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PHYTOCHEMICAL, PHARMACOLOGICAL AND NUTRITIONAL VALUES OF MANGIFERA INDICA: AN OVERVIEW

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ABSTRACT:

Naturally occurring products are an important source of new compounds that lead to drugs in all major diseases. *Mangifera indica* (M.I.) commonly known as mango belongs to the family *Anacardiaceae* & genus *Mangifera*, which consists of about 30 species of tropical fruiting trees. Mangifera indica consists of active substances with high therapeutic potential. The ethnomedicinal parts of the plant viz roots, stem, bark, leaves, flowers, and fruits are widely used to treat various diseases and disorders. It has a wide range of medicinal uses, including anti-inflammatory anti-hyperglycemic, hepatoprotective, antibacterial, anticancer, immunomodulatory, antiulcer, and antioxidant, properties. The objective of the overview is to highlight the information on the plant's botanical description, pharmacological actions, and its traditional uses. The authors collect research and review articles for findings of other additional potential and therapeutic effects. The current overview emphasizes the phytochemical investigation, pharmacological actions, and nutritional value of Mangifera indica. By using this overview, the researcher finds future scope related to phytoconstituents that are responsible for therapeutic activity the overview.

Keywords: Mangifera indica, Mangiferin, Mango, Pharmacological activity

1.0 INTRODUCTION:

India has various systems of health like Ayurveda, Unani, Homeopathy, and Naturopathy that are mentioned even in the Vedas and other scriptures. These systems existed together with allopathic, containing vast, safe, and ongoing usage of multiple herbal drugs.[1] It is one of the Ayurvedic remedies for relieving acidity and digestion caused by pitta (heat). Mangiferin has potent antioxidant, antilipid peroxidation, immune-modulating, cardiotonic, hypotension, wound-healing, antidegenerative, and anti-diabetic effects. Various parts of plants are used as a dentifrice, antiseptic, astringent, diaphortic, stomachic, vermifuge, tonic, laxative, and diuretic and to treat diarrhea, dysentery, anemia, asthma, bronchitis, cough, hypertension, insomnia, rheumatism, toothache, leucorrhoea, hemorrhage, and piles. All parts are used to treat abscesses, broken horn, rabid dog or jackel bites, tumors, snakebites, datura poisoning, heat stroke, miscarriage, anthrax, blisters, mouth wounds, tympanitis, colic, constipation, glossitis, indigestion, bacillosis, bloody dysentery, liver and kidney disorder, excessive urination, teantus, and respiratory disorder.[2] A wide range of phytochemicals have recently been observed in Mangifera indica such as mangiferin, catechins, gallic acid, protocatechuic acid, propyl and methyl gallate, anthocyanins, quercetin, rhamnetin, kaempferol and ellagic acids.[3] As a result, Mangifera indica (M.I.) exhibits various pharmacological potentials, such as

anti-cancer, anti-inflammatory, anti-diabetic, anti-oxidant, anti-bacterial, anti-fungal, anthelmintics, gastroprotective, hepatoprotective, anti-plasmodial, anti-hyperlipidemic[4], immune-stimulating activities.[5]

Table 1: Taxonomical Classification [6]

Kingdom	Plantae
Class	Mangoliopsida
Phylum	Mangoliophyta
Order	Sapindales
Family	Anacardiaceae
Genus	Mangifera
Species	Indica

1.1 Botanical Description:

The genus Mangifera indica originates in tropical Asia, with the greatest number of species found in Borneo, Java, Sumatra, and the Malay Peninsula. Mangifera indica is now cultivated all over the tropical and subtropical world for commercial fruit production, as a garden tree, and as a shade tree for stock.[7] M. indica is a large evergreen tree as shown in Figure 1. It is 10-45 m high, bark thick, rough, dark grey; leaves linear-oblong or elliptic-lanceolate, 10-30 cm long and 2-9 cm wide, resinous odor, flower tiny, reddish-white or yellowish green, pungently odorous and melliferous; fruit forms a large drupe exceedingly variable in form and size: flesh (mesocarp) whitish-yellow or orange, firm, soft, absent or very little in others; seed solitary, ovoid-oblique, encased in a hard compressed fibrous endocarp (stone).[8]

Figure 1: Mango tree with fruits.

1.2 Ethnomedicinal uses:

For centuries, diverse components of mango have been employed for an extensive range of ethnomedicinal purposes.[9]

Roots & Bark: Used as astringent, acrid, refrigerant, styptic, anti-inflammatory antisyphilitic, vulnerary, antiemetic, and diarrhea. They are useful in vitiated conditions of pitta, metorrhagia, calonorrhagia, pneumorrhagia, lecorrhoea, syphilis, uteritis, wounds, ulcers, and vomiting. The juice of fresh bark has a strong effect on mucous membranes, in menorrhea leucorrhoea, diarrhea and bleeding piles.

Leaves: Used as astringent, refrigerant styptic, healing of wounds and constipating. They are also helpful in vitiated conditions of cough, hiccup, hyperdipsia, burning sensation, hemoptysis, hemorrhages, wounds, ulcers, constipation dysentery, pharyngopathy, scorpion string, and stomachopathy. The ash of burnt leaves is useful in burns and scalds. For the treatment of throat diseases, the smoke from burning leaves is inhaled.

Flowers: Used as astringent, refrigerant, styptic, vulnerary, constipating and haematinic. The dried flowers are useful in vitiated conditions of pitta, haemorrhages, haemoptysis, wounds, ulcer, anorexia, dyspepsia, uroedema gleet, catarrh of bladder, diarrhoea, chronic dysentery and anemia.

Fruits: The unripe fruits are acidic, acrid, antiscorbutic, refrigerant, digestive, and carminative. They are helpful in dysentery ophthalmia, eruptions, urethrorrhoea, and vaginopathy. The ripe fruits are refrigerant, sweet, emollient, laxative, cardiotonic, hemostatic, aphrodisiac, and tonic. They are helpful in vitiated conditions such as vata and pitta, dyspepsia, cardiopathy, hemoptysis, hemorrhages from the uterus, lungs, and intestine, emaciation, anorexia and anemia.

Stone: The seed kernel of the mango has a high-protein content (8.5%) and is rich in gallic acid. Possessing sweet, acrid, astringent, refrigerant, anthelmintic, constipating, hemostatic, vulnerary, and uterine tonic. This kernel is beneficial in conditions associated with pitta and cough imbalances, as well as in treating helminthiasis, chronic diarrhea, dysentery, haemorrhages, hemoptysis, haemorrhoids, ulcer, bruises, leucorrhoea, menorrhagia, diabetes, heat burn, and vomiting.

1.3 Nutritional Importance:

Nutrients from various food components have played a vital role in maintaining the normal function of the human body. These functional or medicinal foods, phytonutrients, and phytomedicines play significant roles in maintaining and enhancing health and modulating the immune system to prevent specific diseases.[10] Mangifera indica is the most popular fruit due to its unique flavor and good nutritional value. It is one of the best sources of vitamins like vitamins A, B, and C and also has different materials such as calcium, magnesium, potassium, sodium, phosphorous, and iron. Citric, Tartaric, and Malice acids are also present in Magifera indica in small quantities.[11] The detailed nutritional content and phytochemical composition of Mango is shown in Table 2 and Table 3 respectively. Figure 2 and Figure 3 represent Phytoconstituents and Ethnomedicinal uses of various parts of Mango.

Table 2: Nutritional content of Mango

Vitamin A	Vitamin A is an essential content of Mangifera indica. It is essential for vision and protection against aged relaxed muscular degeneration. It helps to stimulate the circulation of blood in the mucous membrane and skin thus beneficial for various skin disease treatments.[12]
Vitamin C	The unripe mangoes and mature mangoes exhibit elevated levels of vitamin C, a component known to reduce LDL cholesterol levels in the body. Incorporating Mangifera indica into one's diet building resistance against infections and effectively neutralizes detrimental oxygen-free radicals.[13]
Prebiotic fiber	Present in Magnifera Indica helps in the growth of beneficial bacteria in the gut and prevent gastrointestinal disorders like ulcer, and irritable bowel syndrome.[14]
Copper	Mango peels are rich in copper which is essential for the formation of blood cells and acts as a cofactor for many enzymes.[15]
Potassium	It is a component of cell and body fluids that contributes to heart rate and blood pressure. Fresh mango is a very rich source of potassium.[16]

Table 3: Phytochemical Composition of Mango

Plant parts	Chemical constituents	Ethno-medicinal uses
Stem bark	Terpenoidal saponn indicoside A & B, Manghopana, Mangifera indicleanone[17] Mangifera indicasterol, manglupenone Mangifera indica coumarin, triacontane.[18]	Aqueous extracts of mango are used for the treatment of various diseases such as syphilis, anemia, scabies, diabetes, cutaneous infections, menorrhagia, and diarrhea[25]
leaves	Protocatechuic acid, catechin, mangiferin, alanine, glycine, kainic acid, shikimic acid, tetracyclic, terpenoids.[19]	Juices of leaves used for dysentery and ashes of burnt leaves used for scalds.[26]
Fruits	Mangiferin, Xanthophyll esters, cartenes, and tocopherols.[20]	Facilitates to prevent colon cancer by calming inflammation and juice made from the fruit acts as a restorative tonic used in heat stroke.[27]
Seed	Polyphenols such quercetin, Kaempferol, gallic acid, tannin, xanthone.[21]	Seed kernel in hemorrhages and bleeding hemorrhoids, seed can also be applied on the burn, to treat Asthma.[28]
Flower	Alkyl gallates such as gallic acid, methyl gallate ethyl gallate.[22-23]	Dried mango flowers serve as astringent in cases of diarrhea and chronic dysentery. Powder helps in the treatment of allergy dermatitis.[29]
Root	3-hydroxy-2-(4–methylbenzoyl)-chromone and 3-methoxy-2-(4-methyl benzoyl)-chromone, chromones.[24]	The paste of Mangifera indica roots applied on palms and soles to cure fever. The paste of root helpful in the healing of mouth wound.[30]

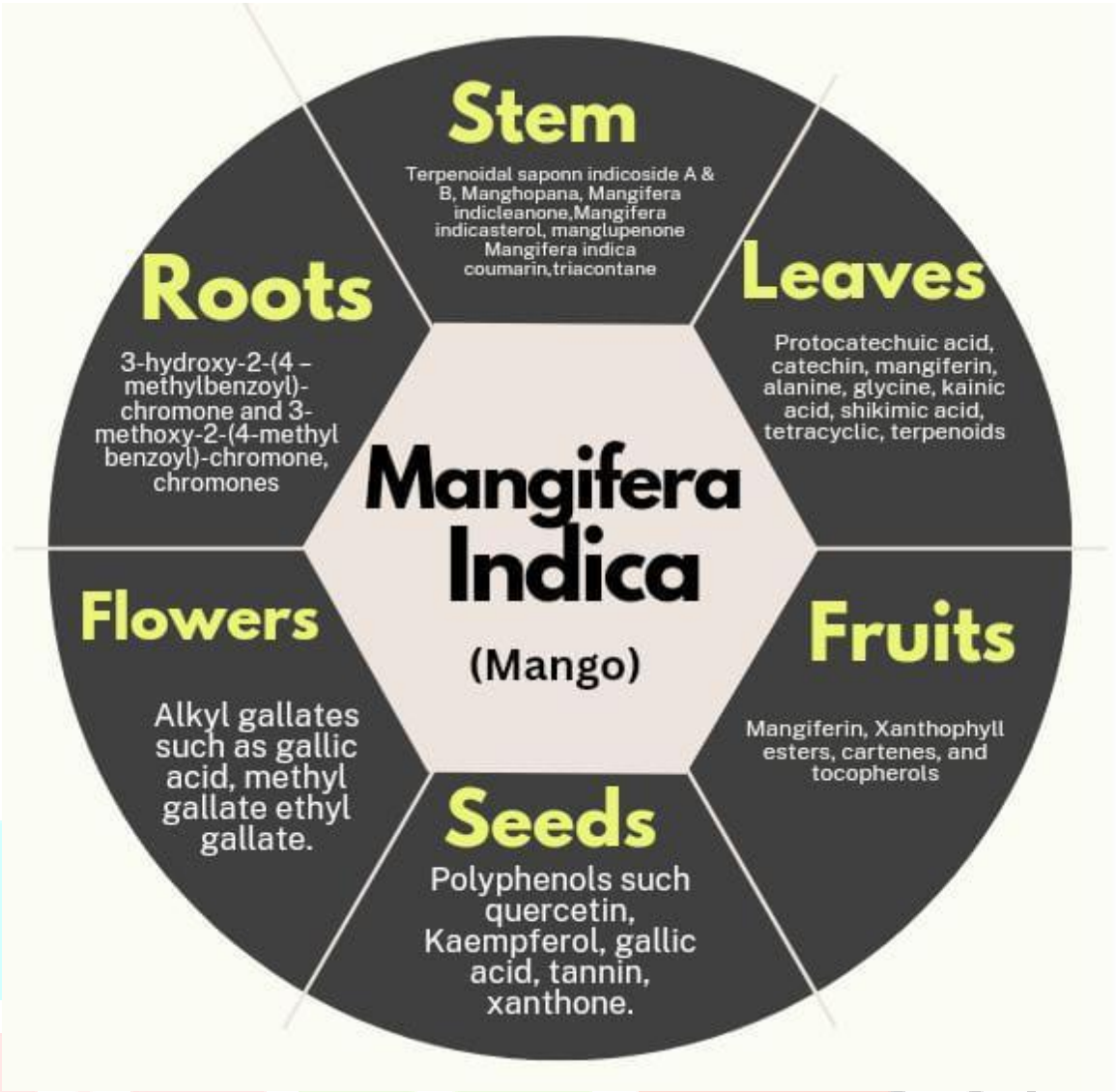

Figure 2: Phytoconstituents present in various parts of Mango.[17-24]

Figure 3: Ethnomedicinal uses of various parts of Mango.[25-30]

1.4 Pharmacological Action:

Every component of these plants possesses medicinal significance and has been traditionally employed to address a variety of ailments. Numerous in vitro and in vivo investigations have been conducted to unveil the diverse pharmacological capabilities of M. indica. Various segments of M. indica tress have been demonstrated potential in offering anti-fungal, anti-cancer, anti-plasmodial, hepatoprotective, immune-modulating, anthelmintic, and anti-hypertensive effects.[31] The following pages will focus on the pharmacological activities excreted by the Mangifera indica.

1.4.1 Anti-inflammatory activity

The anti-inflammatory activity of the aqueous extract of leaves of the Mangifera indica variety (Thotapuri) shows the best action. The activity was carried out by the carrageenan-induced rat paw edema used to assess acute inflammation and the cotton pellet granuloma was used to examine chronic inflammation. Diclofenac sodium a standard drug (10 mg/kg) used for both models. In these techniques, ethanol extracts and ethyl-acetate at a dose of 300mg/kg have shown significant activity which is comparable to that of the standard.[32] Numerous studies indicate that extracts derived from mangoes possess anti-inflammatory properties in experimental models of ulcerative colitis. In a recent investigation, the administration of mango beverages from the fruits of the Mexican variety and containing vitamins and polyphenols resulted in the alleviation of colitis symptoms. The effect was attributed to the modulation of the PI3K/ AKT/ mTOR pathway.[33] Additionally, in another study, aqueous extract obtained from the stem-bark extract from M. indica which is rich in flavonoids and polyphenols demonstrated the ability to attenuate colitis symptoms in a model of colitis.[34]

1.4.2 Anti-Hyperglycaemic activity

The study showed that a significant (P<0.05) increase in the fasting blood glucose concentrations was obtained in the alloxan-induced diabetic rats. When the diabetic rats were induced with the ethanol leaf extract of Mangifera indica showed significant (P<0.05) decreases in the fasting blood glucose levels compared with the untreated diabetic rats.[35]

Further exploration of the anti-diabetic and hypolipidemic effects of Mangifera was conducted using rat models for both type 1 and type 2 diabetes. Type 1 and type 2 diabetic rats were induced by administering streptozotocin. The stem bark of m. indica was used in the study at a dose of 10 and 20mg/kg was administrated intra-peritoneally in both type 1 and type 2 diabetic rats. Mangifera exhibited notable inhibitory effects on alpha amylase and alpha-glucosidase activities, surpassing the effects observed with the standard drug, acarbose. Additionally in the type 2 diabetic rat models, Mangifera demonstrated anti-diabetic effects by significantly reducing total cholesterol, LDL, triglyceride, and VLDL levels, which concurrently elevated HDL levels. These findings underscore the potential therapeutic benefits of Mangifera in managing diabetes and associated lipid abnormalities.[36]

1.4.3 Anti-ulcer activity

Histopathological findings also confirmed the antiulcer activity of M. indica leaf extracts in albino rats. The antiulcer potential of the petroleum ether and ethanol extracts of leaves of mango was evaluated against in vivo aspirin-induced gastric ulcer. The ulcer index was substantially decreased by petroleum ether 250mg/kg and ethanol extract 250mg/kg of leaves of mango trees.[37],[38] Other findings show that mangiferin affords gastroprotection against gastric injury through the antisecretory and antioxidant mechanisms of action.[39]

1.4.4 Analgesic and Antipyretic activity

The anti-pyretic activity of Mangiferai indica was assessed using extracts from its stem and bark in the mouse model. The results indicated a significant reduction in yeast induced hyperpyrexia following the administration of the extract.[40]

1.4.5 Hepatoprotective activity

Three poylphenolic principles, 1,2,3,4,6-penta-O-galloyl-β-D-glucopyranose (PGG), methyl gallate (MG), and gallic acid (GA), were isolated from the ethanolic extract of seed kernels of Thai mango. Evaluating their hepatoprotective potentials against liver injury in rats induced by carbon tetrachloride. The result shows that the extract has significant anti-oxidant activity.[41] Hepatoprotective activities in mango seed kernels demonstrate the various chemopreventive properties of mango pulp extract (MPE) was evaluated in alteration in liver of Swiss albino mice. Modulating of cell groeth regulators, MPE was found to be effective in combating oxidative stress induced cellular injury in mouse liver.[42]

1.4.6 Antioxidant activity

Recent studies have shown that these free radicals developed during the metabolic process contribute to various wide range of diseases such as acquired immunodeficiency syndrome, ischaemic diseases, neurological disorders, and many others.[43] Phytochemicals like ascorbic acid methyl gallate and tannic acid show significant anti-oxidant activity and their leaf extracts inhibit lipid peroxidation which is against lipofundin-induced oxidative stress.[44]

1.4.7 Anticancer activity

Cancer ranks among the foremost global challenges, following cardiovascular disease. Therefore, it is crucial to explore innovative treatment approaches to address these worldwide concerns. Polyphenols found in Mangifera indica, such as gallotannin, phenolic acids, mangiferin, and quercetin demonstrate chemo-preventive effects against diverse cancer types owing to their anti-inflammatory and antioxidant properties.[45] Mangiferin was found to mitigate oxidative stress and inhibit methylmercury-induced DNA damage in human neuroblastoma cell line IMR-32.[46] Further study was conducted for the antitumoral effects of ML extracts on MDA-MB-231 highly and MCF7 minimally invasive breast cancer cells and MCF10 non-tumorigenic cells at IC50 >200 µg/ml.[47] The anti-proliferative effect is shown by the accumulation of cells in the G2/M phase of cell cycles with 90% methanolic extract of Mangifera indica leaves. The leaf extract of Mangifera indica in different concentration ranges (62.5-500µg/ml) showed

anticancer activity. The leaf extract inhibits cancer cell proliferation in vitro mainly by accumulating cells in the G2/M phase.[48]

1.4.8 Immunoregulation

Mangiferin has been considered as a candidate for immune regulators. As an immune-stimulant, it rescued the cyclophosphamide-induced immune depression, such as the lymphoid organ atrophy, less cellular response, low antigen-specific IgM, more lipid peroxidation, and decreased superoxide dismutase activities. It also increased remarkably the levels of serum hemolysis IgG and IgM in mice.[49]

1.4.9 Antiallergic and Antihelmintic activity

The stem bark of the mango tree contains an aqueous extract with chemical constituents known as vimang and mangiferin. These compounds exhibit anti-allergic and anti-helmintic activities. The experimental study showed mice infected with the nematodes trichionella spiralis were orally induced vimang or mangiferin at doses of 500 or 50 mg per kg body weight per day respectively. Treatment resulted in a significant decrease in serum levels of specific anti-Trichinella IgE throughout the parasite life cycle. Furthermore, in a separate experiment involving rats, oral administration of vimang and mangiferin over 50 days inhibited mast cell degranulation, as assessed by the passive cutaneous anaphylaxis test. The test involved sensitization with infected mouse serum possessing a high IgE titre, followed by stimulation with the cytosolic fraction of T. spiralis muscle larvae. The pivotal role of IgE in the pathogenesis of allergic disease, these findings suggest that vimang and mangiferin may hold therapeutic potential for such conditions.[50],[51]

1.4.10 Antibacterial activity

The aqueous and ethanol extract of leaves and stems of mango at 50 and 25 mg/mL has been found sufficient activity against bacteria, Staphylococcus aureus, Streptococcus aeruginosa, Candida albicans, Enterococcus faecalis.[52] The antibacterial ability of extract also found against Salmonella enterica, Listeria monocytogenes, Escherichia coli.[53] Antibacterial activity of mango extracts upon gram-negative and gram-positive bacteria and yeast Candida albicans was also demonstrated.[54],[55] And the antibacterial activity of mango extract is due to the presence of mangiferin and gallotannin.[56]

1.4.11 Anti-Diarrheal activity

It is one of the most infectious diseases, caused by drinking contaminated or unsafe water, poor sanitation and hygiene, eating raw meat, and food intolerance, and it accounts for 3.2% of mortalities worldwide.[57],[58]

Organisms responsible for this disease include microbial communities like Escherichia coli, Candida albicans, Vibrio cholerae, Shigella flexneri, Staphylococcus aureus, and Salmonella typhi. According to WHO reports, diarrhea accounts for approximately 1.6 million deaths in developing countries, causing 28% mortality in infants in Africa and southeast Asia due to sever gastroenteritis[59],[60] Further study about the anti-diarrheal activity, he reported that the flavonoid present in MI inhibits intestinal motility and hydro electrolytic secretion, it also able to inhibit intestinal secretory responses induced by prostaglandins this may be a possible mechanism which supports the anti-diarrheal activity of Mangifera indica.[61]

1.4.12 Antibone resorption

The chemical constituent mangiferin is responsible for the inhibitition of parathyroid-hormone-stimulated bone resorption in mice.[62]

1.4.13 Antifungal

The antifungal potential of methanol, ethanol, and aqueous extracts was found against Alternaria alternate at 6.25 mg/mL concentration.[63]

1.4.14 Antiviral

Mangiferin was considered an antiviral agent for herpes simplex virus.[64],[65] HIV and hepatisis B virus.[66] In an in-vitro, mangiferin demonstrates effectiveness against herpes simplex viruses (HSV) type 2. Notably, mangiferin does not directly deactivate HSV-2 but inhibits the late stages of HSV-2 replication.[67] In laboratory conditions, mangiferin exhibited the capability of replication of HSV-1 within cells.[68] Additionally, mangiferin demonstrated the ability to counteract the cytopathic effects of HIV.[69]

1.4.15 Antimalarial activity

The stem bark extract of M.I. was evaluated for anti-plasmodial activity against Plasmodium yoeliingeriensis. The extract exhibited a schizontocidal effect during early infection and also demonstrated repository activity.[70] in-vitro antimalarial activity of chloroform methanol (1:1) extract of M.I. was evaluated. The extract showed good activity of Plasmodium falciparum in-vitro with a growth inhibition of 50.4% at 20 μg/mL.[71]

1.4.16 Laxative

Mangiferin significantly accelerated gastrointestinal tract (GIT) movement at oral doses of 30 mg/kg and 100mg/kg by 89% and 93% respectively.[72]

1.4.17 Antiparasitic activity

In a neonatal mouse model, mangiferin at 100mg/kg blocks Cryptosporidium parvum and similarly to the same dose of 100mg/kg of an active drug, paromomycin.[73]

1.4.18 Gastroprotective

Mangiferin, a naturally occurring glucosyl xanthone derived from M.I. was investigated as a novel gastroprotective agent in mice subjected to gastric injury induced by ethanol and indomethacin. The impact of mangiferin on gastromucosal damage was evaluated by determining changes in the mean gastric lesion area or ulcer score in mice. Additionally, the effects on gastric secretory volume and total acidity were assessed in 4-hour pyrolus ligated rats. These findings strongly suggest that mangiferin provides gastroprotection against ethanol and indomethacin-induced gastric injury, likely through its snit-secretory and anti-oxidant mechanism of action.[74]

1.4.19 Anti-tumor-anti-HIV activity

The stem bark mango has shown significant cytotoxic activity against the breast cancer cell MCF 7, MDA-MB-435, and MDA-N, as well as against a colon cancer cell line(SW-620 and a renal cancer cell line 786-0.[75] Ethanol and water extract (1:1) of dried aerial parts of mango was administered to mice intraperitoneally at a dose of 250 mg/kg was inactive against Leuk-P388.[76] Mangiferin dose when time-dependent inhibits the proliferation of K562 leukemia cells and induces apoptosis in K563 cells line present in-vitro studies, most likely by down-regulating bcr/abl gene expression.[77] The findings indicate that Mangifera has the potential to act as a naturally existing chemopreventive agent.[78]

2.0 CONCLUSION:

Medicinal plants have shown promising potential in the prevention of various diseases. They have been used for many years with minimal or no side effects, making them a secure and readily available option for treating various disorders. In this overview of Mangifera indica, we have gathered information on the phytochemical, pharmacological, and nutritional values of mango. The extensive pharmacological actions attributed to various components of this tropical fruit, such as antioxidant, anti-inflammatory, anti-hyperglycemic, hepatoprotective, antibacterial, anticancer, immunomodulatory, and antiulcer properties to its anti-cancer effects, illuminate its therapeutic potential. Furthermore, the rich nutritional content of Mangifera indica, encompassing essential vitamins and bioactive compounds, solidifies its status as not only a flavorful delight but also a powerhouse of health benefits. Its medicinal virtues and nutritional richness make it a valuable asset in the realm of preventive healthcare and wellness. As we continue to unravel the mysteries of its pharmacological actions and nutritional content, it is with anticipation that we look towards a future where this tropical gem might play an even more significant role in promoting health and vitality.

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