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Review Article

An Overview of the Ethno-Pharmacological Potentials of *Moringa Oleifera* Lam, "The Miracle Tree"

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Abstract

Moringa oleifera Lam belonging to the Moringaceae family is a small/middle-sized tree about 10m in height with wide distribution in the tropics and subtropics of Asia and Africa. It is a multipurpose tree with an impressive profile of medicinal uses, high nutritional value, and compelling water purifying attributes. Various parts of this plant such as the flower, seed, immature pod, stem bark, leaf and root, possess anti-oxidant, anticancer, antimicrobial, anti-ulcer, anti-hepatotoxic, antihypertensive, anti-hyperlipidaemic, antidiabetic, antispasmodic, antiepileptic, antipyretic, anti-inflammatory and analgesic properties. Phytochemical constituents isolated from different parts of the plant are 4-(α-L-rhamnopyranosyloxy)-benzylglucosinolate, L-arabinose, D-galactose, D-glucuronic acid, L-rhamnose, D-mannose, D-xylose and leucoanthocyanin. Others includes, glycoside niazirin, niazirinin and three mustard oil glycosides, 4-[4'-O-acetyl- α -L-rhamnosyloxy) benzyl] isothiocyanate, niaziminin A and B , isothiocyanate, thiocarbanates, 0-[2'-hydroxy-3'-(2''-heptenyloxy)]-propylundecanoate0-ethyl-4-[(α -1-rhamnosyloxy)-benzyl] carbamate, methyl-p-hydroxybenzoate and β-sitosterol . An overview of the pharmacological actions and medicinal uses of the plant is outlined in the present paper.

Keywords: *Moringa oleifera*, Medicinal plant, Tropics/subtropics, Pharmacological properties, Dietary supplementation

INTRODUCTION

The plant kingdom is nature's gift to mankind. It represents a rich source of many compounds for medicinal purposes which if properly harnessed, could open up a vibrant frontier for the development of life saving drugs. With its good efficacy and low toxicity profile, this plant is useful for various pathological disorders. There is also the need for the development of drugs from plant sources to combat the challenges posed by the increasing resistance by various pathogenic organisms to existing drugs.

Moringa oleifera Lamarck, Synonym *Moringa pterygosperma* Gaerth (family Moringacaee), is commonly known as Drumstick tree, horseradish tree, Shigru, and by several other names in the different communities of the world where the tree is found (The Wealth of India, 1962; Qaiser, 1973; Dhar and Gupta 1982; Anwar *et al*., 2007; Goyal, 2007) This rapidly-growing tree is now widely cultivated and has become naturalized in many countries in the tropics and subtropics. For centuries, this plant has been promoted for traditional medicinal uses. Different parts of this plant: the root, stem bark, leaf, flower, fruit (pods) have been employed for various ailments in Asian South and Central America, Caribbean and Oceania countries (The wealth of India, 1962; Fahey, 2005; Goyal *et al*., 2007; Aggarwal *et al*., 2011). Interestingly, all parts of the *Moringa oleifera* tree are edible and have long been consumed by humans.

Other traditional uses of this tree include: use as animal forage, domestic cleaning agent, green manure, fertilizer, biopesticide, biogas, foliar nutrient (Makkar and Becker, 1996 and 1997 ; Freiberger 1998; Fuglie 1999,2000; Dillard and German 2000; Fahey 2005; Goyal, 2007) Moringa seed oil, also known as Ben oil, is a sweet non-sticking, non-drying oil that resists rancidity. It has been used in salads, for fine machine lubrication, and in the manufacture of perfume and hair care products (Tsaknis *et al*., 1999). The plant can also be used to enhance the shelf–life of fat–containing foods, due to the presence of various types of antioxidant compounds such as ascorbic acid, flavonoids and carotenoids (Dillard and German, 2000). One of the best known uses for *Moringa* is the use of the powdered seed to flocculate contaminants and purify drinking water (Berger *et al*., 1984; Olsen, 1987; Gassenschmidt *et al*., 1995). The seed extracts have been used traditionally for purification of drinking water due to its high level of cationic proteins. This extract mediates high sedimentation efficiency of suspended mineral particles and bacteria. The cationic seed polypeptide has been employed to disinfect heavily contaminated water and also possesses bactericidal activity (Madsen *et al.*, 1987; Kalogo *et al*., 2000; Suarez *et al.*, 2003; Ghebremichael *et al*., 2005). The seed is also eaten green, roasted, powdered and steeped for tea or used in curries (Anwar *et al.*, 2007).

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Moringa oleifera is an important food commodity with enormous potential as a natural nutritional supplement in developing countries. The flowers, immature pods and leaves are used as highly nutritive vegetables in many Asian countries and parts of Africa. It is a good alternative to some leguminous seeds as a source of high quality protein. In the Philippines, the plant is referred to as "mother's best friend" because of its use to increase milk production in nursing mothers and is also prescribed for anaemia (D' souza and Kulkarni, 1993; Estrella *et al*., 2003). *Moringa oleifera* noodles has been reported to increase breast milk productivity and the udder gland enlargement of the female rats. (Titi Mutiara Kiranawati, and Nunung Nurjanah, 2014) Various parts of the plant have been reported to be rich sources of natural antioxidants such as β-carotene, Vitamin C and tocopherol (Freiberger *et al*., 1998). The high levels of iron, calcium, phosphorus, copper, riboflavin, folic acid, pyridoxine and essential amino acids such as methionine, cysteine, tryptophan and lysine present in this plant make it an ideal dietary supplement (Makkar and Becker, 1996; 1997).

This review attempts to bring together most of the available scientific findings on various parts of *Moringa oleifera* plant in order to stimulate comprehensive investigations of the multifaceted potentials of the plant. The Pharmacologic attributes of the various parts of this plant are detailed below (Table 1).

Antioxidant and anticancer activities

Epidemiological studies have shown that foods rich in antioxidants, such as fruits and vegetables provide protection against degenerative diseases such as Alzheimer's, coronary heart disease and the aging process, and also endows consumers of such foods with a low risk for various cancers (Abdulla and Gruber, 2000). Virtually all portions of the *Moringa oleifera* tree possess antioxidants which play critical protective roles in cancer prevention (Atawodi *et al*., 2010). The flowers of this plant are also reported to contain high levels of flavonoids such as quercetin and kaempferol (Rangaswani and Sankarasubraiman, 1946). Bajpai *et al*., (2005) reported that the antioxidant activity of the leaf extract was due to the presence of Kaempferol.These are compounds with phenolic hydroxyl groups which possess antioxidant properties. Quercetin and other flavonoids have been shown to inhibit the production of nitric oxide and tumor necrosis factor by Kupffer cells when stimulated by injury (Kawada *et al*., 1998). These flavonoids have been reported to protect cells against x-ray-induced damage, inhibit mutation, block cell cycle progression and prevent initiation of carcinogenesis in laboratory animals (Abdulla and Gruber, 2000). *Moringa oleifera* pod extract have also been reported to act against DMBA-induced kidney injury in mice by a mechanism related to its antioxidant properties (Paliwal R et al, 2011)

Moringa oleifera leaves are used worldwide as a nutritional supplement (Ramachandran *et al*., 1980; Dhar and Gupta, 1982) as they contain significant quantities of antioxidants such as vitamin A , vitamin C and vitamin E (Siddhuraju *et al.*, 2003; Ferreira *et al*., 2008; Verma *et al.*, 2009; Sreelatha and Padma, 2009) . The leaves are a potential source for antitumour activity (Singh *et al*., 2009). High levels of tocopherol are found in different parts of the plants, especially the leaves and the green seeds (Murakami *et al*., 1998; Guevara *et al*., 1999; Rao *et al*., 2001). Vitamin E is an antioxidant composed of tocopherols. The latter halts lipid peroxidation reactions initiated by free radicals in cellular and subcellular membranes by metabolizing peroxides, maintaining intracellular redox potentials and preventing cellular injury and cancer (Murakami *et al*., 1998; Rao *et al*., 2001). The paste of the leaves significantly increase the activity of carcinogen detoxifying Gluthathione-*S*-transferase in the stomach, oesophagus and liver of Swiss mice (Ferreira et al., 2008). Alcohol extract of the leaves has been shown to be radioprotective and to inhibit inducible nitric oxide synthase expression (Ferreira *et al*., 2008; Park *et al*., 2011). The extract has been reported to reduce chromosomal aberrations and exert a protective role against bone marrow cells clastogenicity (Ferreira *et al*., 2008). Previous reports demonstrated the presence of Niaziminin, a thiocarbamate, in the leaves, that exhibited antitumour activity against Epstein-Barr virus early antigen (Murakami *et al*., 1998; Nordberg and Arner, 2001). The cytotoxic activity of the leaf extract of this plant was also demonstrated on human multiple myeloma cell lines (Parvathy and Umamaheshwari, 2007).

The seed and immature pods also have demonstrable antioxidant and cancer chemoprotective activity (Santos *et al*., 2005). Bharali *et al*., (2003) showed that oral administration of the alcoholic extract of *Moringa oleifera* green pods to mice, increased the levels of liver carcinogen metabolizing enzymes such as cytochrome P450, cytochrome b5, gluthathione peroxidase and Gluthathione-*S*-transferase. *Moringa oleifera* can serve as an alternative to leguminous seeds as a source of high-quality protein and antioxidant compounds.

Antimicrobial activities

Previous studies have shown that the seeds, flowers, leaves, root and stem bark of *Moringa oleifera* have demonstrable antimicrobial activity against a broad spectrum of bacteria and fungi (Bhatnagar *et al*., 1961; Eilert *et al*., 1981; Madsen *et al*., 1987; Cáceres *et al*., 1991; Anwar and Rashid 2007; Jabeen *et al*., 2008; Shahid *et al*., 2008; Bukar *et al*., 2010; Prashith *et al*., 2010; Lűrling and Beckman 2010). *Moringa oleifera* flower has been shown to possess antimicrobial activity against gram positive organisms such as *Bacillus subtilis*, *Staphylococus aureus* and gram negative bacteria such as *Escherichia coli*. *Klebsiella pneumonia* (Talreja, 2010). Bhatnagar *et al*., (1961) reported that the aqueous extracts of the seed and juice from the stem bark exhibited antibacterial activity against *S. aureus*. The crude seed extracts and fresh leaf juice have also been shown to inhibit the growth of *P. aeruginosa* and *S.aureus* (Cáceres *et al*., 1991; Rathman *et al*., 2009). Jabeen et al, 2008 reported antimicrobial activity of the crude seed extracts against, *B. subtilis*, *S. aureus* and fungi species such as *F. solani*. Steam distillate fractions of *Moringa oleifera* inhibited the growth of *E .coli*, *S. aureus*, *K. pneumonia*, *P. aeruginosa* and *B. subtilis* and fungi such as *A. niger*, *A. oryzae* , *A .terreus* and *A. nidulans* (Prashith *et al*., 2010). Hueih-Min Chen (2007) demonstrated antifungal activities of ethanolic leaf extracts of this plant. Other reports of the antifungal activity of the crude extracts of the leaf and the seed against the following dermatophytes: *T. rubrum*, *T. mentagrophytes*, *E. floccosum*, and *M. canis* have been documented *(*Chuang *et al*., (2007). Cáceres and Lopez (1991) reported the antibacterial activity of the seed against pyodermia causing *S. aureus* in mice.

Table 1:
Some common pharmacological attributes of the root, stem bark and leaves of *Moringa oleifera*

Plant part	Pharmacologic Properties	References
Root	Anti-inflammatory	Ezemuzie *et al*., 1996 Ndiaye et al 2002; Sashidhara et al,2009
	Antifertility/abortifacient	Shukla et al 1988b; Shukla et al 1989.
	Antioxidant	Lalida P et al 2013; Atawodi et al 2010
	Central nervous system depressant	Gupta et al 1999; Ray el al 2003
	Hepatoprotective	Ruckmani et al 1998
	Antimicrobial	Nikkon et al 2003
	Antiurolithiatic	Karadi et al, 2006, Karadiet et al, 2008
	Antispasmodic and Anti-ulcer	Caceres et al, 1992
Stem bark	Antioxidant /anticancer	Bharali et al 2003; Atawodi et al 2010
	Antimicrobial	Bhatnagar et al 1961, Gojal and Osman, 2013
	Antihypertensive/Antidiuretic	Caceres et al, 1992, Limaye et al 1995
	Antispasmodic and Anti-ulcer	Caceres et al, 1992
	Antiinflamatory	Caceres et al, 1992
	Tanning hide	Beltrán-heredia et al 2009
Leaves	Anti-atherosclerotic/anti-hyperlipideamic	Denen Atsukwei et al 2014; Ara and Amran 2008;
	Antimicrobial	Chumark et al 2008; Ghasi et al 2000; Ndong et al 2007b
	Antihyperglycemic	Ayanbimpe et al 2009; Bukar et al 2010;; Cáceres et al 1991; Chung et al 2007
	Antihypertensive/cardioprotective	
	Antiinflammatory/wound healing	Ara and Amran 2008; Jaiswal et al 2009; Ndong et al 2007a
	Anti-oxidant/anticancer	Dangi et al 2002; Faizi et al 1994a, 1994b, 1995; Nandave et al 2009 Rathi et al 2006; Atawodi et al 2010; Chumark et al 2009; Kumar and Pari 2003; Murakami et al 1998; Nandave et al 2009; Rao et al 2001 Siddhuraju and Becker 2008; Singh et al 2009; Sreelatha and Padma 2009;
	Anti-ulcer	Verma et al 2009.
	Central nervous system depressant	Debnath and Guha, 2007; Pal et al 1995
	Hepatoprotective	Pal et al 1996
	Nutritional supplementation.	Buraimoh et al 2011; Ndong et al 2007b; Pari and Kumar 2002; A. B. Sallau et al 2013
	Thyroid Hormone regulation	Dhar and Gupta 1982; D'Souza and Kulkarni 1993; Estrella et al 2000; Freiberger et al 1998; Fuglie 1999; Makkar and Becker 1996, 1997; Ramachandran et al 1980; Thurber and Fahey 2009;
	Immuno-stimulant	Tahiliani and Kar 2000;
	Memory Enhancement	Gupta et al 2010
	lactagogum effect	Ganguly et al. 2005; Ganguly and Guha 2006, 2008; Mohan et al 2005; Obulesu and Rao 2011 Titi Mutiara K & Nunung Nurjanah 2014
Seeds/Pods/ Fruit	Anticoagulant/water purification	Berger et al 1984; Broin et al 2002; Garcia-Fayos et al 2010; Gassenschmidt et al 1995; Ghebremichael et al 2005; Kalogo et al 2000; Madsen et al 1987; Olsen 1987;
	Anti-nephrotoxic effect	Paliwal R et al 2011
	Antihyperlipidemic	Sanchez-Martin 2010; Sanchez-Martin et al 2010; Suarez et al 2003
	Antihypertensive	
	Antiinflammatory	Francis et al 2004; Mehta et al 2003 Faizi et al 1998
	Antimicrobial	Agrawal and Mehta 2008; Mahajan and Mehta 2007, 2010; Mahajan et al 2007a, 2007b, 2009 Arafat M. Goja & Mohamed S. Osman 2013, Bukar et al 2010; Cáceres et al 1991; Chuang et al 2007; Eilert et al 1981; Jabeen et al 2008
	Antioxidant/anticancer/ hepatoprotective	Karthy et al 2009 ; Oluduro et al 2010; Suarez et al 2005 Guevara et al 1999; Obioma et al 1997; Santos et al 2005;
	Nutritional	Singh et al 2009; Hamza 2010
	Anthelminthic/larvicidal	
	Used for dental caries, and rubefacient	Oliveira et al 1999 Coelho et al 2009; Ferreira et al 2009
	Antimicrobial	
Gum	Hepatoprotective	Fuglie 1999; 2000, Sharida Fakurazi et al 2012
	Antioxidant	Talreja 2010
Flower		Ruckmani et al 1998 Rangaswani and Sankarasubraiman 1946

The active antimicrobial compounds in the seed and root have been identified as 4-(α-L-rhamnosyloxy) benzyl isothiocyanate which was shown to be bactericidal against Mycobact. Phlei and *B. subtilis* (Eilert *et al*., 1981); and 4-(β-D-Glucopyranosyl-1 4-α-L-rhamnopyranosyloxy)-benzyl thiocarboxamide also reported to be bactericidal against *S. dysenteriae*, *B. cereus*, *E. coli* and *S. typhi* (Oluduro *et al*., 2010). More fascinating is the reported antibacterial potential of the seed extracts of *Moringa oleifera* against methicillin-resistant *S. aureus* (MDR-MRSA) and its ability to restore the effectiveness of B-lactam antibiotics against MRSA (Karthy *et al*., 2009). Crushed seeds and seed extracts of *Moringa oleifera* have been used as flocculants to clarify drinking water (Madsen *et al*., 1987; Kalogo *et al*., 2000; Suarez *et al*., 2003; Ghebremichael *et al*., 2005). Cationic polypeptides have been isolated and characterized from the seed extracts by recombinant DNA technology and cation exchange chromatography and shown to mediate both the sedimentation of suspended particles such as bacterial cells and to exert a bactericidal activity against human pathogens (Gassenschmidt *et al*., 1995; Broin *et al*., 2002; Suarez *et al*., 2003, 2005; Garcia-Fayos *et al*., 2010; Sanchez-Martin *et al*., 2010). Resent study conducted as preliminary research to evaluate the efficacy of extract's parts of *Moringa oleifera* (seeds, leaves and bark) on the reduction of bacterial load in the water revealed that seed extracts had more possessed antimicrobial activities against coliform and faecal coliform, and it can be used as natural coagulant agents in the reducing of suspended materials and microbial inhibition in water. (Arafat M. Goja1 and Mohamed S. Osman, 2013)

A polypeptide from *Moringa* seed has been found to exert bactericidal action by inducing membrane destabilization and cytoplasmic leakage in susceptible microorganisms (Suarez *et al.,* 2003). Cationic antimicrobial peptides are expressed constitutively by a wide range of organisms including prokaryotes, eukaryotes, and other higher organisms and represent an integral part of the innate immunity response, which is the first line of defense against pathogens (Boman, 1991; Hancock *et al*., 1995). Both the recombinantly produced and the synthetic versions of the *Moringa oleifera* seed peptides have been shown to have coagulant activity and to exert bactericidal effect on many pathogenic bacterial strains, including antibiotic-resistant isolates of *Staphylococcus, Streptococcus and Legionella* species (Suarez *et al*., 2003). These antimicrobial peptides will become increasingly important for the treatment of emerging multi-resistant bacterial strains, because unlike antibiotics, they are reported to prevent microbes from developing resistance mechanisms against the peptides over a long period of time. These peptides exert bactericidal action directly and non-specifically on the membranes of susceptible microorganisms, making it difficult for the microorganisms to develop resistance to them (Zasloff, 2002; and Koczulla and Bals 2003.

Antihypertensive and diuretic activities

Various parts of *Moringa oleifera* plant have been shown to possess antihypertensive and diuretic effect, making this plant a prospective material for future antihypertensive regimen (Cáceres *et al*., 1992). The plant's root, leaves flower, seeds and gum, all possess diuretic activity (Cáceres *et al*., 1992). Karadi *et al*., (2006, 2008) reported the antiurolithiatic activity of the aqueous and ethanolic root extracts of *Moringa oleifera* in Wistar albino rats. Four compounds, niazinin A and B, niazimicin, niaziminin A and B isolated from the ethanolic extract of the leaves produced hypotensive and bradycardiac effects in anaesthetized rats, presumably mediated through calcium antagonistic effects (Gilani *et al*., 1994; Faizi *et al*., 1994b). Alkaloid salts obtained by fractionation of the water extracts of the leaves also produced negative inotropic effect on the isolated frog heart (Dangi *et al*., 2002). Mustard oil glycosides, thiocarbamate glycosides isolated from *moringa* leaves have been reported to possess blood pressure lowering effects (Faizi *et al*., 1994a, 1994b, 1995). Ethanolic and water extracts of the pods showed pronounced antihypertensive effect. The active principles in this fraction are the thiocarbamate and isothiocyanate glycosides (Faizi *et al*., 1995). Limaye *et. al.*, demonstrated the hypotensive effects of the stem bark extracts in dogs. Other studies showed Methyl-*p*-hydroxybenzoate and β-Sitosterol as the hypotensive principles in *Moringa oleifera* pods. (Faizi *et al*., 1998)



A



B



C

Plate 1

(a) Leaf, (b) Pod and (c) flower of *Moringa oleifera*

Antihyperlipidaemic

The extracts of *Moringa* leaves possess significant hypocholesterolemic activity and causes a lowering of triglyceride levels in the serum of high-fat diet fed rats (Ghasi *et al*., 2000 ; Ara *et al*., 2008) . This action is attributed to the presence of β-Sitosterol (Ghasi *et al*., 2000). In other studies (Mehta *et al*., 2003) *Moringa* fruit was found to lower the serum cholesterol, triglyceride, phospholipids, low density lipoprotein (LDL) and very low density lipoprotein (VLDL). The cholesterol to phospholipids ratio, (atherogenic index) in hypercholesterolaemic rabbits was reported to be decreased, while the high density lipoprotein (HDL)/total cholesterol (TC) ratio (the anti-atherogenic index) was increased. The reported *in–vitro* and *in-vivo* antioxidant, antiperoxidative and hypolipidaemic effects of the leaf extracts of the plant (Chumark *et al*., 2008; Ndong *et al*., 2007b; Nandave *et al*., 2009) in addition to the anti-inflammatory properties are significant to give the plant a role in the management of atherosclerosis (Gupta *et al*., 2007) . The hypolipidaemic effect of the ethanol leaf extract of *Moringa oleifera* mainly in terms of reduction in serum lipids and body weight loss of rats has also been reported (Atsukwei *et al*, 2014).

Antidiabetic

The leaves, fruits and stem bark of *Moringa oleifera* have been reported to have antidiabetic activity (Kar *et al*., 2003; Francis *et al*., 2004; Ndong *et al*., 2007; Jaiswal *et al*., 2009). N-benzylcarbamates, benzylnitriles and a benzyl ester isolated from the methanolic extract of its dried fruits have been shown to be the active principles responsible for the insulin secretagogue activity of the plant (Francis *et al*., 2004). The hypoglycaemic effect might be mediated by quercetin-3-glucoside and fiber contents in the leaves the plant (Ndong et al., 2007a). Hyperglycaemia resulting from defective function of the pancreatic β-islet cells or defective insulin, results in a number of complications: cardiovascular, renal, ocular, and neurological (WHO, 1994). The World Health Organisation (WHO) has emphasized the rational use of indigenous medicinal plant for treating diabetes Mellitus (WHO, 1994). *Moringa oleifera* has a high potential for being developed as a hypoglycaemic drug.

Antihepatotoxic activity

Moringa oleifera leaf, flower and root extracts have been shown to possess significant hepatoprotective effect in laboratory animals (Gilani *et al*., 1997; Ruckmani *et al*., 1998; Buraimoh *et al*., 2011). This effect is attributed to the presence of quercetin a flavonoid with hepatoprotective activity in the plant (Gilani *et al*., 1997). Aqueous and alcoholic extracts of the root and flower showed antihepatotoxic activity in rats subjected to acetaminophen-induced liver damage (Ruckmani *et al*., 1998) an effect that was attributed to the ability of the plant to restore/increase liver glutathione levels (Fakurazi *et al*., 2008). The hepatoprotective effects of the alcoholic leaf extract was evaluated in rats with liver damage due to antitubercular drugs (Pari and Kumar, 2002; Kumar and Pari , 2003; Ashok and Pari , 2003). The extract was found to accelerate recovery from hepatic damage induced by isoniazid, rifampicin and pyrazinamide (Pari and Kumar, 2002, Kumar and Pari, 2003). The seed extract was also reported to ameliorate liver fibrosis in rats (Hamza, 2010). Rats treated with *Moringa Oleifera* flowers and leaves hydroethanolic extracts showed a significant reduction in the severity of Acetaminophen-Induced liver damage (Sharida Fakurazi et al 2012).

Antispasmodic and anti-ulcer effects

Moringa oleifera has traditionally been employed in India for the treatment of diarrhea (The wealth of India, 1962; Fuglie, 1999; Jadhav *et al*., 2000). The reported spasmolytic effect of the plant's root, stem bark, leaves and flower provides the pharmacologic basis for the traditional use of the plant for diarrhoea (Cáceres *et al*., 1992, Gilani *et al*., 1992, 1994; Hameed-Un-Nisa *et al*., 1998). One proposed mechanism of antispasmodic activity is via blockade of Ca^{2+} channels and is reported to be due to the presence of 4-(α-L-rhamnosyloxy) benzyl-*0*-methyl thiocarbamate in the leaves of the plant (Gilani *et al*., 1992). The aqueous and methanolic extracts of *Moringa oleifera* leaves, and the methanolic extracts of the flower showed anti-ulcerogenic effects by inhibiting gastric lesions induced by aspirin, serotonin and indomethacin in rats (Pal *et al*., 1995). Debnath and Guha, 2007 reported the anti-ulcerogenic effects of *Moringa oleifera* mediated by increased enterochromaffin cell count and serotonin levels due to an action on gastric tissue $5\text{-}HT_3$ receptors. The reported spasmolytic, and anti-ulcerogenic effects should make this plant an ideal therapy for the management of peptic ulcers.

Anti-inflammatory properties

The root, stem bark, leaves, flower, root and seed of *Moringa oleifera* have all been reported to possess anti-inflammatory and wound healing properties (Cáceres et al., 1992, Ezeamuzie *et al*., 1996; Rathi *et al*., 2006; Hukkeri *et al*., 2006; Mahajan *et al*., 2007, 2009, Mahajan and Mehta, 2010). The root extract was screened for anti-inflammatory activity using the rat paw edema and the rat 6-days air pouch inflammatory models. Oral administration of the extract inhibited carrageenan-induced rat paw edema in a dose-dependent manner. In tests used to evaluate the plant's effect in acute inflammation, and the inhibition of cellular accumulation and fluid exudation, the extract was reported to possess anti-inflammatory potentials (Ezeamuzie *et al*., 1996).The ethanolic seed extract has also been reported to show immunosuppressive activity in experimental immune inflammation (Mahajan and Mehta 2010) and to inhibit inflammation associated with the development of arthritis (Mahajan *et al*., 2007a and 2007b). The extracts should therefore be useful in the treatment of both acute and chronic inflammatory conditions. Mahajan *et al*., 2007; Shailaja *et al*., 2009, reported inhibitory activity of *Moringa oleifera* seeds on systemic and local anaphylaxis. Medhi *et al*., (2009), Ndiaye *et al*., 2002 also confirmed the anti-inflammatory activities of the alcoholic extract of the plant root using the carrageenan-induced paw edema in mice and rats respectively. A clinical study (Agrawal and Mehta, 2008) reported the anti-asthmatic effect of the seed kernels of *Moringa oleifera* in patients with bronchial asthma. Administration of the seed extract resulted in the improvement of both the symptoms and indices of lung function in the patients. Thus, establishing the therapeutic role of this plant in the inflammatory conditions of asthma. Two compounds, aurantiamide acetate 4 and 1, 3-dibenzyl

Urea 5 have been identified as the anti-inflammatory constituents from *Moringa* root (Sashidhara *et al*., 2009).

Central nervous system (CNS)

Extracts of the root and leaf of this plant have been reported to possess analgesic, anticonvulsant and CNS depressant effects in laboratory animals (Pal *et al*., 1996; Gupta *et al*., 1999; Ray *et al*., 2003; Ray *et al*., 2004). The methanolic extract of the root potentiated sleeping time induced by a number of CNS depressants such as diazepam, meprobamate and pentobarbitone (Gupta *et al*., 1999). This central depressant effect may be due to modulation of 5-hydroxytryptamine pathways by *Moringa oleifera* (Ray *et al*., 2004). The plant extract potentiated morphine and pethidine-induced analgesia and inhibited strychnine and Leptazol-induced convulsions (Gupta, 1999). Ray *et al*., (2003) reported inhibition of penicillin-induced convulsion in rats treated chronically with aqueous extracts of the root. The seeds of *Moringa oleifera* have also been reported to possess antipyretic properties (Oliveira *et al*., 1999).

Antifertility

Moringa oleifera is reported to possess potent antifertility properties (Prakash, 1987; Shukla *et al*., 1988a, 1988b). Aqueous extracts of the root and bark showed post-coital antifertility effect in rats and have been demonstrated to induce foetal resorption in pregnant rats (Prakash *et al*., 1987). Aqueous and alcohol extracts of the root have been reported to be teratogenic and to cause abortion in rats (Nath *et al*., 1992). They are also repoprted to possess anti-oestrogenic as well as anti-progrestational effects (Shukla *et al*., 1987, 1988b, 1989). The plant may therefore be a better alternative to existing oral and hormonal contraceptives in view of its low toxicity profile**.**

Miscellaneous activities

The Aqueous leaf extract of *Moringa oleifera* is reported to have the potentials to modulate thyroid hormone levels and may be useful in treating hyperthyroidism. Reduction in serum T_3 concentration and an increase in the T_4 concentration have been reported (Tahiliani and Kar, 2000). The report showed an inhibitory action of the leaf extract on the peripheral conversion of T_4 to T_3. The leaves and flowers are reported to have medicinal potentials as anthelminth (Bhattacharya *et al*., 1982). The seed extract has larvicidal activity against mosquitoes that transmit dengue and yellow fever (Ferreira *et al*., 2009; Coelho *et al*., 2009). *Moringa oleifera* leaf extract has been reported to enhance memory via nootropics activity (Mohan *et al*., 2005). Other studies also substantiated this memory-enhancing effect of *moringa oleifera* (Ganguly *et al*., 2005; Ganguly and Guha, 2006, and 2008). Amelioration of colchicine-induced Alzheimers disease by the leaf extract was shown to be mediated via modification of brain monoamines important for memory (Ganguly and Guha, 2008). The root and bark of the plant has also been shown to possess local anesthetic properties (Medhi *et al.*, 1996). Processing *Moringa oleifera* leaves by boiling reduces the level of its antinutrients value (Sallau *et al*., 2012). Callus derived from shoots and roots of *Moringa. Oleifera* seedling have also been reported to produced peroxidase at a significantly higher level than that produced by the native plant (Lalida *et al* 2013)

Conclusion

Various parts of the *Moringa oleifera* tree are reported to have various medicinal attributes. These parts of *Moringa oleifera* have been incorporated into various marketed herbal formulations for a variety of health disorders. The seed extract of the plant has been proposed as an eco-friendly natural coagulant alternative that is used for the clarification of drinking water (Suarez *et al*., 2003). If the medicinal potentials of *Moringa oleifera* are fully harnessed, the plant may prove to be the wonder drug of this century. The combination of antihypertensive, antidiuretic, antidiabetic, antihyperlipidaemic, anti-inflammatory and antioxidant potentials of various portions of *Moringa oleifera* suggests this plant as a future ideal drug for the prevention of cardiovascular diseases.

The presence of high levels of antioxidants: vitamins A, C and E, with high cancer chemo-preventive potentials will make this plant very beneficial to the aging population of the western world whose dietary preferences have predisposed them to colon cancer and other cardiovascular diseases. For individuals in the developing countries, where low economic potentials result in under-nutrition, dietary deficiencies and malnutrition (Thurber and Fahey 2009), taking formulations of *moringa* as a dietary supplement will be highly advantageous. In addition, *Moringa oleifera* should find use as a rich source of protein, antioxidant and antimicrobial all combined in one drug for patients with HIV who have to contend with muscle wasting, the use of anti-tubercular and antimicrobial drugs in fighting opportunistic infections. The different parts of *Moringa oleifera* plant hold great potentials for in-depth investigation for the purpose of drug development

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