NUTRITIONAL IMPORTANCE AND PHARMACOLOGICAL ACTIVITY OF MANGIFERA INDICA

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ABSTRACT
The mango fruit obtained from Mangifera indica belonging to the family Anacardiaceae. Mangifera indica is the most popular fruits due to its unique flavour and good nutritional value. It contains various phytochemical like Beta-carotene, quercetin, astragalin and protects the body against free radical damage. It is a good source of vitamins like vitamin A, B and C. It contains different minerals such as calcium, magnesium, potassium, sodium, phosphorous and iron. It also contains in small quantity citric, tartaric, malic acid. The fruit root, bark, flower, and leaves are used in different disease and have various pharmacological activity like Anti-inflammatory, anthelmitic, anticancer, eye diseases, hepatoprotective, antimicrobial, immunomodulatory, antiulcer, antioxidant and anti-hyperglycaemic activity. It is traditionally used in various diseases and disorders like anti-diarrhoeal, dysentery, syphilis, analgesic, and urinary disorders. According to WHO reports in developing countries up to 80% of people use traditional medical therapies against various ailments as the first line of defences. Traditional medical systems have played an imperative role in the healthcare in all societies.

KEYWORDS: Mangifera indica, Vitamin A, Mangiferin, Minerals, Phytochemicals.

INTRODUCTION
India having various systems of health like Ayurveda, Unani, Siddha, Homeopathy and Naturopathy that mentioned even in the Vedas and other scriptures. These systems existed side-by-side with Allopathic containing very long, safe and continuous usage of many herbal drugs.[1] Traditional medical systems have played an imperative role in the healthcare in all societies. According to a WHO report, in developing countries, up to 80% of people use...
traditional medical therapies against various ailments as the first line of defences.\cite{2} Ayurveda is the mother of all forms of modern medicine. It is based on the belief that health and wellness depend on a delicate balance between the mind, body and spirit. The primary focus of Ayurvedic medicine is to promote good health, rather than fight disease. Ayurveda recognizes the interaction between humans and nature (elements that compose our body also make up the Earth).\cite{3} \textit{Mangifera indica} has been an imperative herb in the Ayurvedic and home-grown medical systems for over 4000 years. \textit{Mangifera indica} is belonging to family Anacardiaceae, \textit{Mangifera indica}, which consists of about 30 species of tropical fruiting trees in the flowering plant, According to Ayurveda, different medicinal properties are accredited to different parts of \textit{Mangifera indica} tree.\cite{4} The fruit root, bark, flower, and leaves are used by tribal’s and all Indians to treat various diseases and disorders, it is also used as a holy plant and it is also used as fuel and for furniture making. It is specially used to control heart diseases, urinary disorders, dysentery, eye diseases, diarrhoea, syphilis, ulcer, diabetes, kidney stone, sunstroke, tuberculosis, an intestinal disorder, blood purification, nasal bleeding, amoebiasis and piles.\cite{5}

**BOTANICAL DESCRIPTION**

The genus \textit{Mangifera indica} originates in tropical Asia, with the greatest number of species found in Borneo, Java, Sumatra, and the Malay Peninsula. \textit{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.\cite{6} \textit{M. indica} is a large evergreen tree, 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 odour; flowers tiny, reddish white or yellowish green, pungently odorous and melliferous; fruit forms a large drupe exceedingly variable in form and size: fruit skin thick or thin, leathery, green, yellowish or red, often dotted with numerous glands: flesh (mesocarp) whitish-yellow, yellow or orange, firm, soft or juicy, sub-acid or sweet, richly aromatic: fibres throughout the flesh in some types, absent or very little in others; seed solitary, ovoid-oblique, encased in a hard compressed fibrous endocarp (stone).\cite{7}

**SCIENTIFIC CLASSIFICATION**

<table>
<thead>
<tr>
<th>Kingdom</th>
<th>Plantae</th>
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<tbody>
<tr>
<td>Subkingdom</td>
<td>Tracheobionta</td>
</tr>
<tr>
<td>Superdivision</td>
<td>Spermatophyta</td>
</tr>
<tr>
<td>Division</td>
<td>Magnoliophyta</td>
</tr>
</tbody>
</table>
Class : Magnoliopsida  
Subclass : Rosidae  
Order : Sapindales  
Family : Anacardiaceae  
Genus : Mangifera  
Species : M. Indica[8] 

![Image of mango plant and fruits]

Fig.1: (A) Whole plant of mango, (B) Seed kernel, (C) Seed, (D) Fruits of mango

MACROSCOPY AND MICROSCOPY

Table No.1: Macroscopy and microscopy of different parts of M. indica

<table>
<thead>
<tr>
<th>MACROSCOPY OF DIFFERENT PARTS</th>
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</thead>
<tbody>
<tr>
<td><strong>Leaves</strong></td>
</tr>
<tr>
<td><strong>Stem bark</strong></td>
</tr>
<tr>
<td><strong>Root</strong></td>
</tr>
<tr>
<td><strong>Seed</strong></td>
</tr>
</tbody>
</table>

MICROSCOPY OF DIFFERENT PARTS

| **Leaf**                       | The transverse section of the leaf denoted the presence of the epidermis, palisade and spongy mesophyll and vascular bundles. |
| **Stem**                       | The presence of cork cells, bundles of fibers, single fibers, prisms of calcium oxalate crystals, pitted vessels and sclereids in the stem. The transverse section stem bark exposed the presence of epidermis, cork, cortex, vascular bundles |
and the pith.

| Root | Anisocytic stomata, epidermal cells, unicellular trichomes, starch granules, xylem vessels in the leaf and bundles of fibers, cork cell, a prism of calcium oxalate crystals, bundles of fibers with calcium oxalate crystals and single pitted fibers with the lumen in the root. The transverse section of root revealed the presence of epidermis, cortex, vascular bundle and the pith.\[11\] |

**FORMULATIONS AND VARIANTS**

Vimang is the brand name of a standard aqueous stem bark extract of selected varieties of *Mangifera indica* L., which contains an exact mixture of components including polyphenols, triterpenes, phytosterols, fatty acids, and microelements. This pharmaceutical active ingredient is used to produce Vimang tablets (300 mg) and a 1.2% cream which have been protected by patent and are registered as a Phyto drug, food supplement or cosmetic by the Cuban health regulatory agencies. Previous experiments on that extract have shown that it has antioxidant, anti-inflammatory, analgesic immunomodulatory\[12-18\] and antioxidant properties.\[19\] Patients with acute herpetic neuralgia using Vimang in a hospital in Cuba received a daily dose of 1800 mg of extract (two coated Vimang® tablets 300 mg each, three times daily before meals, results suggested that vimang® supplementation might be beneficial to prevent and treat neuropathic pain.\[20\] Vimang® capsules were organized with 300 mg of a dry extract obtained from *Mangifera indica* L. stem bark. This extract was prepared by decoction with water for 1 h and then it was concentrated by evaporation and spray-dried to obtain a fine homogeneous brown powder with a particle size of 30–60 mm. The quality control analysis reported more than 50% of total polyphenols from Novatec Laboratory (La Habana, Cuba).\[21\]

**NUTRITIONAL IMPORTANCE**

Nutrients from various food components have played a vital role in maintaining normal function of the human body. These functional or medicinal foods and phytonutrients or phytomedicines play positive roles in maintaining and enhancing health and modulating immune function to prevent specific diseases.\[22\] *Mangifera indica* is the most popular fruits due to its unique flavor and good nutritional value. It is a good source of vitamin like vitamin A, B, C and also have different minerals such as calcium, magnesium, potassium, sodium, phosphorous and iron. Citric, Tartaric and Malice acid are also present in *Mangifera indica* in small quantity.\[23\]
Iron  
*Mangifera indica* having iron in a large amount useful for people who is suffering from anemia. Women become week after their menopause they should take *Mangifera indica* for fulfillment of iron requirements.

Vitamin A  
Vitamin A is 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.[24]

Vitamin B₆  
Vitamin B6 is also known as pyridoxine *Mangifera indica* is a very good source of this vitamin. Homocysteine is an amino acid present in the blood that damage blood vessel linings, vitamin B6 have an ability to lowering the level of homocysteine within the blood thus helpful in preventing heart disease like stroke, coronary artery disease.

Vitamin C  
The level of vitamin C is high in unripe as well as ripe *Mangifera indica* that has been shown to lower LDL cholesterol level within the body. Consumption of *Mangifera indica* helps in the development of resistance against infectious agents and scavenges harmful oxygen free radicals.[25]

Fiber  
It is rich in fiber content which helps in digestion by breaking down protein which facilitates absorption of food.

Prebiotic fiber  
Present in *Mangifera indica* helps in growth of beneficial bacteria in the gut and prevent from various gastrointestinal disorders like an ulcer, irritable bowel syndrome.[26]

Pectin  
It is a chemical compound that is high in *Mangifera indica*. According to various study, it was shown that pectin has an effective action against gastrointestinal tract cancer.

Copper  
*Mangifera indica* peels are rich in copper which required for the production of blood cells and act as a cofactor for many enzymes.[27]

Potassium  
It is an important component of cell and body fluids that helps controlling heart rate and blood pressure. Fresh *Mangifera indica* is a very rich source of potassium.[28]

**PHYTOCHEMICAL STATUS, TRADITIONAL, AND ETHANOMEDICINAL USES**

<table>
<thead>
<tr>
<th>Plant parts</th>
<th>Chemical constituents</th>
<th>Traditional &amp; ethnomedicinal uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stem bark</td>
<td>Terpenoidal saponn indicoside A &amp; B, Manghopana, Mangifera indicaleanone[29], Mangifera indicasterol, manglupenone Mangifera indica coumarin, triacontane.[30]</td>
<td>Aqueous extract traditionally used for the treatment of syphilis, anemia, scabies, diabetes, cutaneous infections, menorrhagia, diarrhea. [38]</td>
</tr>
<tr>
<td>Leaves</td>
<td>Protocatechuic acid, catechin, mangiferin, alanine, glycine, kainic acid, shikimic acid, tetracyclic triterpenoids. [31]</td>
<td>Juice of leaves used for dysentery and ashes of burnt leaves used for scalds. [39]</td>
</tr>
<tr>
<td>Fruit</td>
<td>Mangiferin, Xanthophyll esters, carotenes, and tocopherols. [32]</td>
<td>Help to prevent colon cancer, calming inflammation, fruit Juice acts as a restorati ve to nic used in heat stroke. [40]</td>
</tr>
</tbody>
</table>
Table 1. Phytochemical properties of Mangifera indica parts

<table>
<thead>
<tr>
<th>Part</th>
<th>Phytochemical Properties</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed</td>
<td>Polyphenols such as quercetin, Kaempferol, gallic acid, tannin, xanthone. [33]</td>
<td>Seed kernel in hemorrhages and bleeding hemorrhoids, seed can also be applied on the burn, to treat Asthma. [41]</td>
</tr>
<tr>
<td>Flower</td>
<td>alkyl gallates such as gallic acid, methyl gallate ethyl gallate. [34-35]</td>
<td>Dried Mangifera indica flowers serve as astringents in cases of diarrhea, chronic dysentery. Powder help to reduce allergy dermatitis. [42]</td>
</tr>
<tr>
<td>Root</td>
<td>3-hydroxy-2-(4’-methylbenzoyl) chromone and 3-methoxy-2-(4’-methyl benzoyl)-chromone, chromones. [36]</td>
<td>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. [43]</td>
</tr>
<tr>
<td>Pulp</td>
<td>vitamins A and C, xanthophylls and β-carotene and Root of Mangifera indica contains the chromones, 3-hydroxy-2-(4’-methyl benzoyl)-chromone. [37]</td>
<td>Mangifera indica pulp mixed in drinking milk after it provides energy, strength to the body. The pulp of Mangifera indica used for sauces, soups, making. [44]</td>
</tr>
</tbody>
</table>

Fig.2. Structure of various phytochemicals

**PHARmacological activity**

**Anti-inflammatory activity**

Wiechowski et al., Investigated that the aqueous extract of leaves of Mangifera indica shows significant anti-inflammatory activity. The activity was evaluated by carrageen induced rat
paw edema method for acute inflammation and cotton pellet granuloma method for chronic inflammation. The mechanism by which *M. indica* produces an anti-inflammatory response like scavenging of free radicals and elevating antioxidant molecule thus the production of cytokines the major mediator of progression of acute inflammation were prevented.[45-46]

**Anti-hyperglycaemic activity**

Dineshkumar et al., (2010) investigated the anti-diabetic and hypolipidemic effects of mangiferin in type 1 and type 2 diabetic rats models. Streptozotocin was used to induce type 1 and type 2 diabetic rats. Mangiferin contains stem bark of *M.indica* (at a dose 10 and 20mg/kg) was administrated intra-peritoneally in type 1 and type 2 diabetic rats. Mangiferin showed the appreciable alpha-amylase and alpha-glucosidase inhibitory effect when compared with standard drug acarbose. It also has anti-diabetic due to lowering, total Cholesterol, Triglyceride, LDL, and VLDL level and elevation of HDL level in type 2 diabetic model rats.[47] Kemasari et al. (2011) evaluated antihyperglycemic, activity of ethanolic extract of *Mangifera indica* leaves in alloxan induced diabetic rats. Alloxan produced a significant increase in serum glucose, creatinine, urea, uric acid, ALT, AST levels. Treatment with *Mangifera indica* extract produced decrease in alloxan induced glucose, urea, uric acid, and creatinine levels. There was a significant decrease in total protein, haemoglobin, body weight, albumin and globulin. Administration of *Mangifera indica* to diabetic rats reduced the effect of alloxan and increased the levels of above parameters. The results suggest *Mangifera indica* to be beneficial for the treatment of diabetes mellitus.[48]

**Antioxidant activity**

Pitchaon et al., (2012) was studied three methods to evaluate the antioxidant activity of the mango seed kernel extract, namely, DPPH radical scavenging activity, ABTS cation radical scavenging activity and ferric thiocyanate assay in comparison to α- tocopherol, ascorbic acid, methyl gallate and tannic acid. The result of the study revealed that the extract has significant anti oxidant activity.[49] Joona et al. (2013) studied on *Mangifera indica* leaves and its active constituents, it contains various phytoconstituents like ascorbic acid methyl gallate and tannic acid which have significant antioxidant activity and its leaves extract inhibit lipid peroxidation which protects against lipo fundin'-induced oxidative stress.[50]
Antiulcer activity

Neelapu Neelima et al., (2012) investigated the antiulcer potential of the petroleum ether and ethanol extracts of leaves of *M. indica* against in vivo aspirin-induced gastric ulcer assay. The petroleum ether (250mg/kg) and ethanol extracts (250mg/kg) of leaves of *M. indica* plant significantly reduced the ulcer index. Histopathological findings also confirmed the antiulcer activity of *M. indica* leaves extracts in albino rats.[51] Prabhu et al.(2015) Studied that the ethanolic extract of *Mangifera indica* kernel has antiulcer activity induced by pyloric-ligation model and is significantly active against antiulcer activity.[52]

Analgesic activity

Rajalakshmi et al., (2015) evaluated analgesic activity induced by pyloric ligation model and algeria produced in mice by hot plate method and acetic acid nociceptive pain stimuli. The pain reducing effect was related to the *Mangiferin* content, which was effective in a dosage of 12.5-50mg/kg. Oral administration of a water extract from the leaves of *Mangifera indica* (125-500mg/kg) with Vitamin C (1mg/kg injection) daily for a week prior to administration of formalin was able to reduce pain.[53]

Anthelmintic

Gehad et al., (2013) studied Infections with *Strongyloides stercoralis* and other helminths of immature fruits extracts of *Mangifera indica* L. were evaluated for inhibition of larval development. In the phytochemical analyses, tannins and flavonoids were the metabolites identified. Aqueous extracts of immature fruits at the dose of 100 mg/1ml showed 100 % inhibition of larval development. In vitro results indicate that this fruit could assist activity against *Strongyloides stercoralis* control.[54]

Antibacterial activity

Doughari et al., (2008) studied the ethanolic and acetone extract of leaves of *Mangifera indica* L. and tested against *S. Typhi, B.subtilis, E.coli and K.pneumonia* using the agar well (cup plate) diffusion method and found both extracts were inhibited the growth of gram positive bacteria, with acetone extract exerting more activities on all the gram positive bacteria with zone of inhibition between 15 - 16 mm, and a gram negative bacterium S. typhi (14 mm) at 250 mg/ml.[55] Sanrawal et al. (2013) studied the anti microbial activity on *Mangifera indica* leaves extract by Disc diffusion method for antimicrobial screening of bacterial strains. Methanolic extract shows maximum growth of inhibition against *salmonella*.[56]
Hepatoprotective activity
Hepatoprotective activity was evaluated by Parsad et al., (2007) by using well maintained G2 cells. Hepatic cell injury induced by administration of 7, 12 dimethyl benzanthracene (Dmba) that leads to an alteration in liver of mice. Three polyphenolic 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 Mangifera indica and used to determine hepatoprotective potential against liver injury in rats. Sarath et al.(2009) investigated the Hepatoprotective activity on Mangifera indica kernel extract. It was suggested that Mangiferin responsible for scavenging ROS and free radicals which involve in the cellular injury of mouse liver by modulating cell growth regulators.

Anticancer activity
Joona et al., (2013) studied the Antiproliferative effect preceded by accumulation of cells in G2/M phase of cell cycles with 90% methanolic extract of Mangifera indica leaves. The leaves extract of Mangifera indica on different concentrations range (62.5-500μg/ml) showed anticancer activity. The leaf extracts inhibit cancer cell proliferation in vitro mainly by accumulating cells in G2/M phase. Jagetia et al.(2005) studied the anticancer effects of the ethanolic kernel extract on breast cancer cells were evaluated using MTT, anti-proliferation, neutral red (NR) uptake and lactate dehydrogenase (LDH) release assays showed that the extract is significantly cytotoxic to these cell lines in a dose-dependent manner, and considerably less towards normal breast cells MCF-10A. Jagetia et al.(2005) also studied The cells treated with different concentrations of ethanolic extract of the M. indica kernel (10-1000 μg/mL). M. indica extract appears to be more cytotoxic to both estrogens positive and negative breast cancer cell lines than to normal breast cells. The extract of M. indica, therefore, has potential anticancer activity against breast cancer cells. Antiproliferative activities of Mangifera indica peel might be due to the synergistic actions of bioactive compounds present in them.

Neuropathic Pain Reduction activity
Bárbara et al., (2010) determined neuropathic pain reduction in Formalin-induced Licking and Acetic acid-induced writhing in Mice. Mangifera indica leaf extract contains mangiferin as a therapeutic agent and this could be useful in treating and preventing neuropathic pain.
**Immunomodulatory activity**
Tanveer et al., (2005) investigated the presence of Catechin, Epicatechin, and Oxyresveratrol in Petroleum ether extract of *Mangifera indica* extract implicated that these phytoconstituents possess potent immunostimulants activity because of their strong antimicrobial and antiviral activity. *M. indica* in dose 100-300 mg/kg, p.o. showed significantly increased production of circulating antibodies.\[^{63}\]

**Antidiarrhoeal activity**
Yakubun et al.,(2015) studied the Ethanolic extract of MI extract seed kernel given at various dose 100, 200 and 400 mg/kg body weight and found to be effective against castor oil-induced model of diarrhea. Reduction in the rate of defecation and consistency of faces at the dose 400mg/kg significantly decrease the severity of diarrhea. Ricinoleic acid the active metabolite of castor oil causes diarrhea. It changes electrolyte permeability of intestine and stimulates the release of prostaglandins and peristaltic activity of small intestine. MI extracts increase absorption of water and electrolyte it also increases the weight of intestine when compared to loperamide (standard drug).\[^{64}\] Prabhu et al. (2014) studied the anti diarrheal activity, he reported that the flavonoid present in MI inhibit 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*.\[^{65}\]

**CONCLUSION**
Mango fruit obtained from *Mangifera indica* which is belonging to family Anacardiaceae. It contains vitamin A, B and C, mangiferin and different minerals such as calcium, magnesium, potassium, sodium, phosphorous and iron. It also contains in small quantity citric, tartaric, malice acid. The fruit root, bark, flower, and leaves are used in different disease and it has various pharmacological activity like Anti-inflammatory activity, anthelmintic, antidiarrhoeal, antiasthmatic, anticancer, hepatoprotective, antimicrobial, immunomodulator, analgesic, antiulcer, antioxidant, antihyperglycemic activity. It is used traditionally in various disease and disorder like heart disease, dysentery, syphilis, eye diseases, and urinary disorders. Thus from various pharmacological studies its different parts has been reported to possess various beneficial properties such as anti-inflammatory, anti-hyperglycaemic, antiulcer, analgesic, hepatoprotective, anti-diarrhoeal activity.
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