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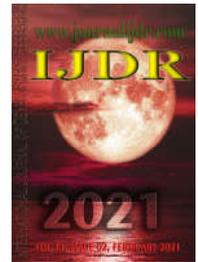
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RESEARCH ARTICLE

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AN OVERVIEW OF THE EFFECTS OF *MORINGA OLEIFERA* ON HEALTH

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ABSTRACT

The rapid growth of cities worldwide, particularly in developing countries, has increased chronic degenerative diseases, such as diabetes, obesity, metabolic syndrome, and cardiovascular diseases. Several medicinal plants such as *Moringa oleifera* have been considered to be used in a plethora of health conditions since they possess many properties, including antioxidant, anticancer, antidiabetic, anti-inflammatory, and antihypertensive actions and the ability to protect against liver damage. This study aimed to review the effects of *Moringa oleifera* on human health. PUBMED and EMBASE databases were consulted, and PRISMA (Preferred Reporting Items for a Systematic Review and Meta-Analysis) guidelines were followed to build this review. According to the criteria of inclusion and exclusion, eight studies were included. *Moringa oleifera* can bring numerous benefits to human health, such as reducing body weight and BMI, glycemic control, improvement in the lipid profile, and increase in plasma levels of vitamin A, in addition to being used in the treatment of cancer. These effects are due to the phytochemical components of the plant that have important anti-inflammatory and antioxidant effects. Furthermore, it can also be a great ally in combating malnutrition due to its high nutritional content.

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INTRODUCTION

The rapid growth of cities worldwide, particularly in developing countries, has increased chronic degenerative diseases, such as obesity, diabetes, metabolic syndrome, cardiovascular diseases (CVD), and cancer (GUEVARA-ARAUZA et al., 2011; CASTELLI et al., 2020). Several medicinal plants have been considered to be used in a plethora of health conditions since they possess many properties, including antioxidant, anticancer, antidiabetic, anti-inflammatory, and antihypertensive actions, as well as the ability to protect against liver damage (BORGONOVO et al., 2020). Included in these plants is *Moringa oleifera*. *Moringa oleifera* is a perennial and arboreal vegetable with a high capacity to adapt to climatic and soil conditions. Moreover, in developing countries, this plant has been used as an alternative in preparing flour for food supplementation to treat malnutrition, especially in children and lactating women (TEIXEIRA, 2012). The flowers and fruits of this plant present many valuable nutrients. The leaves are rich in carotenoids, vitamins,

polyphenols, isothiocyanates, flavonoids, alkaloids, glucosinolates, phenolic acids, tannins, and saponins. All parts of this plant present several biological activities, and for these reasons, they may exhibit many medicinal and biomedical applications (SIVASANKARI et al., 2014; AGUNBIADE et al., 2021); (EZHILARASI et al., 2016). The leaves contain large amounts of protein, vitamins, minerals, and fatty acids. They can also be a relevant calcium source, vitamin C, vitamin A, iron, and potassium. Therefore, it is suggested that a daily intake of 10 g of moringa leaf powder may help treat and prevent malnutrition, improve the immune and antioxidant systems, and prevent several diseases (SU e CHEN, 2020). Due to the nutritional characteristics of *Moringa oleifera*, this study aims to review this plant's health benefits on human health.

MATERIALS AND METHODS

Data source: This review was carried out at MEDLINE - PubMed (National Library of Medicine, National Institutes of Health) and

EMBASE, following the PRISMA (Preferred Reporting Items for a Systematic Review and Meta-Analysis) guidelines. This review intended to answer the following focal question: Does *Moringa oleifera* or its derivatives promote beneficial effects on human health?

Search: Our study included articles published in the last ten years (July 2011 to August 2020) and included clinical trials, double-blind, randomized, placebo-controlled studies, retrospective case-control study and studies with animals. The combination of mesh terms used for the search was: *Moringa oleifera* and blood glucose or diabetes or obesity or lipids or metabolic syndrome or cardiovascular diseases or anti-inflammatory or antioxidant.

Eligible criteria and study selection: Our study included studies that demonstrated the effects of *Moringa oleifera* on human health. Exclusion criteria were non-English articles, literature reviews, abstracts, and letters to the editor.

Data extraction: Two different authors performed the searches in the databases. The results were extracted from eligible articles that indicated the author, sample size, date, and study design.

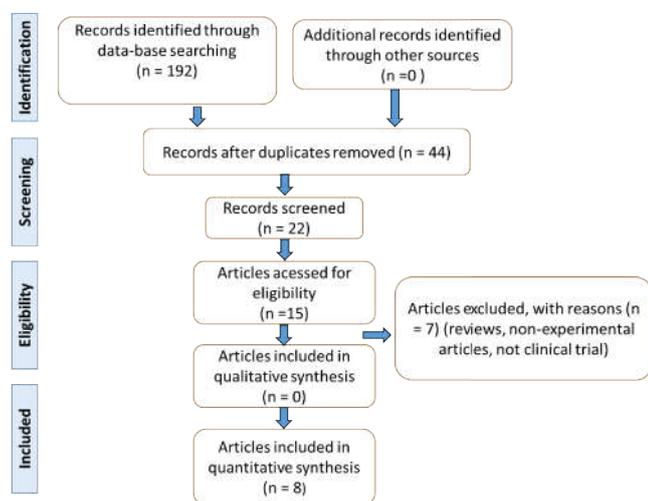


Figure 1. Diagram showing the search results according to the PRISMA guidelines (MOHER et al., 2009)

RESULTS

The literature search resulted in selecting 8 studies (Figure 1) that are shown in Table 1.

DISCUSSION

***Moringa oleifera*:** *Moringa oleifera* is native to the sub-Himalayan regions of Pakistan, India, Bangladesh, and Afghanistan, where it was initially described around 2000 BC as a medicinal herb. The moringa tree has spread to the east (lower parts of China, Southeast Asia, and the Philippines) and to the west (Egypt, Horn of Africa, around the Mediterranean, and finally to the West Indies in America). It is named "Nebedaye", which means "never die" in many African languages, also known as "the Miraculous Tree", "coxinha" or "horseradish". *Moringa oleifera* is found mainly in semi-arid, tropical, and subtropical areas on sandy and dry soil. It is very resistant, being able to withstand severe droughts and moderate frost conditions. *Moringa oleifera* has long been used in herbal medicine by Indians and Africans and is often referred to as a panacea - used to treat more than 300 diseases - as an antioxidant, anticancer, anti-inflammatory, antidiabetic, antimicrobial, and many other conditions. This plant's nutritional potential is remarkable; the leaves are of high protein quality. The seeds are abundant in lipids (mainly stearic acid, saturated palmitic acid, and oleic acid).

Both the seeds and the pods contain high levels of calcium, potassium, sodium, and iron. Moringa extracts are widely used by doctors, healers, nutritionists, and community leaders to treat malnutrition and anemia (MATIC et al., 2018).

Moringa oleifera is consumed not only for its nutritional values but also for its medicinal benefits. Its leaves are a good source of carotenoids with the potential for vitamin A. The leaves also contain 200 mg/100 g of vitamin C, a higher concentration than that found in oranges; they are a good vitamin E source, with concentrations similar to those found in walnuts. The dried leaves present a great source of polyphenolic compounds, such as flavonoids and phenolic acids. Quercetin is found in dry leaves in concentrations of 100 mg/100 g, such as quercetin-3-O-β-d-glycoside (iso-quercetin or isotrifoline). The dried leaves are also rich in water-soluble phenolic compound tannins that precipitate alkaloids, gelatin, and other proteins; the concentrations in dry leaves vary between 13.2 and 20.6 g of tannin/kg, being slightly higher in lyophilized leaves. The leaves are also a significant source of saponins, natural compounds made from an isoprenoid-derived aglycone, covalently linked to one or more portions of sugar.

The concentrations of saponins in the lyophilized leaves vary between 64 and 81 g / kg dry weight. In addition to these components, the leaves still contain alkaloids, glucosinolates, and isothiocyanate (KOU et al., 2018). The seeds of this *Moringa oleifera* are composed of good quality oil that can be used for cooking, soap, cosmetics, and the pharmaceutical industry (PEREIRA et al., 2011), in addition to being rich in proteins (33.9%) and lipids (37.2%). The oil extracted from the seeds has a high oxidation resistance and contains high levels of unsaturated fatty acids, especially oleic (71.6%), with palmitic and behenic (both 6.4%) being the dominant saturated fatty acids (BEZERRA et al., 2004).

***Moringa oleifera* and health effects:** Studies have shown that almost all parts of *Moringa oleifera* can be safely used as food supplements in human nutrition (Table 1). It is also noteworthy that its flour can be used to control glycemia and dyslipidemia in humans and animals, possibly to a wide range of substances with antioxidant, analgesic, antihypertensive activities, tissue protection (liver, kidneys, and heart), anti-ulcer, and others (LEONE et al., 2018). In a study carried out by TEIXEIRA (TEIXEIRA, 2012), it was demonstrated that the Moringa leaf oil contains a high content of lipids and can be indicated as a source of fiber being an alternative for supplementing this nutrient in food products. Although the leaf contains a considerable amount of crude protein, it is predominantly insoluble and with low *in vitro* digestibility, even after heat treatment and chemical agents' action. Among minerals, iron has greater relevance. It also has low levels of anti-nutritional substances so that the moringa leaf can be ingested without nutritional damage (LEONE et al. 2015).

Almost all parts of *Moringa oleifera* can be used as a source of food, as well as in the traditional treatment of various diseases. These parts include leaves, flowers, pods, seeds, roots, bark, and gums; it is traditionally used to treat bronchitis, infections, and fever, among many other diseases due to the antioxidant, antibacterial, antifungal, antidiabetic, neuroprotective, cardioprotective, and anti-inflammatory properties. This plant is also known to modulate the immune system, have diuretic activity, hypocholesterolemic, hepatoprotective properties, increase wound healing rate, and are antihypertensive (TILOKE et al., 2018). Increasing scientific evidence has suggested the effectiveness of Moringa in the treatment of inflammation, hyperlipidemia, hyperglycemia, hypertension, bacterial and viral infections, ulcers, and cancer. Nowadays, it is well known that many of these conditions are caused and/or exacerbated by oxidative stress. Thus, the plant's ability to prevent and treat these conditions may be due to the high level of antioxidant/bioactive compounds, including vitamins, micronutrients, and polyphenols (TUMER et al., 2015). It may be also used as anti-obesity as shown by a study with animal models. In this study, the authors found thirteen metabolites in *moringa oleifera*, such as flavonols, flavones, and phenolic acid.

Table 1. Descriptive table of the effects of *Moringa oleifera* on human health

References	Study model	Treatment	Main results	Conclusion
(LEONE <i>et al.</i> , 2018)	Randomized clinical trial with 9 women and 8 men with DM2.	Subjects were instructed to consume 20 g of powdered MO leaf/day.	A significant reduction in glycemia was observed after 150 min of MO intake.	MO can help control blood glucose levels in patients with DM2.
(BOATENG <i>et al.</i> , 2018)	Randomized double blind study with 35 children aged 4-11 years with vitamin A deficiency.	Children received powdered MO leaves added to food for six months.	There was a significant increase in Vitamin A levels in all children who consumed MO.	MO can help to combat vitamin A deficiency in children.
(DIXIT <i>et al.</i> , 2018)	Randomized clinical trial with 140 participants aged 21-50 years and with a BMI of 27 to 29.9 kg / m ² .	Participants received 450mg of capsules with MO, twice a day and were instructed to eat a diet with 1800kcal / day and to walk 5 times a week.	The use of capsules with MO led to a significant reduction in body weight and BMI when compared to placebo. There was also a reduction in LDL-c and an increase in HDL-c.	The use of MO helps in weight loss and also in improving the lipid profile.
(TSHINGANI <i>et al.</i> , 2017)	Randomized double blind clinical trial with sixty adult patients who were with stable HIV / AIDS.	30 patients received MO powder daily for 6 months, and 30 made up the control group.	After 6 months, it was seen an increase in body weight and body mass index of patients who received MO.	The use of MO can be performed to improve the nutritional status of HIV-positive patients.
(TAWEERUTCHANA <i>et al.</i> , 2017)	Prospective randomized, double-blind, placebo-controlled study with 9 women and 7 men with DM2 (20-70 years).	Participants were instructed to consume powdered MO capsules (4g / day for breakfast and dinner for one month).	There were no significant changes in glycemia, HbA1c, AST, ALT.	The use of MO in capsules did not influence the blood glucose of the study participants.
(NGAMUKOTE <i>et al.</i> , 2016)	Randomized crossover study with 6 healthy women and 4 men.	Study participants received aqueous MO extract (500 mg on a first visit and 500 mg after 2 weeks).	There were no changes in glycemia, but there was an increase in antioxidant capacity.	The use of MO can contribute to the reduction of oxidative stress since it increases the antioxidant capacity.
(ANTHANONT <i>et al.</i> , 2016)	Quasi-experimental study with 5 women and 5 men.	Participants received MO powder in the following sequence: 0g in the first week; 1g after two weeks; 2g after two more weeks; 4g after two more weeks.	There was a significant increase in insulin levels. There were no changes in glycemia, creatinine, AST and ALT.	MO interferes with insulin release but no significant change in blood glucose was observed.
(KUSHWAHA <i>et al.</i> , 2012)	Randomized clinical trial with 33 women, 40-55(NGAMUKOTE <i>et al.</i> , 2016) years old.	Patients were instructed to consume 7g / d of powdered leaves of MO.	It was observed a significant reduction in fasting blood glucose (from 125.6 ± 9.15 to 106.7 ± 7.23 mg / dL).	MO can help control glycemic levels.

BMI: Body Mass Index; DM2: Type 2 diabetes mellitus; HbA1c: Glycated Hemoglobin; MO: *Moringa oleifera*; AST and ALT: liver enzymes

Moreover, they found that this plant showed a significant effect on decreasing the final weight of high fat diet-induced obesity animals and also reduced the percentage of adiposity index, glycemia, HOMA-IR, insulin, leptin, and vaspin. They observed an increase in the levels of omentin, adiponectin, and GLUT-4 expression. Furthermore, they investigated the use of hard gelatin capsules of *Moringa oleifera* (400 mg) on fifteen women, 45-55 years and with a body mass index of 29-34 kg/m² for eight weeks. In these women, it was observed a significant decrease in the average body mass index, total cholesterol, and LDL compared to the beginning of the treatment (EZZAT *et al.*, 2020). According to Singh *et al* (SINGH *et al.*, 2014), *Moringa oleifera*, besides being widely used as an antioxidant, can bring benefits to wound healing, anti-tumor, hypotensive, antipyretic, anti-hepatotoxic, anti-epileptic, anti-inflammatory, anti-ulcer, diuretic, hypocholesterolemic, antifungal, antibacterial, and anti-cardiovascular agent. Moreover, the leaf extract is also able to reduce hyperglycemia, dyslipidemia, and diabetes mellitus. Selim *et al* (SELIM *et al.*, 2021) showed that the supplementation of rabbits with *Moringa oleifera* augmented dressing out percentage, intestinal length, spleen index, and reduced abdominal fat index. These authors also showed increased serum levels of total globulin and protein but reduced AST and ALT. The supplementation also reduced serum levels of triglycerides, total cholesterol, and LDL-c. It also increased the activity of Glutathione peroxidase and decreased the levels of malondialdehyde. Akinrinde *et al* (AKINRINDE *et al.*, 2020) investigated the effects of *Moringa oleifera* in an animal model of renal ischemia-reperfusion injury and observed that this plant could improve this condition since decreased creatinine levels and H₂O₂ and increased the levels of antioxidant enzymes such as glutathione.

The authors concluded that this plant could reduce the deleterious effects of renal ischemia-reperfusion injury due to decreased tissue oxidative stress. According to the review performed by Xiao *et al* (XIAO *et al.*, 2020) *Moringa oleifera* is valuable due to its versatile utilization as a food additive and supplement therapy. This plant shows a critical role in several immune-related diseases. Besides reducing pathogens such as fungi, bacteria, viruses, and parasites, it can inhibit chronic inflammation, including ulcerative colitis, asthma, and metabolic diseases. Moreover, it can ameliorate chemical and physical irritation-induced immune disorders, including drug side effects, metal poisoning, or adverse events produced by food additives. The authors also show that *Moringa oleifera* can help treat autoimmune diseases, such as rheumatoid arthritis, multiple sclerosis, and atopic dermatitis. Due to these several activities and few side effects, *Moringa oleifera* has a significant potential to treat several disorders.

CONCLUSION

Moringa oleifera can bring numerous benefits to human health, such as reducing body weight and BMI, glycemic control, improvement in the lipid profile, and increase in plasma levels of vitamin A, in addition to being used in the treatment of cancer. These effects are due to the phytochemical components of the plant that have important anti-inflammatory and antioxidant effects. Furthermore, it can also be a great ally in combating malnutrition due to its high nutritional content.

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