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A review on phytochemistry and pharmacology of *Moringa oleifera* leaves (*Moringaceae*)

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Abstract
Moringa oleifera Lam (*Moringaceae*) is a highly valued plant, distributed in many countries of the tropics and subtropics. It is widely used as a nutritive herb and prossesses valuable pharmacological activities. The present article describe ethnopharmacology, phytochemistry, nutritives values and pharmacological activities, like anthelminthic, anti-inflammatory, hypolipidemic, anti-diabetic etc. of *Moringa* leaves. Finally, being that the leaves are the most used part of the plant, their contents in terms of bioactive compound and their pharmacological properties are discussed. Many studies conducted on cell lines and animals seem concordant in their support for these properties. However, there are still too few studies on rabbit to recommend *Moringa* leaves as medication in the prevention or treatment of diseases. Therefore, further studies on rabbit are recommended.

Keywords: *Moringa oleifera*, ethnopharmacology, phytochemistry, Nutritional uses, Moringaceae

1. Introduction
Moringa oleifera Lam (synonym *Moringa pterygosperma* Gaertner) belong to the monogeric genus *Moringa* of *Moringaceae* family who contain 13 species namely: *Moringa arborea*, indigenous to Kenya; *Moringa pygmaea* indigenous to Somalia; *Moringa borziana*, indigenous to Somalia and Kenya; *Moringa rivae*, indigenous to Kenya and Ethiopia; *Moringa longituba* indigenous to Kenya, Ethiopia and Somalia; *Moringa stenopetala* indigenous to Kenya and Ethiopia; *Moringa ruspoliana* indigenous to Ethiopia: *Moringa ovalifolia* indigenous to Namibi and Angola; *Moringa peregrine* indigenous to Ted sea and Horn of Africa; *Moringa drouhardii*, *Moringa hildebrandtii* indigenous to Madagascar; *Moringa concanensis*, *Moringa oleifera* indigenous to sub-Himalayan tracts of Northern India [1, 2]. It has been introduced and become naturalized in other parts of India, Pakistan, Afghanistan, Bangladesh, Sri Lanka, Southeast Asia, West Asia, the Arabian peninsula, east and west Africa, southern Florida, throughout the West Indies, and from Mexico to Peru, Paraguay, and Brazil[3]. In Puerto Rico, it is grown chiefly as an ornamental and in fencerows and hedges and has become naturalized along roadsides on the coastal plains and lower foothills. In its native habitat, annual temperature fluctuations tend to be very large, with minimum and maximum shade temperatures ranging from -1 to 3 ºC and from 38 to 48 ºC during the coldest and warmest months, respectively [2,3]. In this region annual rainfall ranges from 750 to 2200 mm. Reseda is highly drought tolerant and is cultivated in semiarid and arid regions of India, Pakistan, Afghanistan, Saudi Arabia and east Africa, receiving an annual rainfall as low as 300 mm, although such sites are probably irrigated or are characterized by a high water table. In Puerto Rico, Reseda has become naturalized to a limited extent on sites with an annual rainfall between 1000 and 1800 mm [2, 3]. *Moringa oleifera* is a fast-growing, deciduous tree. It can reach a height of 10–12 m (32–40ft) and the trunk can reach a diameter of 45cm (1.5ft). The bark has a whitish-grey colour and is surrounded by thick cork. Young shoots have purplish or greenish-white, hairy bark. The tree has an open crown of drooping, fragile branches and the leaves build up a feathery foliage of tripinnate leaves [4]. Figure 1, 2 and 3 was *Moringa oleifera* plant


Fig 1: *M. oleifera*


Fig 2: *M. oleifera* flowers *leaves*


Fig 3: *M. oleifera* clove

2. Method

In the present review, information regarding phytochemiestry, medicinal properties Biological activity of plants was gathered via searching books and scientific databases including Science Direct, Elsevier, PubMed, Google Scholar, Springer, etc. databases.

2.1. Taxonomy classification

Moringa oleifera is shown in scientific division to become from Kingdom: *Plantae*, Division: *Magnoliophyta*, Class: *Magnoliopsida*, Order: *Brassicales*, Family: *Moringaceae*, Genus: *Moringa*, Species: *Moringa oleifera* [5].

2.2. Phytochemistry

Moringa oleifera leaves contain polyphenol, simple sugar, tannins, vitamins, rhamnose, carotenoids, phytates, phenolic acids, flavonoids, alkaloids, isothiocyanates, saponins, oxalates and glucosinolates triterpenoid [29, 7].

Moringa oleifera leaf contain 8.13g/kg of vitamin A [6], 6.6-6.8 mg/100 g of β-carotene [7], 6,88g/kg of magnesium, 677.77g/kg of Iron, 3.10mg/100g of vitamin B1, 210mg/kg of vitamin C, 10,2mg/kg of vitamin B2, pumpkin and apricots (6.9, 3.6 and 2.2 mg/100 g, respectively). β-carotene is more concentrated in the dried leaves, 17.6 to 39.6 mg/100 g of dry weight (DW) [8, 9]. It is great source of polyphenols their contain 2090 to 12.200 mgGAE/100 g of DW [12, 13].

Moringa oleifera leaves are an interesting source of flavonoids compounds. Total flavonoids [concentration in dried leaves ranges from 5.059 to 12.16 mg/g of DW [15], 21.0 to 61.62 mgRE/g of DW [10, 16], to 4.59 mg/g of DW, [17, 18, 15, 19, 20], 5.47 to 16.64 mg/g and 1.5 to 3.5 mg/g of DW, respectively [16, 21, 22]. *Moringa oleifera* leaves have been reported to be rich source of alkaloids.

Moringa oleifera leaves are an importante source of tannins. Their concentrations range between 5.0 and 12.0 gTAE/kg [14, 26, 27], between 13.2 and 20.6 gTAE/kg [28]. The saponins concentration in dried leaves is between 64 and 81 gDE/kg [31, 29, 26], 50 gDE/kg of DW [26, 23, 30]. *Moringa oleifera* leaves present high contents of Oxalates. Their concentration in dried leaves range from 25 to 31 g/kg of DW [22, 26], 430 to 1050 mg/100 g of DW [32, 27], 21 and 23 g/kg of DW in freeze-dried leaves [24, 28].

2.3. Traditional uses

The benefits for the treatment or prevention of disease or infection that may accrue from either dietary or topical administration of *Moringa* preparations (e.g. extracts, decoctions, poultices, creams, oils, emollients, salves, powders, porridges) are not quite so well-known [33, 34].

All plant parts of *Moringa oleifera* are traditionally used for different purposes, but leaves are generally the most used [35, 36]. In particular, they are used in human and animal nutrition and in the traditional medicine. Leaves are rich in protein, mineral, beta-carotene and antioxidant compounds [11, 25], which are often lacking among the populations of underdeveloped or developing countries. *Moringa* leaves are added to food preparations as additional food. In traditional medicine, these leaves are used to treat several ailments including, swellings, parasitic diseases, cuts typhoid fever, arthritis, malaria, diseases of the skin, genito-urinary ailments, hypertension and diabetes. [25, 35, 36, 37]. *Moringa oleifera* leaves can be directly consume raw or extract of an aqueous infusion [11, 33, 36]. We used *Moringa oleifera* juice to decrease glucose levels, and glandular swelling, hemorrhoids, toothache, uterine disorder [35, 38, 39, 40].

2.4. Biological activity

2.4.1 Anthelminthic properties

This study of Tayo *et al.*(2014) [41] assessed *in vitro* the efficacy of infused and macerated aqueous extract as well ethanolic extract of *Moringa oleifera* against fresh eggs, embryonated eggs, L_1 and L_2 larvae of *H. contortus*. The results were expressed in terms of mean inhibition percentage of egg embryonation, mean inhibition percentage of egg hatch and mean percentage of larval mortality. An overview of results revealed that ethanolic leaf extract of *M. oleifera* was most efficient on eggs by inhibiting 60.3% and 92.8% eggs embryonation at 3.75 and 5 mg/ml respectively with a significant difference, which contributed to obtaining the lowest LC_{50} value of 0.985 mg/ml. This extract also inhibited 99% egg hatching of *H. contortus* at 5 mg/ml with an LC_{50} value of 1.7 mg/ml [41]. Concerning activity on larvae, the ethanolic extract was also most potent against them by inducing 98.8% and 100% mortality of L_1 and L_2 larvae at 5 mg/ml respectively. Infused aqueous extract was more efficient on eggs than on larvae with an IC_{50} value less than 2 mg/ml and an LC_{50} value more than 3.5 mg/ml. Macerated aqueous extract showed good activity [41]. Ethanolic estrac of *Moringa oleifera* leaves shown more anthelminthique activity against India earthworm *Pherritima posthuma*, compare to *Vitex negundo* [42]. *Moringa oleifera* leaves could find application in the treatment of avian coccidiosis in veterinary practice [43].

2.4.2 Anti-Inflammatory and Immunomodulatory Properties

After treatment with bacterial lipopolysaccharide (LPS) Coppin *et al.* (2013) [19] found that *Moringa oleifera* leaves were able to inhibit nitric oxide (NO) production by macrophage cells. Das *et al* (2013) [44] demonstrated the anti-inflammatory and immuno dulatory effects of *Moringa oleifera* leaves after many *in vitro* and *in vivo* studies in animal model. *Moringa oleifera* leaves ethyl acetate was able to inhibits human macrophage cytokine production (TNF-α, IL-6 and IL-8) induced by extract of cigarette smoke and by LPS [66]. *Moringa oleifera* leaves contain many bioactive may be involved in the anti-inflammatory process. Among them, the flavonoïds such as quercetin was able to inhibit activation of NF-kB and also the subsequent NF-kB-dependent downstream events and inflammation [44]. The flavonoïds such as quercetin and kaempferol, the phenolic acid and other phytochemicals proprieties were identified as the most potent anti-inflammatory, antibacterial and anti-oxydant [46, 5]. This plant have recommended after many *in vitro* and *in vivo* studies in treating hyperglycemia, hyperlipidemia, and inflammation [5, 45].

2.4.3 Hypolipidemic Properties

Moringa oleifera leaves hypolipidemic effects are reported in literature [46]. In one experiment Chumark *et al.* (2008) [47] examined the hypolipidemic effects of *Moringa oleifera* leaves in rabbits fed for 12 weeks with high-cholesterol diet (5%). He was concomitantly treated a group with *Moringa oleifera* leaves extract (0.1 g/kg BW/day). At the end of the experiment, rabbits treated with *Moringa oleifera* leaves presented a triglycerides and total cholesterol, HDL, LDL significantly reduced of 75.4%, 44.2% 52%, 42.7% and

respectively, compared to rabbits only fed with high-cholesterol diet. He note a consequent reduction of 86.52% of internal carotid atherosclerotic plaque formation [47]. The *Moringa oleifera* leaves were identified as the most potent cholesterol lowering action in the serum of high fat diet rats [49]. *Moringa* leaves has been found to lower the serum phospholipids, triglycerides, cholesterol, very low density lipoprotein (VLDL) low density lipoprotein (LDL) cholesterol to phospholipid ratio. Many bioactive compounds such as phenolic compounds, flavonoids may contribute to these effects and play important roles on lipid regulation [48].Phenolic compound of *Moringa oleifera* leaves extract seem to be binding bile acids by forming insoluble complexes, delaying the cholesterol absorption and involved in the inhibition of pancreatic cholesterol esterase activity reducing and increasing their fecal excretion with theoretical decreasing of plasma cholesterol level [49].

2.4.5 Hepato and Kidney Protective Properties

The methanol fraction of *Moringa oleifera* leaves extract showed Hepato protectives effects in rats. Oyagbemi *et al.* (2013) [67] observed an increment alkaline phosphatase (ALP), blood urea nitrose (BUN), creatinine, aspartate aminotransferase (AST) and alanine aminotransferase (ALT) in serum following an administration of the extract of *Moringa oleifera* leaves in mice. Oyagbemi *et al.* (2013) [67] speculated that leaves might predispose to hepatic and kidney damage. In this mice, histopathological examinations did not reveal any histological lesions in the sinusoids or central vein [50]. The authors observed a reduction of serum ALT, AST, ALP [51, 52] and BUN and creatinine [53] in animals treated with the extract of *Moringa oleifera* leaves. These findings were confirmed by histological examinations, which revealed an amelioration of the hepatic and kidney damages induced by drugs, in animals treated with *Moringa oleifera* leaves. Similar results were obtained by Adeyemi et Elebiyo. (2014) [63]. In rats fed with high fat diet and co-treated with *Moringa oleifera* leaves, Das *et al.* (2012) [65] observed a reduction of ALT, AST and ALP and a lower liver damage. This result suggesting a potential role of the leaves in the prevention of nonalcoholic fatty liver disease (NAFLD) [65].

2.4.6 Hypoglycemic Properties

The anti-diabetic effects of some medicinal plant were strengthened by scientific data as herbal remedies for diabetes are recognized in different societies [54]. Ajit *et al.* (2003) [64] reported that hypoglycemic activity of *Moringa oleifera*, with significant blood glucose lowering activities has been confirmed. Methanol extract of its dried fruit powder has produced N-Benzyl thiocarbamates, N-benzyl carbamates, benzyl nitriles and a benzyl; which prove to trigger insulin release significant from the rodent pancreatic beta cells, and have significantly from the rodent pancreatic beta cells, and have cycloxygenase enzyme and lipid peroxidation inhibitory activities [55]. Hypoglycemic and anti-hyperglycemic activity of *Moringa oleifera* leaves may be probably due to the presence of terpenoids, which appears to be involved in the stimulation of the β-cells and the subsequent secretion of preformed insulin [56].

Moringa oleifera leaves contain many compound was able to involve in the glucose homeostasis. The isothiocyanates of *Moringa oleifera* leaves seem to reduce insulin resistance and hepatic gluconeogenesis [57]. However, the polyphenol of *Moringa oleifera* leaves such as phenolic acids and flavonoids, may contribute to its effects on glucose homeostasis.

2.5 Nutritional uses

Moringa oleifera is the most nutrient-rich plant yet discovered. This humble plant has been making strides in less-developed societies for thousands of years, and significant nutritional research has been conducted since the 1970s[12]. *Moringa* provides a rich and rare combination of nutrients, amino acids, antioxidants, antiaging and anti-inflammatory properties used for nutrition and healing. *Moringa* is sometimes called "Mother's Best Friend" and "Miracle Tree." Since 1998, the World Health Organization has promoted *Moringa* as an alternative to imported food supplies to treat malnutrition [12].

Moringa leaves contain all of the essential amino acids, which are the building blocks of proteins. It is very rare for a vegetable to contain all of these amino acids. And *Moringa* contains these amino acids in a good proportion, so that they are very useful to our bodies. These leaves could be a great boon to people who do not get protein from meat [58]. *Moringa* even contains arginine and histidine two amino acids especially important for infants. Arginine and histidine, are especially important for infants who are unable to make enough protein for their growth requirements. Experts tell us that 30% of children in sub-Saharan Africa are protein deficient. *Moringa* could be an extremely valuable food source [58]. *Moringa* leaves added to cattle feed increased their daily weight gain by up to 32 percent. Feed of milk cows was supplemented with 15 to 17 kilograms of fresh *Moringa* leaves daily, and the cattle's milk production increased by 43 percent. Feed supplemented with 2 kg dry matter and milk production increased by 58 percent. Then feed supplemented with 3 kg dry matter per day, and milk production increased by 65 percent. Imagine what would be possible if milk production in developing countries could be increased in this way. It could prevent untold suffering of people with protein deficiency [59].

Freshly harvested *C. pubescens* and *Moringa oleifera* leaves were offered to the animals at 20% of their liveweight at the ratios of 100:0 (MO), 75:25 (M25), 50:50 (M50), 25:75 (M75), and 0:100 (M100), in addition to the concentrate feed offered to the animals. There were significant differences in the total DM intake, litter size at weaning, average daily weight gain per kid and milk yield of does, on the different treatments ($P<0.05$). However, there was no significant difference in crude protein intake, initial average body weight, and gestation length as well as litter weight at birth. It was concluded that *Moringa oleifera* can be used to replace *Centrosema pubescens* without adverse effects on the reproductive performance of rabbits [60].

The results of Odetola *et al.* (2012) [61] suggest that *Moringa oleifera* Lam possess good dietary protein quality for optimal growth of rabbits and be incorporated in the rabbit's diets up to 15% inclusion levels without any detrimental effects on the performance, haematology, serum biochemistry, and carcass and organ weights of growing rabbits. Ewuola *et al.* (2002) [62] suggested that feeding *Moringa oleifera* up to 15% inclusion in rabbit diet will not have adverse effect on the biochemical response of the growing rabbits [61].

3. Conclusion

Moringa oleifera is an interesting plant who contain many bioactive compound. *Moringa oleifera* leaves are rich in polyphenol, phenolic acids vitamins, carotenoids, flavonoids, alkaloids, saponins, isothiocyanates, tanins and glucosinolates. The high contribution in bioactive compound may explain the pharmacological properties ascribed to *Moringa oleifera* leaves. Many *in vitro* and *in vivo* studies in animals have widely confirmed numerous pharmacological properties. However, few evidences on rabbit beings are available. Therefore, it is too early to recommend *Moringa oleifera* leaves as medication in the prevention or treatment of diabetes, cardiovascular disease, dyslipidemia, cancer and infective diseases. Further studies aimed to confirm the pharmacological effects of *Moringa oleifera* on rabbit beings and, at the same time, ensuring its safety on rabbit health consequently to a chronic or long-term use should be encouraged.

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