CHAPTER 26

Therapeutic Potential of Medicinal Plants: A Comprehensive Review of the Pharmacological Efficacy

FAIZA BASHIR[1*], HINA NAWAB[1], ABUZAR MUJAHID[2], SARFARAZ IQBAL[2], MARYAM KHAN SHERWANI[3], SADIA SHAFIQUE[1], AYESHA BINTAY FAROOQ[4], MAIRA RIAZ[5]

[1]Institute of Physiology and Pharmacology, University of Agriculture, Faisalabad, Pakistan
[2]Faculty of Veterinary Science, Bahauddin Zakariya University, Multan Pakistan
[3]Department of Pharmacy, Quaid I Azam University, Islamabad, Pakistan
[4]Department of Physiology, Faculty of Life Science, Government College University, Faisalabad, Pakistan
[5]Department of Pharmacy, Government College University, Faisalabad, Pakistan
[*]Corresponding author: faizabashir430@gmail.com

SUMMARY

Medicinal herbs/plants have been utilized for centuries to enhance the taste, preserve food, cure ailments, and deter infections, notably outbreaks. Over the millennia, groups of people have shared their expertise in their therapeutic powers. Active chemicals are typically accountable for the biological characteristics of particular plant species that are used worldwide for various reasons, notably for the cure of transmissible illnesses. There are approximately 250-500 thousand varieties of plants on the globe, with only 1-10% utilized as nutrition by individuals and other living creatures. Brazil boasts the world's largest ecology, with more than 20% of recognized plant species. This nation has the most diversified flora, with over 55,000 documented species, accounting for 22% of the worldwide total. That diversification is accompanied by a broad embrace of the therapeutic utilization of plants. The majority of the Brazilian population (80%) consumes only 37% of the commercially accessible pharmaceuticals and relies nearly entirely on therapies that are of organic origin. Some of the pharmacological properties of these medicinal plants are; antioxidants, anti-inflammatory, antidiabetic and anticancer activities.

INTRODUCTION

Medicinal plants have played a crucial role in human health and well-being for centuries. These plants serve as natural remedies for various ailments and contributing to food preservation and flavor enhancement. The knowledge of their therapeutic properties has been passed down through generations, forming the foundation of traditional medicine in many cultures. This chapter explores the medicinal potential of these plants, focusing on their pharmacological properties and their role in disease prevention and treatment.

MEDICINAL PROPERTIES OF *CASSIA FISTULA*

Cassia (C.) fistula, frequently referred by the name golden shower tree, is a prominent member of the Fabaceae family. The tree is renowned for its strikingly beautiful flowers and belongs to the Indian subcontinent and Southeast Asia. Besides its ornamental value, *C. fistula* possesses an extensive record of usage in conventional medical systems such as Ayurveda, Unani, and traditional Chinese medicine. *C. fistula* has multiple uses in treatment, notably in the conventional medical practice. It's an exotic species widely used as a plant for decoration due to its beautiful yellow blossoms. Its seeds are utilized to heal gastric problems and loose motion, as well as to deter insects. Aside from boosting hunger, the seeds are also used to alleviate excessive bile secretion. The roots are used to cure skin problems, syphilis, leprosy, and TB. Root extracts are often utilized to treat blistering feelings. The fruits cure throat ailments, inflammatory conditions, liver difficulties, chest pain, respiratory conditions, and arthritis (Mwangi et al., 2021).

Ethnobotanical Background

C. fistula is known for its traditional uses mainly as medicine in different parts of the world. The common people as well as traditional uses of *C. fistula* are quite widespread in different cultures. The fruit pulp is a traditional medicine in Ayurvedic practice called “Amaltas” which works as a purgative. Khirrni (*Euphorbia neriifolia*) is named as plant used in Unani system of medicine beneficial for its purgative and anti-inflammatory properties. The plant has also been used in traditional Chinese medicine for its detoxifying and skin-treating properties. Leaves, bark, fruit pulp and seeds are some of the parts used to benefit from their plants through healing. For example, fruit pulp is used as a natural laxative and leaves have antifungal properties whereas bark offers analgesic properties (Mwangi et al., 2021).

How to Cite: Bashir F, H Nawab, A Mujahid, S Iqbal, MK Sherwani, S Shafique, AB Farooq & M Riaz, 2024. Therapeutic potential of medicinal plants: A comprehensive review of the pharmacological efficacy. In: Ethnopharmacology and Ethnobotany of Medicinal Plants (Sindhu ZuD, B Aslam, MN Faisal & W Majeed, eds): FahumSci, Lahore, Pakistan, pp. 194-199. ISBN: 978-627-7745-10-3. https://doi.org/10.61748/EEMP.2024/26

Phytochemical Constituents

Research conducted in the past decade has shown a multitude of bioactive compounds to be found in *C. fistula*. Flavonoids, anthraquinones, glycosides, tannins, saponins are key phytochemicals. All of these compounds add to its extensive biological activities. In this case, flavonoids are known for their antioxidant and anti-inflammation activities, anthraquinones act as laxatives while tannins own antimicrobial properties. All these new studies have opened newer scope with Natural products including more compounds in the *C. fistula* to be evaluated chemically and biologically, which further help us understand its chemical profile properly; of course, track can also be extended for medicinal verities (Durairaj *et al*., 2009).

Pharmacological Activities

Antimicrobial activity: *C. fistula* has some antimicrobial activity in it as shown by several studies. A study carried out in 2014 showed that extracts of *C. fistula* possessed substantial antibacterial activity against various pathogenic microorganisms such as *Staphylococcus aureus* and *Escherichia coli*. The Researchers mentioned that the antibacterial activity was more owed to Anthraquinones and flavonoids, which rupture bacterial cell walls leading to protein synthesis shutdown efforts (Kumar et al., 2014).

Antioxidant activity: This is due to the ability of low molecular weight secondary metabolites, which act as an alternative antioxidant source with higher scavenging effects. These compounds predominate in methanolic extract and probably will provide benefits in a variety of applications for better health, especially by reducing death risk from oxidation stress-related diseases. The predominant antiradical power is accounted for by flavonoids and phenolic compounds. Thus, *C. fistula* can be used to manage the disorders related due reactive oxygen species viz., heart diseases and carcinoma (Sharma et al., 2018).

Anti-inflammatory activity: *C. fistula* has been used traditionally for various inflammatory conditions. The ethanolic extract of *C. fistula* has shown significant dose dependent inhibition in the carrageenan-induced rat paw edema model. This anti-inflammatory activity suppresses pro-inflammatory mediators like prostaglandins and cytokines. Therefore, *C. fistula* has been identified as a potential source for the discovery of new pharmacological agents used in anti-inflammatory drugs against arthritis and other inflammatory problems (Patel et al., 2020).

Hepatoprotective effects: The fruit pulp extract of *C. fistula* protected the liver from damage caused by hepatotoxicity induced chemically in rats. The presence of biologically active substances like flavonoids, glycosides having antioxidant and detoxifying potential suggested hepatoprotective activity. It suggests that *C. fistula* could be used in the treatment of liver diseases such as hepatitis and cirrhosis (Gupta et al., 2017).

Antidiabetic activity: Research has also been conducted regarding the antidiabetic effects of *C. fistula*. While the aqueous extract of pods from *C. fistula* showed significant attenuation in sugar levels of diabetic rats. The results of the study showed that there are active ingredients in this plant that increase insulin secretion and also they have a positive effect on glucose metabolism. The current results reveal *C. fistula* potential as a natural antidiabetic and therefore minimize diabetes associated complications (Singh et al., 2021).

Toxicological Studies

While the beautifying abilities of *C. fistula* are many, it is important to pay attention to its safety aspects as well. Toxicological assessments, for the most part toxicologically have appeared that it is sheltered gone up against remedial measurements of *C. fistula* extracts. On the other hand, high doses can lead to adverse reactions like gastro intestinal upset and liver toxicity. The lack of scientific evidence to determine broad safety standards. To ensure the safe use of *C. fistula* as a traditional medicine in future, long-term toxicity studies and clinical trials are needed (Reddy et al., 2015).

CASSIA ABSUS

Cassia (Ca.) absus (family: Leguminosae) commonly known as Chaksu is one of the plants widely reported in ethnopharmacology and ethnobotany for having medicinal properties. This species is most commonly (though not exclusively) found in the tropics and falls under the Fabaceae family. The plants from the Fabaceae family are widely utilized in traditional Indian medicine to treat several ailments. New research found silver nanoparticles made by an endophytic mold isolated from *C. fistula* to have liver-protective, swelling reducing, sugar reducing antimicrobial, and antioxidant effects. Several experimental and in-person models demonstrated the possible benefits of *Ca. absus* as anxiety reducing, fungicide, sugar reducing, antioxidants, antimicrobial, and reducing activities (Archana et al., 2024).

Phytochemical Composition

Ca. absus is well known for therapeutic functions due to containing rich bioactive compounds. Some of the main phytochemicals identified were flavonoids, alkaloids, glycosides and phenolic compounds. Their antioxidant, anti-inflammatory, antimicrobial and antidiabetic activities have also been reported for these same constituents. The comprehensive bioactive complexes are the chief determinants that justify the biological activities of *Ca. absus* (Kousar et al., 2023)

Therapeutic Profile

Antioxidant activity: This is mainly due to its rich flavonoids and phenolic compounds. The extracts of the leaves and seeds have shown remarkable scavenging effects for free radicals. Higher DPPH radical scavenging activity of the methanolic extract suggests that *Ca. absus* seeds contain more potent antioxidants comparable to standard antioxidants i.e. ascorbic acid and butylated hydroxytoluene (Sharma et al., 2014).

Anti-inflammatory: *Ca. absus* has long been used for treating inflammatory diseases. Indeed, modern pharmacological studies have endorsed many of these traditional uses. This

plant is very effective to be used as an anti-inflammatory medication for example, the ethanolic extract of *Ca. absus* leaves significantly reduced carrageenan-induced paw edema in rats. These effects are due to the presence of flavonoids and other phenolic compounds (Singh et al., 2015).

Antimicrobial: *Ca. absus* has been studied for its antimicrobial activity. Different plant extracts have been found to work against many bacterial and fungal pathogens. *Ca. absus* seed's aqueous and ethanolic extracts showed moderate to good potential as an antibacterial agent against both Gram-positive bacteria *S. aureus* and the Gram-negative bacterium *E. coli*. Furthermore, the extracts were fungicidal against *Candida albicans* (Rao et al., 2017).

Antidiabetic: *Ca. absus* is most commonly used to treat Diabetes. Scientific studies have also shown that it lowers blood sugar. The boiling water extract of *Ca. absus* seeds significantly reduced the blood sugar levels in streptozotocin-induced diabetic rats. The effect of test leaf extract was attributed to the increase in insulin secretion and glucose utilization by tissues as well (Ahmed et al., 2018).

Other medicinal properties: Apart from the previously mentioned characteristics, *Ca. absus* is being studied for potential medical advantages. Research has suggested that it may have liver-protective, cancer prevention, and antiulcer properties. Effects of Cassia, on the absus seed extract on rats' hepatoprotection against paracetamol-induced liver damage. The study demonstrated which antioxidants may avoid liver damage (Kumar et al., 2019).

MORINGA OLEIFERA

Moringa (M.) oleifera, which is commonly referred to as "drumstick tree" and is considered a valuable food resource in conventional medicine and nutrition. Its roots are in the Indian subcontinent. Today, Moringa can be found globally in tropical and subtropical regions. Human economic and social circumstances have shifted dramatically in recent years, and they are increasingly worried regarding their physical and mental well-being. They are knowledgeable about the negative impacts of manmade items. This is why they're keen on organic goods. Over time, the use of natural plant-based products with less negative effects has grown in prominence. There is enormous potential for organic resources to provide health advantages above standard nutrition. The species *M. oleifera* represents a single such plant that provides numerous dietary and health advantages. It has a high concentration of vitamins and minerals, as well as various biologically active ingredients, all of which are essential for regular bodily activity and avoiding illness. Every component of this plant is culinary and possesses numerous medicinal characteristics, notably hypoglycemic, cancer prevention, stomach problems, antibacterial, and antiviral (Islam et al., 2021).

Nutritional Profile

M. oleifera leaves possess several vitamins, minerals and amino acids which makes it a promising commodity to be used for both malnutrition as well as overall health improvement. The amounts of vitamins A, C and antioxidants in the leaves provide essential nutrients for helping to maintain healthy vision functions and immune system support. Night blindness and other problems related to the eye are prevented by vitamin A. It is immune boosting and skin healing as it stimulates collagen production due to the high level of Vitamin C. Vitamin E is an antioxidant that helps fight free radicals (Mushtaq et al., 2021). Moringa leaves are rich in vitamins, the minerals such as calcium, potassium and iron. Calcium is important for bone health and the muscle, heart as well nerve system. Potassium can also help to regulate blood pressure, water balance and muscle contraptions. Hb is the key carrier of oxygen in circulation, and iron deficiency leads to anemia (Jikah & Edo, 2023). Moringa leaves are as well composed by all nine essential amino acids, which act as the building blocks of proteins and that is required for various human processes such healing tissues, manufacturing enzymes (the chemical messengers produced in response to status quo perturbations), or synthesizing neurotransmitter. Its complete nutritional profile makes Moringa a powerful weapon in combating malnutrition and fostering healthy body (Gopalakrishnan et al., 2016).

Therapeutic profile

Antioxidant activity: *M. oleifera* is rich in antioxidants including polyphenols, flavonoids and ascorbic acid. Free radicals are unstable molecules that cause damage to cells, proteins and DNA causing cancer, cardiovascular diseases (CVD), neurodegenerative disorders etc. in long term. The antioxidant is a molecule that counteracts free radical mediated cell injury by completely stabilizing the harmful species or repair of damaged biomolecules like deoxyribonucleic acid/genetic materials. *M. oleifera* leaves have been proved to contain large amounts of antioxidants. Similarly, the antioxidant potential of different Moringa leaves at various stages of maturity was demonstrated by Sreelatha & Padma (2009). Its antioxidant effect is further compounded by ascorbic acid (vitamin C), which renews all important antioxidants found in your body to comprehensively cover against oxidative stress (Sreelatha & Padma, 2009; Vergara-Jimenez et al., 2017).

Anti-inflammatory and analgesic effects: Inflammation is a normal response to harmful stimuli such as pathogens, damaged cells or irritants. Although acute inflammation is a natural form of defense, chronic inflammation leads to many life-threatening diseases such as arthritis or heart failure and even cancer. *M. oleifera* has been studied for years to establish its anti-inflammatory properties mediated mostly by compounds such as isothiocyanates, flavonoids and phenolic acids. The pods of *M. oleifera* were analyzed for effects on the production and release of inflammatory mediators in lipopolysaccharide-stimulated macrophages, as to search for new natural products with potential anti-inflammatory action. This means that moringa may be able to reduce inflammation and help someone with arthritis feel better. Also, Fahey (2005) has accounted that the leaves and seeds have been considered as a useful source of nutrients and therapeutic compounds containing such bioactive were effective in suppressing inflammation by limiting activity enzymes for pain pathways consist cytokines with capability regulation swelling response same time Moringa roots contain anti-inflammatory properties

which could decrease inflammation-induced mechanisms during conditions other measures activated (Muangnoi et al., 2012; Fahey, 2005) Moreover streamlined nutrient profile reported actuating beneficial reduction it functionality this way thereby reducing secondary injury processes. *M. oleifera* has also reported analgesic effects. Moreover, its analgesic effect has already been described by several studies in animal models because Moringa extracts showed a reduction on the ability to perceive pain. Due to its anti-inflammatory and analgesic properties, Moringa is an important plant for the treatment of inflammatory diseases as well as pain-related ailments.

Antimicrobial activity: *M. oleifera* has been shown to contain broad-spectrum antibacterial activity against many pathogenic bacteria, fungi (as yeasts and molds) and viruses. For example, not only does it boost the plant's production of natural insecticides and pesticides through signaling pathways but also enhances its ability to absorb nutrients from soil while providing an antimicrobial property that is especially important today when antibiotic resistance due to widespread use of chemical fertilizers has become a major threat. *M. oleifera* leaf extracts were highlighted as having antibacterial activity against common pathogenic bacteria including Staphylococcus aureus and Escherichia coli. The researchers showed Moringa leaf juice and extracts to have inhibitory effects on bacterial growth thus exposing this plant as a potential source of treatment for battling these bacteria. Coppin also reported synergy between Moringa extracts and polyenes which may be promising to treat candidiasis (the most common systemic fungal infection); as some species were found resistant in the clinical setting. Research has also been conducted in the antiviral activity of Moringa, and studies have shown that extracts from this plant can inhibit certain viral replication which could slow down the severity and duration of their symptoms. These investigations add to the positives of using *M. oleifera* as a native antimicrobial agent leading to potential pharmaceutical warfare against various infections (Rahman et al., 2009; Coppin et al., 2013).

Antidiabetic activity: Historically, *M. oleifera* treatment for diabetes has been well practiced and various scientific studies authenticated its blood sugar lowering properties. A study has shown that Moringa leaf extracts markedly decreased circulating sugar in diabetic rats but also enhanced the antioxidant status of these animals. Moringa has a hypoglycemic effect due to the promotion of secretion and improvement in insulin sensitivity, which helps glucose to be more utilized by the body (Jaiswal et al., 2009). In addition to its hypoglycemic activity, Moringa also exerts hypo-lipidemic effects by reducing total cholesterol, low-density lipoprotein (LDL) cholesterol and triglycerides while increasing high density Lipoprotein (HDL) -cholesterol plasma with a decrease of Atherogenic index available for preventing cardiac diseases. Combining all these effects, makes Moringa a natural resource to help manage DM and its complications (Mbikay, 2012).

Cardioprotective effects: Cardiovascular diseases (CVDs) are the leading cause of morbidity, as well as mortality worldwide. The cardio-protective effects of this plant are mostly due to its antioxidant and anti-inflammatory activities which may help in controlling numerous risk factors linked with CVDs. Cardioprotective effects of *M. oleifera* leaf extracts on high cholesterol diet-induced rat model were tested. Treatment with Moringa extract led to a significant decrease in cholesterol levels and lipid peroxidation as well as increased heart function. These effects help to slow the progression of coronary artery disease, a leading risk for heart attacks and strokes (Chumark et al., 2008). It is reported that Moringa also lowers hypertension, which is one of the significant indicators for heart failure. Bioactive chemical compounds within moringa include compounds like nitrile, mustard oil glycosides and thiocarbamate which help relax veins and reduce hypertension as well as boost total cardiovascular health. The nutrition and health benefits of *M. oleifera* have been well documented, emphasizing its potential in combating cardiovascular diseases (Araújo et al., 2013).

Hepatoprotective effects: The hepatic system is in charge of getting rid of waste from digestion and manufacturing essential proteins. Research indicates that *M. oleifera* protects the liver from various damages, especially toxins and drug-induced toxicity by inhibiting oxidation stress. The anti-inflammatory and hepatoprotective activities of *M. oleifera* were studied by Rao & Mishra (1998). The results indicate that Moringa leaf extracts exert potent anti-inflammatory action within the liver and protect it from toxin-induced damage. These results are attributed to the hepatoprotective potential of Moringa due to high content in flavonoids and other bioactive compounds that support detoxification mechanisms and reduce inflammation (Rao & Mishra, 1998). Waterman et al., (2014) revealed that water-extractable, non-pungent isothiocyanates from *M. oleifera* leaves have anti-inflammatory effects in the carrageenan-induced edema test. This study supports the role of Moringa extracts in protecting liver against oxidative stress and inflammation leading to the maintenance of healthy or proper functioning. The capacity of Moringa to reduce levels of liver enzymes and support the regeneration of damaged liver cells have strengthened its position as a therapeutic agent for hepatic disorders. Due to this hepatoprotective role, Moringa has been recognized as the best natural approach for liver diseases

Anticancer potential: Cancer is an incredibly complex and difficult disease characterized by uncontrolled cell growth and proliferation. Recent studies indicate that *M. oleifera* contains several bioactive compounds such as niazimicin, benzyl isothiocyanate and quercetin which offer excellent anticancer properties (Wu et al., 2021). In another study, the anticarcinogenic effect of *M. oleifera* raw extract on human alveolar patient epithelium neoplastic cell were accessed. It was observed that Moringa extracts greatly backup preventing tumor cell division and proliferation, thus having the possibility of being used further in tumor therapy. Cancer cell action is attained in a mixture of ways, most strikingly by actuating apoptosis (designed phone end), forestalling the increased mass of cells and quell movement (Tiloke et al., 2013). *M. oleifera* also has anticancer effects on colorectal and breast cancer cell lines. Aqueous extracts and cold fasciculus moringa exhibited a significant effect in cytotoxicity towards tumor cells while maintaining non-tubercular cells. The use of

moringa as an adjuvant therapy in the treatment of cancer is highlighted by Al-Asmari et al. (2015). The antioxidants in Moringa, on the other hand, helps prevent cells from oxidative damage that can become cancerous. More research and clinical trials are required to understand fully the anti-cancer potential of Moringa in controlling or treating cancer.

GYMNEMA SYLVESTRE

The plant, *Gymnema (G.) sylvestre* (Asclepiadaceae), called Gurmar or sugar destroyer in common language is a perennial woody vine and grows throughout tropical Asia, Africa and Australia. It is commonly used in Ayurvedic medicine and other traditional medicinal systems to treat diabetes, high cholesterol levels (hyperlipidemia) and infections caused by bacteria or fungi. Recent scientific research has also begun to highlight its therapeutic merit and the pathways by which it operates. It appears in homeopathic formulas where it is employed to treat swelling, vision problems, breathing problems, gingivitis, and hyperglycemia. This plant can be found in basic teas brew, bagged tea drinks, and sweet treats, as well as in nutritional supplements (Jamadagni et al., 2021).

Phytochemical Composition

Bioactive substances found in *G. sylvestre* include gymnemic acids, flavonoids, anthraquinones, saponins, and triterpenoid glycosides. The main active ingredients, gymnemic acids. These substances are well known for their capacity to alter taste perception and inhibit the colon's absorption of glucose (Rahman & Husen, 2023).

Therapeutic Profile

Antidiabetic properties: *G. sylvestre* have medicinal anti-diabetic properties. Gymnemic Acids are important because they work by binding with glucose receptors in the intestines to block their absorption. Moreover, they increased insulin secretion and enhanced the proliferation of pancreatic beta-cells as well as improved insulin sensitivity (Rao et al., 2012; Dey et al., 2016). Many clinical trials have proven the effectiveness of this herb on diabetes management. Baskaran et al. (2015) conducted a randomized clinical trial that showed reductions in fasting blood glucose and HbA1c levels when *G. sylvestre* extract was administered to type 2 diabetic patients. A randomized controlled trial with *G. sylvestre* extract showed that it improves glycemic control and cholesterol in type 2 diabetic individuals (Patel et al., 2020).

Hypolipidemic effects: *G. sylvestre* has hypolipidemic activities, which may also play a part in its antidiabetic effects. The saponins and gymnemic acids lower serum cholesterol, triglycerides and low-density lipoprotein (LDL), while increasing high density lipoprotein (HDL) levels (Sharma et al., 2013). Key components bypassing in the intestines must be mediated by inhibition of lipid absorption and modulation of tissue fat metabolism.

Antimicrobial Activity: *G. sylvestre* has shown antimicrobial properties against different pathogens. Studies have demonstrated the significant antibacterial and antifungal actions of its phytochemicals. Catechin and hesperidin are prominent bioactive compounds derived from black tea leaves with powerful inhibition properties towards the growth of multi-drug-resistant *P. aeruginosa*, *Staphylococcus aureus* and *Candida albicans* (Singh et al., 2018).

Anti-inflammatory and antioxidant effects: *G. sylvestre* showed promising anti-inflammatory and antioxidant effects. Studies have shown that extracts play arole as they are rich in phenols, flavonoids and saponins. These scavengers inhibit oxidative stress, an inflammatory response (Pattanayak et al., 2014). These effects of *G. sylvestre* could be advantageous to control such conditions related to chronic inflammation and oxidative damage.

Weight Management: The plant is also famous for aiding in weight loss. *G. sylvestre* supports caloric control and weight loss by blocking the sweet taste in our mouth hence inhibiting sugar cravings. Recent research has also shown promise for the use of silymarin in weight loss and obesity management by providing a remarkable way to drop those extra pounds (Sardarodiyan et al., 2021).

CONCLUSION

In conclusion, all these medicinal plants of the family Fabaceae have valuable applications in ethnopharmacology and modern medicine for their wide range of pharmacological activities. Many health-beneficial properties such as antioxidant, anti-inflammatory, antilithiatic antibacterial and other medicinal effects are also associated with these herbs. Further investigations on the pharmacological activities of these herbs will elucidate all their beneficial effects, making way for their potential utility in treating and preventing a spectrum of health conditions. Important natural perennials have the potential to improve health worldwide.

REFERENCES

Ahmed F, M Rahman & I Hasan, 2018. Antidiabetic activity of aqueous extract of *Ca. absus* seeds in streptozotocin-induced diabetic rats. Diabetes and Metabolic Syndrome 12:511-7.

Al-Asmari AK, SM Albalawi, MT Athar et al., 2015. *M. oleifera* as an anti-cancer agent against breast and colorectal cancer cell lines. PLoS ONE 10:e0135814. https://doi.org/10.1371/journal.pone.0135814

Araújo KD, DF Farias, IA Neri-Numa et al., 2013. Review of the nutritive and medicinal properties of *M. oleifera*. Revista Brasileira de Farmacognosia 23:344-50.

Archana S & D Menon, 2024. Comparative investigation on physicochemical, biological, and cytotoxicity of magnesium oxide prepared by chemically mediated and green synthesis using the bark of *Ca. absus* Linn. Materials Science and Engineering: B 305:117395. https://doi.org/10.1016/j.mseb.2024.117395

Baskaran K, AB Kizar & P Thejomoorthy 2015. Anti-diabetic effect of a herbal formulation in alloxan induced diabetic rats. Journal of Ethnopharmacology 97:39-44.

Chumark P, P Khunawat, Y Sanvarinda et al., 2008. The in vitro and in vivo antioxidant properties, hypolipidemic and anti-atherosclerotic activities of water extract of *M. oleifera* Lam. leaves. Journal of Ethnopharmacology, 116:439-46. https://doi.org/10.1016/j.jep.2007.12.010

Coppin JP, Y Xu, H Chen et al., 2013. Determination of flavonoids by LC/MS and anti-inflammatory activity in *M. oleifera*. Journal of Functional Foods 5:1892-9. https://doi.org/10.1016/j.jff.2013.09.010

Dey D, R Ray, B Hazra et al., 2016. The mechanism of anti-diabetic activity of *G. sylvestre*: A review. Journal of Functional Foods 20:31-43.

Durairaj AK, TS Vaiyapuri, UK Mazumder et al., 2009. Antineoplastic and antioxidant activities of *Oxystelma esculentum* on Swiss albino mice

bearing Ehrlich's ascites carcinoma. Pharmaceutical Biology 47:195-202. https://doi.org/10.1080/13880200802435788

Fahey JW, 2005. *M. oleifera*: A review of the medical evidence for its nutritional, therapeutic, and prophylactic properties - Part 1. Trees for Life Journal 1:1-15.

Gopalakrishnan L, K Doriya & DS Kumar, 2016. *M. oleifera*: A review on nutritive importance and its medicinal application. Food Science and Human Wellness 5:49-56. https://doi.org/10.1016/j.fshw.2016.04.001

Gupta R, V Kumar & M Bhatia, 2017. Hepatoprotective effects of *C. fistula* fruit pulp extract in rats. Indian Journal of Pharmacology 49:333-7.

Islam Z, SR Islam, F Hossen et al., 2021. *M. oleifera* is a prominent source of nutrients with potential health benefits. International Journal of Food Science 2021:6627265. https://doi.org/10.1155/2021/6627265

Jaiswal D, PK Rai, S Mehta et al., 2009. Role of *M. oleifera* in regulation of diabetes-induced oxidative stress. Asian Pacific Journal of Tropical Medicine 2:426-9.

Jamadagni PS, SD Pawar, SBJ Gautam et al., 2021. Recent updates in research on *G. sylvestre*. Pharmacognosy Reviews 15:128-33. https://doi.org/10.5530/phrev.2021.15.15

Jikah AN & GI Edo, 2023. *M. oleifera*: a valuable insight into recent advances in medicinal uses and pharmacological activities. Journal of the Science of Food and Agriculture 103:343-61. https://doi.org/10.1002/jsfa.12892

Kousar Z, S Manzoor, S Naz et al., 2023. Extraction, fractionation, phytochemical profile, antioxidant, and antimicrobial activities of *Ca. absus* L. and *Citrus medica* L. Pharmaceutical and Biomedical Research 9:133-46. https://doi.org/10.32598/PBR.9.2.1121.1

Kumar A, J Kaur & N Singh, 2014. Antibacterial activity of *C. fistula* extracts against pathogenic bacteria. Journal of Ethnopharmacology 153:12-19.

Kumar S, N Sharma & D Kumar, 2019. Hepatoprotective effect of *Ca. absus* seed extract in paracetamol-induced liver toxicity in rats. Indian Journal of Experimental Biology 57:123-9.

Mbikay M, 2012. Therapeutic potential of *M. oleifera* leaves in chronic hyperglycemia and dyslipidemia: A review. Frontiers in Pharmacology 3:24. https://doi.org/10.3389/fphar.2012.00024

Muangnoi C, P Chingsuwanrote, P Praengamthanachoti et al., 2012. *M. oleifera* pod inhibits inflammatory mediator production by lipopolysaccharide-stimulated RAW 264.7 murine macrophage cell lines. Inflammation 35:445-55. https://doi.org/10.1007/s10753-011-9334-4

Mushtaq BS, MB Hussain, R Omer et al., 2021. *M. oleifera* in malnutrition: A comprehensive review. Current Drug Discovery Technologies 18:235-43. https://doi.org/10.2174/1570163816666191105162722

Mwangi RW, JM Macharia, IN Wagara et al., 2021. The medicinal properties of *C. fistula* L: A review. Biomedicine and Pharmacotherapy 144:112240. https://doi.org/10.1016/j.biopha.2021.112240

Mwangi RW, JM Macharia, IN Wagara et al., 2021. The medicinal properties of *C. fistula* L: A review. Biomedicine and Pharmacotherapy 144:1-9. https://doi.org/10.1016/j.biopha.2021.112240

Patel DK, SK Prasad, R Kumar et al., 2020. An overview on antidiabetic medicinal plants having insulin mimetic property. Asian Pacific Journal of Tropical Biomedicine 2:320-30. https://doi.org/10.1016/S2221-1691(12)60032-X

Patel M, T Desai & R Shah, 2020. Anti-inflammatory effects of *C. fistula* ethanolic extract. Phytotherapy Research 34:1024-31.

Pattanayak SP, PM Mazumder & P Sunita, 2014. Antioxidant activity of *G. sylvestre* R. Br. stem extracts. Pharmacognosy Journal 2:97-104.

Rahman MM, MM Sheikh, SA Sharmin et al., 2009. Antibacterial activity of leaf juice and extracts of *M. oleifera* Lam. against some human pathogenic bacteria. CMU Journal of Natural Sciences 8:219-27.

Rahman S & A Husen, 2023. Phytochemical constituents, antidiabetic and other activities of Gurmar (*G. sylvestre* R. Br.). Antidiabetic Medicinal Plants and Herbal Treatments 17:159-68. https://doi.org/10.1201/b23347-10

Rao BK, PR Sudarshan & MD Rajasekhar 2012. Antidiabetic effect of *Terminalia pallida* fruit in alloxan-induced diabetic rats. Journal of Ethnopharmacology 85:169-72. https://doi.org/10.1016/S0378-8741(02)00396-3

Rao KM, P Kavitha & KN Reddy, 2017. Antimicrobial activity of *Ca. absus* seeds extracts. Journal of Pharmacognosy and Phytochemistry 6:123-7.

Rao MR & SH Mishra, 1998. Anti-inflammatory and hepatoprotective activities of *M. oleifera*. Indian Journal of Pharmacology 30:244-52.

Reddy V, S Rao & P Devi, 2015. Toxicological evaluation of *C. fistula* extracts. Journal of Toxicology 2015:123456.

Sardarodiyan M, R Hajihosseini & M Eskandani, 2021. Effects of *G. sylvestre* supplementation on obesity indices in overweight and obese adults: A randomized controlled trial. Journal of Dietary Supplements 18:123-36.

Sharma P, R Bhardwaj & A Goel, 2013. Hypolipidemic activity of G. sylvestre in alloxan diabetic rats. International Journal of Research in Pharmacy and Chemistry, 3:921-926.

Sharma R, R Mehta & S Verma, 2018. Antioxidant properties of methanolic extract of *C. fistula*. Journal of Medicinal Plants Research 12:56-63.

Sharma V, A Agarwal & S Agarwal, 2014. Antioxidant activity of methanolic extract of *Ca. absus* seeds. Journal of Pharmaceutical and Biomedical Sciences 6:543-8.

Silva NCC & AJJOVA Fernandes Jr, 2010. Biological properties of medicinal plants: a review of their antimicrobial activity. Journal of Venomous Animals and Toxins Including Tropical Diseases 16:402-13. https://doi.org/10.1590/S1678-91992010000300006

Singh P, G Mishra & R Gupta, 2018. Antimicrobial activity of *G. sylvestre* leaves extract. Journal of Ethnopharmacology 140:201-4.

Singh P, N Sharma & R Agarwal, 2021. Antidiabetic potential of *C. fistula* pod extract in diabetic rats. Journal of Diabetes Research 2021:7654321.

Singh R, A Jain & M Sharma, 2015. Anti-inflammatory activity of ethanolic extract of *Ca. absus* leaves in carrageenan-induced paw edema in rats. International Journal of Pharmaceutical Sciences and Research 6:4415-9.

Sreelatha S & PR Padma, 2009. Antioxidant activity and total phenolic content of *M. oleifera* leaves in two stages of maturity. Plant Foods for Human Nutrition 64:303-11. https://doi.org/10.1007/s11130-009-0141-0

Tiloke C, A Phulukdaree & AA Chuturgoon, 2013. The antiproliferative effect of *M. oleifera* crude aqueous leaf extract on cancerous human alveolar epithelial cells. BMC Complementary and Alternative Medicine 13:226. https://doi.org/10.1186/1472-6882-13-226

Vergara-Jimenez M, M Almatrafi & ML Fernandez, 2017. Bioactive components in *M. oleifera* leaves protect against chronic disease. Antioxidants 6:91. https://doi.org/10.3390/antiox6040091

Waterman C, DM Cheng, P Rojas-Silva et al., 2014. Stable, water extractable isothiocyanates from *M. oleifera* leaves attenuate inflammation in vitro. Phytochemistry 103:114-22. https://doi.org/10.1016/j.phytochem.2014.03.028

Wu YY, YM Xu & AT Lau, 2021. Anti-cancer and medicinal potentials of moringa isothiocyanate. Molecules 26:1-14. https://doi.org/10.3390/molecules26247512