties: Drumstick tree contains a lot of minerals, vitamins and other phytochemicals which are necessary for the growth and development. Calcium, potassium, zinc, magnesium, iron, and copper are abundant in the leaves of the horseradish tree. Calcium, which is considered to be one of the vital minerals for human development. Horseradish-tree contains vitamins such as vitamin A beta-carotene, vitamin B such as folic acid, pyridoxine, and nicotinic acid, as well as vitamins C, D, and E. Anti-cancer substances such glucosinolates, isothiocyanates, glycoside compounds, and glycerol-1-9-octadecanoate, as well as phytoconstituents like tannins, sterols, terpenoids, flavonoids, saponins, anthraquinones, alkaloids, and reducing sugar, are found. Leaves of horseradish-tree are low in caloric value, hence these can be used in obese food [9]. The pods are fibrous and beneficial for the treatment of digestive disorders and the prevention of colon malignancy. The amino acid content of the horseradish tree's pods, leaves, and flowers is 30, 44 and 31%, respectively. Palmitic, linolenic, linoleic, and oleic acids were identified in similar amounts in immature pods and flowers. Nowadays, Moringa powder is used as a supplement for iron tablets, thus curing anemia. Moringa oleifera has been claimed to contain more iron than spinach [10].

Table 1: Various amino acids, micronutrients and nutrients present in *Moringa oleifera*

Amino acids		Micronutrients		Nutrients
Essential	**Non-essential**	**Minerals**	**Vitamins**	
Arginine	Alanine	Calcium	Vitamin A	Proteins
Histidine	Aspartate	Magnesium	Vitamin B_2	Lipids
Leucine	Cysteine	Sulphur	Vitamin B_3	Carbohydrates
Lysine	Glutamate	Sodium	Vitamin B_7	Fibres
Methionine	Glycine	Potassium	Vitamin B_{12}	
Phenylalanine	Proline	Phosphor	Vitamin C	
Threonine	Serine	Iron	Vitamin E	
Tryptophan	Tyrosine	Zinc		
Valine		Copper		

Processing of *Moringa oleifera*: Maximum plants drop their nutritional goods after processing. Related to the nutritional content of fresh, sprouted and fermented Moringa seed powder, phytochemicals were found to be greater in fresh seeds powder and amino acid content in fermented and sprouted seeds powder. This may be attributed to biochemical activity during sprouting and bacterial action throughout fermentation. Though, the outcome of boiling, seething and bleaching on the conservation of the nutrient content of horseradish-tree leaves was investigated in a study. Among all of the techniques, boiling technique is the most effective as it lowers the content of cyanide, oxalate and phytate, most considerably than the further two techniques. The

obtainability of iron and antioxidant content is increased by boiling. Therefore, the refined seed flour of Moringa can be used to treat problems with malnutrition [11].

Preservation Methods: Horseradish-tree may be stored without a nutrient loss for a long period of time. The leaves can be preserved by either drying or freezing them. With the exception of vitamin C, drying leaves in a lower temperature oven retains the bulk of the nutrients compared to freeze-dried leaves. Therefore, to maintain nutrients in the leaves, drying can be achieved using inexpensive household appliances such as stoves. The dehydration preservation process extends the shelf life of horseradish trees while maintaining their nutritional content. Drying is the oldest and most widely used process for the preservation of Vegetables and fruits. Drying out of food retains and protects nutrients by eliminating the moisture required for bacteria, yeasts, and molds to live. Drying makes changes in the characteristics of the food, including discoloration, loss of fragrance, changes in textures, nutritional value, and alterations in physical appearance and shape [12].

Phytochemistry: Analysis of the phytochemicals of Horseradish-tree provides the chance to investigate several constituents that are somewhat special. Species of Moringa contain numerous phytochemicals, like alkaloids, saponins, tannins, phenolic acids, steroids, glucosinolates, terpenes, and flavonoids. Various phytoconstituents present in Moringa gives many pharmacological benefits. Regardless of the genus's high phytochemical content, only specific species were investigated for their constituents, specifically, Moringa concanensis, Moringa peregrina, Moringa stenopetala, as well as Moringa oleifera, and major of the research concentrated on the leaves of the plant. The phytochemical quality of horseradish-tree has implications for its use as a food plant and as a source of micronutrients as well as its medicinal effects [13].

Flavonoids: Moringa oleifera has inflated free radical scavenger action, primarily because of greater flavonoid material. The bulk of flavonoids present in the Moringa oleifera as a form of flavonol and glycoside. The abundant source of polyphenol constituents like flavonoids and phenolic acids is the dry leaves of horseradish-tree [14]. Flavonoids present in the Horseradish-tree are effective against microbial infection as a structure contains a benzo-pyrone ring. It is indicated that the consumption of flavonoids protects from the contradiction of long-lasting ailments linked to oxidative stress, comprising cardiac ailment and malignancy. Leaves of Horseradish-tree are a noble source of flavonoids. Rutin, quercetin, rhamnetin, kaempferol, apigenin, and myricetin are the most common flavonoids found in Moringa. Quercetin is found as quercetin-3-O-d-glucoside in the dried leaves of the horseradish tree (iso-quercetin or isotrifolin). Quercetin, with several therapeutic properties, is a potent antioxidant. It has hypolipidemic, anti-diabetic and hypotensive properties. Phenolic acids are a type of phenolic chemical found naturally in plants that has antioxidant, anti-inflammatory, anti-mutagenic, and anti-tumor properties. They are made up of hydroxybenzoic acid and hydroxycinnamic acid [15].

Glucosinolate: Glucosinolates are common in Moringa species. 4-O-(α-L-rhamnopyranosyloxy)-benzyl glucosinolate is the most abundant glucosinolate found in horseradish trees. Glucosinolates are the secondary metabolites present in the plant. It has been found that both glucosinolates and isothiocyanates have significant properties that promote health. In the leaves of the horseradish tree, three isomers of 4-O- (α-L-acetyl rhamnopyrosyloxy)-benzyl glucosinolate have been identified, which are dependent on the maturity and physiological characteristics of the leaves. When plant tissues are disrupted, such as by cutting or chewing, myrosinase is released, which reacts with glucosinolates to produce isothiocyanates. Isothiocyanates have recently become a main focus in science because of numerous biological functions, like antitumour, antidiabetic, anti-inflammatory, and antimicrobial activity. Isothiocyanate is usually existing as volatile oil and unstable at room temperature. Indistinct, isothiocyanate present in horseradish-tree is almost constant; since structure contains extra sugar moiety which presents at room temperature as a solid [16].
Bennett et al., stated in the year 2003 that leaves, seeds, and roots of horseradish-tree contain glucosinolates and phenolics, without detection of proanthocyanidin or anthocyanidins [17].

Phenolic acid: Gallic acid is the most common phenolic acid found in horseradish leaves. The leaves included modest amounts of elagic acid, ferulic acid, caffeic acid, o-coumaric acid, and chlorogenic acid, as well as gentisic acid, syringic acid, r-coumaric acid, and sinapic acid [18].

Terpenes: The main carotenoid present in the leaves of horseradish-tree is Lutein. Horseradish-tree

contains α-carotene which typically found in plants with green leaves [19].

Alkaloids: A class of chemical compounds primarily containing basic nitrogen atoms are alkaloids**.** Two new glycosides of pyrrole alkaloids Marumoside A and Marumoside B glycosides, as well as Pyrrolemarumine -4"-O-α-L-rhamnopyranoside, were isolated from Moringa oleifera leaves [20].
Sterols: A sterol glycoside, β-sitosterol-3-O-D-galactopyranoside, was isolated from a *Moringa oleifera* stem bark chloroform extract. The main steroidal components in *Moringa* peregrina oil were β-sitosterol (56.76%), campesterol (23.24%), and stigmasterol (8.11%). Horseradish tree leaves and seeds were used to isolate β-sitosterol [21].

Saponins: Leaves of horseradish-tree is a noble source of saponins, which is a natural constituent that is prepared from covalently bonded sugar moieties, i.e., isoprenoid-derived aglycone. Saponins have anti-tumour properties [22].

***Moringa oleifera* is used as a food additive:** There is mounting evidence that including horseradish-tree improves the physicochemical and organoleptic qualities of food and foodstuffs, as well as their shelf life. The antibacterial activity of many components of the horseradish tree has been demonstrated. Moringa seed and leaf extracts are antimicrobial, preventing bacteria from growing. Ethanolic extract of leaves of horseradish-tree shows wide-spectrum action against foodborne pathogens: *E. coli, P. aeruginosa, S. aureus* and *E. aerogenes.*

Because of the presence of numerous types of antioxidant elements, such as ascorbic acids, phenolics, flavonoids, and carotenoids, *Moringa oleifera* enhances the shelf life of fat-containing diets. There is some data from research that indicates that horseradish-tree used to increase the organoleptic properties of foodstuff items such as pastries and meat [23].

Medicinal Uses of *Moringa oleifera*: Horseradish-tree is sometimes mentioned as a panacea, and more than 300 diseases can be healed by it. Horseradish-tree is widely used by Indians and Africans as herbal medicine. The existence of phytoconstituents makes it a worthy therapeutic mediator. The roots, bark, leaves, blossoms, fruits, and seeds of the horseradish tree have traditionally been used to treat a variety of ailments, including stomach tumour, hysteria, scurvy, paralysis, helminthic bladder, prostate issues, sores, and other dermal contagions [24]. Anticancer, antipyretic, antiepileptic, anti-inflammatory, antiulcer, spasmolytic, diuretic, antihypertensive, hypoglycemic, cholesterol-lowering, antioxidant, antibacterial, antifungal, antidiabetic, anti-asthmatic, and hepatoprotective are its medicinal properties. It has been and continues to be used to avoid, cure or treat many illnesses and diseases by folk medicine practitioners. It is also used in household medication formulation in various parts of the globe as an alternate medication for the cure and management of allergies, inflammation, and ailments. Because of these described purposes, the bioactivity of horseradish-tree has achieved remarkable consideration over the past era, thus leads to a rise in consideration and understanding of its pharmacological roles and fundamental mechanisms [25].

Anti-diabetic Effect: Various constituents are found in leaves of horseradish-tree that are involved in glucose homeostasis. One of the examples is isothiocyanates that diminish insulin resistance as well as hepatic gluconeogenesis. Glucose homeostasis is affected by phenolic acids and flavonoids, prompting β-cell Mass and role and rising sensitivity to insulin in exterior tissues. Moringa has been shown to be beneficial in the treatment of both type 1 and type 2 diabetes. Retinopathy, atherosclerosis, and nephropathy are all complications of diabetes. Horseradish tree can be used to cure such problems. Blood glucose interacts with proteins as hyperglycemia progresses, resulting in advanced glycated end products (AGEs). RAGE, a protein present on the surface of immune cells, binds to these AGEs. As a result of this treatment, the transcription of cytokines like interleukin-6 and interferons rises. Cell adhesive molecules are disseminated on the endothelial surface of arteries at the same time. The promotion of transendothelial migration leads to arterial inflammation and atherosclerosis. Ethyl alcohol and water extract of the aerial parts of *Moringa peregrine* showed antidiabetic action as opposed to streptozotocin-diabetic rats by dropping the glucose level in the blood. The extract reduced the mRNA expression of PPARα1, PPAR-γ, and HMG-CoAR, which are responsible for fat homeostasis, throughout the study [26]. In mice infected with streptozotocin, a seed extract from the horseradish tree reduced lipid peroxidation and increased the synthesis of antioxidant enzymes [27]. Streptozotocin is a type of antibiotic that is used to treat infections. The generation of superoxide and reactive oxygen species (ROS) in beta cells is aided by ATP dephosphorylation activities and xanthine oxidase. In hyperglycemic

patients, beta cells are destroyed. As a result, more glucose enters the cell's powerhouse, releasing reactive oxygen species. As a result, β-cells have a low number of antioxidants, which leads to apoptosis. It reduces insulin release, resulting in an increase in blood glucose level [28].

Anti-cancer effect: Usage of horseradish-tree is being explored in the treatment of different cancers. The keyway used for the antitumor action of horseradish-tree is by preventing multiplication via programmed cell death. Leaf and bark extracts of horseradish-tree inhibit breast, pancreatic, and colorectal cancer cell growth effectively [29]. Methanolic extract of *Moringa concanensis* root bark prevents the multiplication of malignant hepatoma cells via key paths by regulating caspase 9 and caspase 3 [30]. According to a study, the horseradish tree can protect biological cells from oxidative DNA damage linked to cancer and degenerative diseases. Using a human tumour KB cell line as a model system, The antiproliferative and apoptotic effects of aqueous leaf extracts of the horseradish tree. The leaf extracts contained phenolic components such as quercetin and kaempferol, flavonoids, and trace quantities of alkaloids, according to qualitative analyses [31]. An aqueous extract of horseradish tree leaves, according to the Jung study, exhibits substantial anticancer effect against lung cancer cell lines as well as a range of other cancer cells. Inside human cancer cells, the extract causes apoptosis, slows tumour cell proliferation, and reduces reactive oxygen species levels. *Moringa oleifera* seed extract inhibits the neuroblastoma cell line by 95% when tested against a variety of tumour cell lines (lung, liver, colon and neuroblastoma). Amongst bioactive constituents when formulated in form of phytonanoparticles from horseradish-tree, niazimicin and thiocarbamate was found to have strong antitumor action [32].

Anti-oxidant effect: The Moringa oleifera tree contains around 40 natural antioxidants. Numerous antioxidant compounds, such as ascorbic acid, carotene, quercetin, kaempferol, flavonoids, phenolics, isothiocyanates, polyphenols, and rutin, are found in leaves; myricetin, tocopherols, and lectins are found in seeds; procyanidins are found in stem and root bark; palmitic acid, phytosterols, and 9-octadecen Leaf extracts in methyl alcohol and acetone, aqueous root extracts, stem and pod extracts in methanol all have a diverse antioxidant profile [33]. Horseradish tree has a high phenolic content, which leads to their high antioxidant action. By donating or accepting electrons, phenolic compounds stabilize radicals formed in cells, thus acting as antioxidants. Leaves of horseradish tree contain a greater number of antioxidants and hence these can be used in patients with inflammatory disorders such as malignancy, hypertension, and heart diseases. In the extract of leaves of *Moringa oleifera*, a number of other constituents present like tannins, flavonoids, saponins, terpenoids and glycosides, all these constituents have a therapeutic effect. These compounds act as antioxidant, anti-carcinogenic and antimicrobial agents. Phenolic chemicals are employed as important antioxidants for inactivating lipid free radicals and inhibiting the breakdown of hydroperoxides into free radicals due to their redox characteristics. The neutralization of free radicals, the quenching of singlet or triplet oxygen, and the breakdown of peroxides all require these properties. The aqueous leaf extract of the horseradish tree boosts the action of enzymes such as superoxide dismutase, catalase, and glutathione S-transferase and lowers the action of lipid peroxidation, according to a study conducted on normal and diabetic rats. If the extract has a high phenolic and flavonoid content, it is thought to protect against oxidative damage in both healthy and diabetic people. The radical scavenging and antioxidant activity of aqueous ethyl alcohol extracts from lyophilized leaves of Moringa oleifera from various Agro-climatic zones. They discovered that different leaf extracts reduced 89.7–92.0 percent of linoleic acid peroxidation and exhibited dose-dependent scavenging effects on superoxide radicals using the β-carotene-linoleic acid technique. According to a comparative investigation, mature *Moringa oleifera* leaf extract has higher levels of enzymatic and non-enzymatic antioxidants. Both mature and young leaf extracts demonstrate significant reductions of DPPH radicals in the DPPH (2,2-Diphenyl-1-Picrylhydrazyl) free radical scavenging activity assay. The scavenging action was seen more in the mature leaf extract and was attributed to its hydrogen donating capacity [34, 35, 36].

Anti-microbial effect: In order to determine the antimicrobial action of *Moringa* species, a series of investigations were carried out with information that extracts from various parts of horseradish-tree comprising seeds, stem bark, leaves, and root bark can exert antimicrobial action. The seed extract of horseradish-tree constitutes water-soluble lectin which inhibits growth, survival and cell permeability of several species of pathological bacteria. Furthermore, the root extract of horseradish-tree constitutes pterygospermin, which is an active antibiotic that shows antibacterial and fungicidal action. Nowadays horseradish-tree is used for water purification and as

an antiseptic for water treatment, due to its high antimicrobial action. Microorganisms like *Salmonella typhi*, *Vibrio cholera*, and *Escherichia coli* are inhibited by n-hexane and methyl alcohol seed extract of *Moringa oleifera* and *Moringa stenopetala* [37, 38].

In lower concentrations, most of the extracts demonstrated stronger inhibition. In 2016, Elgamily *et al.*, evaluated dental antibacterial and antifungal activity for Ethyl acetate, 2-propanone, and ethyl alcohol extracts of seeds, roots, leaves of Horseradish-tree. Against Streptococcus aureus and Streptococcus mutans, all extracts of *Moringa oleifera* demonstrate inhibition, with ethanol and leaf extract showing the maximum inhibition. The ethyl alcohol extract, on the other hand, showed the most suppression of Streptococcus aureus and Streptococcus mutans of all the extracts, with the leaf extract showing the most inhibition. None of the extracts, on the other hand, prevent *Candida albicans* from growing [38].

It's also been proven that crude extracts of horseradish tree leave and seeds inhibit the activity of microbial proteases, which cause muscle damage in fish and shrimp during storage. As a result, these extracts/preparations can be used to inhibit seafood proteolysis and degradation during storage at low temperatures [39].

The ethyl alcohol seed extract of horseradish-tree exhibits antiviral activity against human herpesvirus-4 (which is known as the Epstein–Barr virus) and herpes simplex virus type 1, along with that hepatitis B virus replication inhibited by hydroalcoholic leaf extracts. Other Moringa components with antibacterial action include 4-(4'-O-acetyl-a-L-rhamnopyranosyloxy) benzyl isothiocyanate, 4-(a-L-rhamnopyranosyloxy) benzyl isothiocyanate, niazimicin, 4-(a-L-rhamnopyranosyloxy) and benzyl isothiocyanate [40, 41].

Anti-inflammatory effect: The anti-inflammatory properties of several sections of the horseradish tree are well documented. The root extract of the horseradish tree, for example, has a significant anti-inflammatory effect on rat paw edema produced by carrageenan. In addition, the n-butyl alcohol seed extract of horseradish-tree has anti-inflammatory effects against inflammation of the ovalbumin-induced airway in guinea pigs. In horseradish-tree, various bioactive constituents are present which shows anti-inflammatory action. One of the constituents like quercetin is present which prevent the activation of nuclear factor kappa B (NF-κB), a necessary step to unchain the inflammatory progression. Other constituents from horseradish-tree like flavonoids and phenolic acid are also involved in an anti-inflammatory activity. Ulcers caused by non-steroidal anti-inflammatory drugs were also inhibited by the *Moringa* species. Abdominal lesions caused due to the aspirin, serotonin and indomethacin can be reduced with the help of extract of horseradish-tree, while the abdominal lesions caused due to indomethacin can be reduced with the help of extract of aerial part of *Moringa peregrine*. TNF-α, IL-4, IL-6, and myeloperoxide, which are responsible for inflammatory bowel disorders, are inhibited by the hydroalcoholic seed extract of the horseradish tree, which lowers inflammatory bowel diseases. The human macrophage cytokine production (tumour necrosis factor-alpha), Interleukin-6, and Interleukin-8, which is produced by cigarette smoking, is inhibited by a leaf extract of the horseradish tree [42, 43, 44].

Anti-fertility effect: Horseradish tree shows antifertility activity. When various portions of the horseradish tree's root and bark are extracted in water, the extract demonstrates post-coital antifertility effect in rats, as well as fetal resorption, which occurs late in pregnancy. Along with that, an aqueous extract of roots of horseradish tree was assessed for estrogenic, anti-estrogenic, progestational and anti-progestational action. Extracted leaves of *Moringa stenopetala* with the help of ethyl alcohol and he stated that the extract of leaves decreases fertility by 73.3%. The extract had oxytocic action in the uteri of guinea pigs and mice. The extract also enhanced the smooth muscle in the mice's uteri, which could lead to uterine atrophy, preventing implantation. The extract of Moringa concanensis stem bark is utilized at 400 mg/kg to prevent implantation by 46 percent. The reaction was solvent-dependent. Unlike trichloromethane, benzine, and ethyl alcohol extract, the ethyl acetate fragment displayed the smallest anti-implantation action [45].

Hepatoprotective effect: Methyl extract of leaves of horseradish tree shows hepatoprotective action, which may be due to the existence of quercetin. The leaves of the horseradish tree have a significant influence on many enzymes in rats' livers, including aspartate aminotransferase (AST), alanine aminotransferase (ALT), and alkaline phosphatase (ALP), as well as lipids and fat peroxidation. These findings confirmed with the help of histological tests which shows that a decrease in damage to the liver and kidney in animals, those they are treated with leaves of horseradish tree. Furthermore, the root and flower extract of the

horseradish tree shows to have hepatoprotective action in opposition to various effects such as the effect of acetaminophen, reducing serum transaminases, alkaline phosphatase and bilirubin levels. Fat peroxidation is an important part of the body's metabolism. Cell damage and nerve dysfunction can occur when internal and external homeostasis are disrupted. The horseradish tree's leaves extract significantly reduces the liver damage caused by a high-fat diet in rats. In mice provoked by streptozotocin, a seed extract from the horseradish tree lowers lipid peroxidation and increases the synthesis of antioxidant enzymes. It also diminished the mice's immunoglobin IgG and IgA function, which declines Interleukin-6 which is accountable for glucose homeostasis and activity of pancreatic beta cells. Bioactive constituents like quercetin, kaempferol, glucomoringin, and chlorogenic acid show numerous biological actions like anti-melanoma, anti-oxidant, hypotensive, anti-inflammatory, hypoglycemic, and anti-dyslipidemic actions [46, 47].

Anti-viral effect: Horseradish-tree has been shown to have antiviral properties in previous studies as a conventional medicinal herb. Ethanolic leaf extract is harmful to the herpes simplex virus, and seeds are harmful to HSV-1. The ethanolic extract of leaves was discovered to have antiviral action against infectious bursal disease virus, foot and mouth disease virus, horse herpes virus, hepatitis virus, and rhinovirus. Newcastle disease virus was shown to have antiviral activity in aqueous seed extract. Treatment of any disease virus with extract of horseradish tree can delay the onset of skin injury, increase the mean survival period, and lower the death rate of HSV1 infected mice. In mice infected with HSV-1, an aqueous extract of leaves of the horseradish tree mediates cellular immunity by lowering virus concentration and restricting the production of herpetic skin lesions. Antiviral effects of *Moringa peregrina* seed oil have also been recorded against HSV. The phytoconstituents like 4-[(4′-Oacetyl-alpha-L-rhamnosyloxy) benzyl] isothiocyanate and niazimicin inhibit the activation of Epstein-Barr virus. At concentrations of 1–50 g/mL, horseradish-tree also inhibited the foot and mouth disease virus. Antiviral action of horseradish tree and rosemary extracts against herpes simplex viruses was investigated by researchers. The antiviral activity of aqueous extract of horseradish tree at a concentration of 200 g/ml was 43.2% and 21.4% for herpes simplex types 1 and 2, respectively. Aqueous extract of horseradish tree shows antiviral activity against HSV-1 in Vero cells. These findings suggest that flavonoid compounds like beta-amyrin can minimize or inhibit HSV-1 yield by preventing viral DNA replication [48, 49].

Miscellaneous Uses: Apart from its nutritional and therapeutic properties, the horseradish tree has a plethora of other noteworthy qualities, making it ideal for aesthetics, agriculture, and industrial applications [50]. Horseradish tree has a lot of potential for purifying domestic water supplies as well as treating agricultural, commercial, and municipal wastewater. Seeds of horseradish tree were discovered to contain a coagulant protein that impaired drinking water purification and was thus useful for wastewater treatment [51]. Seed powder of horseradish tree has piqued scientists' interest because of its ability to coagulate contaminants. A coagulant Lectin was isolated from seeds of the horseradish tree. Carbohydrate recognition proteins are known as lectins [52]. Seeds of horseradish tree have the same coagulation effect as that of alum but seeds of horseradish tree are much more effective for more turbid water. The coagulation efficacy of the horseradish tree differs as per the initial turbidity, but it is recorded that it can decrease turbidity by 92 to 99% [53]. Rural women in Sudan utilize crude seed extract of horseradish tree as an alternative for alum to cure the excessively murky Nile water due to a widespread concern of alum causing gastrointestinal disorders and Alzheimer's disease. Seeds of horseradish tree used as germ-killing in drinking water treatment. Water or a salt solution may be used to remove the coagulant protein from the horseradish tree. The amount of coagulant protein extracted by salt and water differs significantly in terms of volume and efficacy. Purification of the horseradish tree coagulant protein from crude salt extract, on the other hand, might be difficult both technically and financially. *Moringa* seeds could be used to remove cadmium (Cd) from aqueous media at a lower cost than other biosorbents [54]. Horseradish tree seed aqueous solution contains a complex combination of functional groups, predominantly low molecular weight organic acids (amino acids). Because of their propensity to connect with metal ions, these amino acids have been discovered to be a biologically active group of binding agents that function even at low concentrations and are likely to improve metal ion sorption. Proteaceous amino acids have a variety of pH-dependent structural features, including the ability to create a negatively charged environment and play a key role in metal binding. *Moringa oleifera* could be used in pharmaceuticals, functional foods, water filtration, and biodiesel generation [55].

CONCLUSION:

Moringa oleifera is widely cultivated throughout India found in the tropical and subtropical zones of the world. Moringa oleifera is a kind of Moringa popularly known as "The Miracle Tree," "Horseradish-tree," "Drumstick-tree" or "Ben oil tree" because it has great nutritional and Medicinal significance. Around 33 species belonging to the Moringaceae family. Drum stick tree contains minerals, vitamins and other phytochemicals necessary for growth and development. Moringa powder is used as a supplement for iron tablets, thus curing anemia. The pods are beneficial for the treatment of digestive disorders and the prevention of colon malignancy. Extract of horseradish tree shows antiviral activity against HSV-1 in Vero cells. Moringa peregrina seed oil also inhibits the Epstein-Barr virus. Treatment of any disease virus with extract can delay onset of skin injury, increase mean survival period and lower death rate. Extracts from various parts of horseradish-tree exert antimicrobial action. Salmonella typhi, Vibrio cholera, and Escherichia coli are inhibited by n-hexane and methyl alcohol seed extract. Moringa stenopetala extract had oxytocic action in the uteri of guinea pigs and mice. Leaf and bark extracts of horseradish-tree inhibit breast, pancreatic, and colorectal cancer cell growth effectively. Moringa oleifera seed extract inhibits the neuroblastoma cell line by 95% when tested against a variety of tumour cell lines. Moringa has been shown to be beneficial in the treatment of type 1 and type 2 diabetes. The extract reduced the mRNA expression of PPARα1, PPAR-γ, and HMG-CoAR. In mice infected with streptozotocin, a seed extract reduced lipid peroxidation.

Conflict of interests: The authors declare that there is no conflict of interest.

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