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## Mangifera indica Linn (Aam) “the king of fruits:

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### ABSTRACT

*Mangifera indica* is a rough and famous tree, about 8 to 15 meters high with white branch lets and reddish young shoots. Leaves are opposite, shiny and leathery, oblong-ovate to elliptic or obovate-elliptic, 6 to 12 centimeters long, the tip being broad and shortly pointed. In Unani the kernel (*Khasta-e-Aam*) used for the treatment. A lot of pharmacological work has been scientifically carried out on various part of *Mangifera indica* but some other traditionally important therapeutically uses are also remaining to proof till now scientifically. It has astringent, carminative, stomachic, diuretic, anti-diabetic, anti-diarrheal, anti-inflammatory, radio-protective, gastro-protective, antioxidant, anti-allergic, anti-cancer, anti-bacterial, cardio-protective properties etc. The various chemical constituents present in Seeds yield glycosides, a trace of pale yellow essential oil, fat, resin, albumin, chlorophyll2, an alkaloid- jambosine3, gallic acid, 1-galloylglucose, 3-galloylglucose, quercetin and elements such as zinc, chromium, vanadium, potassium and sodium.

**KEYWORDS:** *Mangifera indica*, Mizaj, *Khasta-e-Aam*, Anti-oxidant, *Badal*, Studies.

### 1. INTRODUCTION

Aam belongs to the genus *Mangifera* which consists of about 30 species of tropical fruiting trees. It has been an important herb in Ayurveda and Unani indigenous medical systems for over 4000 years<sup>5,13,73</sup>.

**Origin and Distribution:** Mango tree is a large tree, with a dense and spreading crown. Leaves are oblong to oblong-lanceolate, 10 to 30 centimeters long. The flowers are yellow, small, 3 to 4 millimeters long, borne on erect and hairy panicles, which as often as long as the leaves. The fruit is a drupe, of varying shades of yellow, fleshy, oblong-ovoid, 10 to 15 centimeters long, and slightly compressed, the skin is thin, and in the center is a large flattened, fibrous seed, and when ripe, surrounded by an edible yellow pulp. It is a widely cultivated tree for its fruit, with several varieties in cultivation. The most popular are "carabao" and "piko," and the former used to be the preferred export variety. The Guimaras mango is now considered the sweetest of mango varieties produced in the Philippines. Cultivated throughout the Philippines. In cultivation in the Indo-Malayan region. Now planted in all tropical countries.

**Taxonomical Classification:** Botanical classification of *Mangifera indica* Kingdom: Plantae, Clade: Tracheophytes, Class: Angiosperms, Order: Sapindales, Family: Anacardiaceae, Genus: *Mangifera*, Species: *indica*<sup>5,13</sup>.

**Vernacular name:** Hindi: *Aam*, *Aanb*, Arabic: *Anbaj*, Persian: *Anbh*, Unani: *Aam*, Eng: *Mango* Latin: *Mangifera indica* Linn<sup>1,2,3,4,5,6,7,8,9,10</sup>.

**Botanical Name:** *Mangifera indica* Linn.

**Unani Description of *Mangifera indica* Linn.**<sup>1,2,3,4,7,8,9,10,11,13,14</sup>: It is very famous and big size tree in all over India. The fruits of this plant are edible. The seeds of the fruits called kernel (*Khasta-e-Aam*), which is used in *Safaravi amaraz* (bile origin diseases). Its fruit, unripe fruits, leaves, flowers, root & barks are also used in Unani system of medicine.

**Parts used (*Azja-e-Mustemil*):** Leaves, bark, unripe fruits, ripe fruit, kernel (*Khasta-e-Aam*).

**Temperament (*Mizaj*):** Ripe Fruits: Hot & Moist in 2<sup>nd</sup>.

Kernel (*Khasta-e-Aam*): Cold & Dry in 2<sup>nd</sup>.

Leaf & Flowers: Cold & Dry 1<sup>st</sup>.

**Action (*A’afaal*):** *Muqawwi-e-Aaza-e-Raies*a (Tonic for Heart, Brain, Kidney & Liver), *Muqawwi-e-Meda wa Ama*, (Tonic for stomach & intestine), *Muqaww-e-Gurda wa Masana* (Tonic for Kidney & Bladder), *Muqawwi-e-Bah* (Aphrodisiac), *Muqawwi-e-Aaza-e-Tanaffus* (Tonic for Respiratory organs), *Jali* (detergent), *Musaffi-e-Khun* (Blood purifier), *Daf-e- Bawaseer Khuni wa Badi* (both types of Piles), *Qulanj* (Spasmodic), *Khansi* (Cough), *Hararat-e-Safara* (Hotness of yellow bile), *Musammin-e-Badan* (Adipostias), *Moharrik-e-Badan* (stimulant), *Mudirr-e-Baul* (Diuretic), *Musakin-e-Hararat* (Analgesic).

**Action (*Istemaal*):** *Taqwiyat-e- Aaza-e-Raies*a, *Mushtahi* (Appetizer), *Ziabetes* (Diabetes), Ripe fruits are detergent for skin, Nutrient, the Kernel (*Khasta-e-Aam*) are condenser for stomach. *Masood-e Shaer* (Hair grower), *Mufarreh* (Stimulant), *Mulayyen* (laxative). The juice of fresh leaves of mango tree is beneficial in earache.

**Main action (*Naf-e-Kkaas*):** *Mufarreh aur Musakkin-e-Hararat* (Stimulant and analgesic).

**Side effect (*Muzir Asaraat*):** *Khasta-e-Aam wa Sabz Aam* (Unripe fruits & Green) *Jigar wa Aanton ke liye* (Harmful for Liver & intestine).

**Antidote (*Musaleh*):** *Khane ke bad Dodh* (Milk), and *Roghan-e-Badam Sheereen* (Almond oil) and *Aam ka Maveez (giri)* Kernel.

**Substitute (*Badal*):** *Ek species dusare ki badal hai* (one species is substitute to another species).

**Compound formulations (*Murakkab*):** *Sharbat-e-kery and Murabba-e-Aam*.

**History:** Widely distributed in cultivation in all over India. The Guimaras mango is now considered the sweetest of mango varieties produced in the Philippines. In cultivation in the Indo-Malayan region. Now planted in all tropical countries.

#### Figures:



Mango Plant



Mango on branch



Mangos

#### Folkloric<sup>1,2,3,4,6,5,7,8,9,10,11,12</sup>:

- In the Philippines, decoction of root is considered diuretic. Bark and seeds are astringent.
- In Cambodia, used in hot lotions for rheumatism and leucorrhea.
- In India and Cambodia, solution of the gum from the bark is swallowed for dysentery. Resin is used for apthous stomatitis.
- Cough: Drink infusion of young leaves as needed. Diarrhea: Take decoction of bark or kernel as tea.

- Fluid extract, or infusion, used in menorrhagia, leucorrhoea, hemorrhoidal bleeding, and hemorrhage from the lungs, nasal catarrh.
- Gum resin from the bark and fruit is used as sudorific; also as anti-syphilitic.
- Root bark is a bitter aromatic, and in Sind, used for diarrhoea and leucorrhoea.
- Decoction of leaves with a little honey used for loss of voice. Gum resin from bark, mixed with coconut oil, used for scabies and other parasitic skin diseases.
- Juice of leaves used for dysentery.
- Tea of leaves with a little honey used for hoarseness and aphonia, 4 glasses daily.
- Powdered dried leaves, 1 tsp to a cup of warm water, 4 times daily, used for diabetes. Also, decoction of 10-15 fresh leaves used for the same purpose.
- Ashes of burned leaves used for scalds and burns.
- Infusion of young leaves used in asthma and cough.
- Tea of powdered dried flowers, 4 times daily for diarrhoea, urethritis.
- Juice of peel of unripe mangoes used for skin diseases.
- Seed is vermifuge and astringent, vermifuge; given in obstinate diarrhoea and for bleeding piles.
- Kernel or stone from the green mango considered an anti-helminth.
- For asthma, bleeding piles, chronic dysentery, hematemesis, menorrhagia, leucorrhoea, and round worms, powdered seed is given, with or without honey.
- In Indian traditional medicine, seeds used for vomiting, dysentery, diarrhoea. Paste is made from seed, honey and camphor and applied over the vagina to make the vagina contracted and firm.
- **Dye:** Yellow coloring produced from the leaves, bark, and fruit, dye used in India.

**Ethno-pharmacological** Good source of iron (deficient in calcium); excellent source of vitamins A, B, and C. Fruit contains citric, tartaric and mallic acids. Food: As fruit or mango-ade. Makes a delicious ice cream. Slice and served with cream and sugar, taste has slightly similarity to peaches. Mangoes are canned with syrup, dried and candied, jammed. Unripe mangoes are chutneyed, or pickled in brine. Young, fresh leaves are used in native dishes like "kasui." Also, prepared as tea.

## 2. CHEMICAL CONSTITUENTS

Mangiferin; mangin; piuri-yellow dye; benzoic acid; citric acid; tannin, 10%. The leaves contain 43-46 percent euxanthin acid and some euxanthone. Seed contains a fixed oil, oleostearin, starch, gallic acid, and tannin. The bark exudate yields a resin, gum, ash, and tannin. Study of fruit exudation, "chep" resin, isolated three products: a resin, mangiferone; a resinous acid, mangiferic acid; and a resinol (phenol), mangiferol. Mangostine, 29-hydroxymangiferonic acid, mangiferin and flavonoids have been isolated from the stem bark. Leaves and flowers yield an essential oil containing humulene, elemene, ocimene, linalool and nerol. Methanol extract of twigs yielded 4, 8-Bishydroxymethyl-7-(1-hydroxy-1-methylethyl)-1-(3,4,6-trihydroxy-5-hydroxymethyl-tetrahydropyran-2-yl)-4,7,8-trihydro-naphthalen-2-one<sup>37</sup>. Phytochemical screening of leaves yielded total phenols, flavonoids, tannins, and saponins<sup>38</sup>. Phytochemical screening of leaves yielded the presence of saponins, steroids, tannin, flavonoid, reducing sugars, cardiac glycosides, and anthraquinone<sup>37</sup>. Study of twigs yielded 4, 8-Bishydroxymethyl-7-(1-hydroxy-1-methyl-ethyl)-1-(3,4,6-trihydroxy-5-hydroxymethyl-tetrahydro-pyran-2-yl)-4,7,8-trihydro-naphthalen-2-one<sup>37</sup>. Aqueous extracts of leaves yielded tannins, flavonoid, steroid, cardiac glycoside, alkaloids, and carbohydrates, and proteins<sup>58</sup>. Study of essential oil of leaves from two Brazilian varieties yielded major compounds: variety Espada- sesquiterpenes such as  $\beta$ -selinene (34.90%), cyperene (22.40%), (E)-caryophyllene (16.39%),  $\alpha$ -humulene (10.84%), terpinolene (2.31%) and  $\alpha$ -selinene (2.31%); variety coracao-de-boi—cyperene (32.62%), (E)-caryophyllene (26.91%),  $\alpha$ -humulene (17.21%), terpinolene (2.32%),  $\beta$ -selinene (5.70%) and mycene (2.80%)<sup>69</sup>. GC-MS analysis of six leaf extracts yielded 10 constituents from ten peaks. Terpinyl acetate (5.80%) and phytol isomer (5.12%) were the major constituents and oxirane (3.57%), sabinene (3.24%), beta-pinene (3.34%), beta-myrcene (3.23%), cymene (3.68%), alpha-limonene (2.82%), eucalyptol (1.8-cineol (4.71%), 1,3-benzodioxole, 5-(2-, (3.68%) were minor constituents<sup>75</sup>.

### Pharmacological Action:

- *Syzygium cumini* considered Root, diuretic; bark astringent; seeds, astringent and vermifuge; leaves, pectoral. Considered antiseptic, antibacterial, anti-inflammatory, diaphoretic, stomachic, vermifuge, cardio tonic and laxative. Seed kernel considered antibacterial, anti-diarrheal, antioxidant, antiviral against uropathogens. Ripe fruit considered invigorating, refreshing, fattening, slightly laxative, and diuretic. Rind, fiber, and unripe fruit considered astringent and acid. The pickled unripe fruit is considered stomachic and appetizing.

- Studies have suggested antibacterial, anti-inflammatory, analgesic, hypoglycemic, immuno-stimulatory, antioxidant, anti-diarrheal, anti-asthmatic, anti-hyperlipidemic, anti-gouty arthritis, anti-ulcerogenic, wound healing, anti-helminic, properties.

#### Studies Prove:

- ✓ Antibacterial / Phytochemicals: Study showed that leaf extracts of *M. indica* possess some antibacterial activity against *S. aureus*, *E. coli*, *P. aeruginosa* and provides a basis for its medical use in Uganda. Phytochemical study showed saponins, steroids and triterpenoids, alkaloids, coumarins, anthracenocides, flavonones, tannins and reducing sugars<sup>14</sup>.
- ✓ Effects on Hematologic Parameters ant/ Stem Bark: Study evaluated crude aqueous extract of stem bark extracts of *M. indica* on body weight and hematologic parameters in normal albino rats. Results showed positive effects on the haemopoietic system of test rats evidenced by an increase in levels of hematocrit, RBC, WBC and platelet counts. There was also an increase in the weight of rats<sup>15</sup>.
- ✓ Anti-Inflammatory, Analgesic and Hypoglycemic / Stem Bark: Results of the study support the folkloric use of the plant for painful arthritic and other inflammatory conditions, as well as T2DM<sup>16</sup>.
- ✓ Anti-Clostridium tetany (stimulation) activity: Study showed both the ethereal and ethanolic fractions of leaf extracts of *M. indica* showed anti-clostridium tetani activity<sup>17</sup>.
- ✓ Anti-asthmatic: *Mangifera indica* stem bark effect on the rat trachea contracted by acetylcholine and histamine: Study showed MI blockage of histaminic and muscarinic receptors, supporting the traditional use of MI stem bark in the treatment of asthma<sup>18</sup>.
- ✓ Immuno-stimulant: Study evaluated an alcoholic extract of *Mangifera indica* L. in mice for immuno-modulatory activity. Results showed increased humoral antibody titer and delayed type hypersensitivity in mice suggesting a potential for a drug with immuno-stimulant properties<sup>19</sup>.
- ✓ Anti-hyperglycemic: Study showed leaf extract of *M. indica* possess hypoglycemic activity, possibly due to reduction in intestinal absorption of glucose<sup>20</sup>.
- ✓ Flavonoids / Anti-hyperlipidemic Effect: Flavonoids from *M. indica* effectively reduce lipid levels in serum and tissues of rats with induced-hyperlipidemia. Degradation and elimination of cholesterol were enhanced<sup>21</sup>.
- ✓ Anti-oxidant: Oral administration of flavonoids showed significant antioxidant action in cholesterol-fed experimental rats. The activities of free radical-scavenging enzymes were significantly elevated and lipid peroxide content was significantly reduced in Flavonoid-treated hyper-cholesterolemic rats<sup>22</sup>.
- ✓ Anti-diarrheal Activity / Seeds: Study of the methanolic and aqueous extracts of seeds of *M. indica* showed significant anti-diarrhea activity, the effect partly attributed to the effect on intestinal transit<sup>23</sup>.
- ✓ Anti-Diabetic Activity / Stem Bark: Study showed all extracts had significant anti-hyperglycemic effect in type 2 model rats. The ethanol extracts of stem-barks (*M. indica*) reduced glucose absorption gradually during the whole perfusion period in type 2 rats<sup>24</sup>.
- ✓ Ethno pharmacology / Mangiferin: Mangiferin is a major C-glucosyl from the stem bark, leaves, heartwood, roots and fruits of *M. indica* and has been reported to have a variety of pharmacologic activities including antioxidant, radio-protective, antitumor, immuno-modulatory, anti-allergic, anti-inflammatory, anti-diabetic, antibacterial, among others, supporting the numerous traditional uses of the plant<sup>25</sup>.
- ✓ Polyphenols / Anti-ulcerogenic Activity: Study showed oral pretreatment with *Mangifera indica* leaf decoction decreased the severity of gastric damage in induced-gastric lesions. Two main phenolic compounds isolated were mangiferin and C-glucosyl-benzophenone. The findings show the potential gastro protective properties of the aqueous decoction from *M. indica* leaves<sup>26</sup>.
- ✓ Anti-Cancer / Polyphenols: A Texas Agrilife Research study by food scientists Dr. Susanne Talcott and Dr Steve Talcott found that polyphenol extracts from Mango promote anticancer activity in certain colon and breast cancer cells in lab. The polyphenols also showed some effects on lung, leukemia and prostate cancers. Polyphenolics, more specifically gallotannins, belong to a class of bioactive compounds that can prevent of stop cancer cells. Further studies will look into efficacy and clinical relevance<sup>27</sup>.
- ✓ Antibacterial / Seeds: Bioactive studies of *Mangifera indica* against bacterial isolated from urine samples showed the aqueous and ethanolic seed kernel extract good antibacterial activity against *E. coli*, *S. aureus* and *S. pyogenes*. The antibacterial activity may be due to specific phyto-chemical components. Toxic components were not detected in the seed kernel and also appear to be a safe source of antioxidants<sup>28</sup>.
- ✓ Anti-Diabetic/Dipeptidyl Peptidase IV Inhibitory Activity: The insulin tropic hormone, glucagon-like peptide 1 (GLP-1), a recent addition to diabetes therapy, is metabolized by dipeptidyl peptidase IV, and inhibition of DDP IV enhance GLP-1 which improved insulin secretion and glucose tolerance. Study on the methanolic extract of *Mangifera indica* leaves show the inhibitory effect on DPPIV and present a potential novel approach to diabetes therapy<sup>29</sup>.

- ✓ Toxicological Studies / No Lethality: Study of stem-bark aqueous extract (*M. indica*), by oral or dermal administration, showed no lethality at the limit doses, with no adverse effects. It was non-irritating on skin, ocular, or rectal mucosa. It also had minimal irritancy following vaginal application<sup>30</sup>.
- ✓ Antidiabetic / Seed Kernels: Study evaluated the hypoglycemic potency of seed kernels of *Mangifera indica* ethanol extract in STZ-induced diabetic rats. Results showed potent hypoglycemic activity. Possible mechanism of hypoglycemic action may be through potentiation of plasma insulin effect by increasing pancreatic insulin secretion from regenerated  $\beta$ -cells or its discharge from bound insulin<sup>31</sup>.
- ✓ Mangiferin / Leaves: Studies on mangiferin have shown antioxidant, antitumor, antiviral, anti-HIV, antipyretic, anticancer, antidiabetic, anthelmintic, immuno-modulatory, neuro-protective properties. The study isolated the pharmacologically active mangiferin using an uncomplicated method, with ethanol as solvent to obtain a crude extract<sup>32</sup>.
- ✓ Memory-Enhancing / Fruit : Study evaluated an ethanolic extract of fruit on cognitive performances in step down passive avoidance task and elevated plus maze task in mice. Treatment reversed the aging and scopolamine-induced memory deficits. Results showed effects that are memory-enhancing in nature<sup>33</sup>.
- ✓ Leaves as Functional Food: Study showed aqueous extract of mango leaves to be rich in total phenols and total flavonoids, and as powerful antioxidants should be used in manufacture processes of the natural products as function foods or as dietary supplement with antidiabetic activity and hypoglycemic effect<sup>34</sup>.
- ✓ Cytotoxic Effect on Human Breast Cancer Cell Line: Study evaluated the potential anticancer effects of an ethanolic kernel extract of *Mangifera indica* on breast cancer cell (MDA-MB-231 and MCF-7). Results showed the extract to be more cytotoxic to both estrogen positive and negative breast cancer cell lines than to normal breast cells<sup>35</sup>.
- ✓ Antimicrobial / Leaves: Study evaluated various leaf extracts for antimicrobial activity against human and plant pathogenic bacteria. The hexane-ethyl acetate extract of *Mangifera indica* showed significant inhibition of almost all tested pathogenic organisms<sup>36</sup>.
- ✓ Combination Mangifera Extract and Methotrexate (MTX) in Rheumatoid Arthritis: Study evaluated the possible therapeutic effects and safety of *Mangifera indica* extract (Vimang tablets, 300 mg) combined with methotrexate (MTX) on reducing disease activity in rheumatoid arthritis (RA). Only patients of MTX-Vimang group showed statistically significant improvement in DAS (disease activity score) 28 parameters. In the same group, 100% of patients decreased NSAIDs use<sup>37</sup>.
- ✓ Anti-hyperglycemic / Leaves: Study evaluated the anti-hyperglycemic activity of ethanolic extract of *Mangifera indica* leaves in alloxan induced diabetic rats. Results showed decreased alloxan effect and improvement in the laboratory parameters, suggesting a potential benefit for the treatment of diabetes mellitus<sup>38</sup>.
- ✓ Antioxidant / Protective against Lipofundin-induced Oxidative Stress: Lipofundin is a lipid rich emulsion used in parenteral nutrition, known to induce an oxidative stress state characterized by increase lipid peroxidation and depletion of antioxidants. Study showed Vimang protects against Lipofundin-induced oxidative stress, reinforcing the antioxidant properties of the natural product<sup>39</sup>.
- ✓ Anti-hyperglycemic / Leaves: The insulin tropic hormone, glucagon-like peptide 1 (GLP-1), a recent treatment for type 2 diabetes, is metabolized by DPP-IV (dipeptidyl peptidase IV). Inhibitors of DPP-IV enhance the level of GLP-1, which improve glucose tolerance and increase insulin secretion. Study showed a methanolic leaf extract of *Mangifera indica* to have potent in-vitro DPP-IV inhibitory activity, and may present a novel addition to the treatment of diabetes<sup>40</sup>.
- ✓ Anthelmintic / Leaves: Various extracts of *M. indica* var. Thotapuri and *M. indica* var. Neelam were evaluated for anthelmintic activity against *Pheretima posthuma*. Results showed dose-dependent anthelmintic activity<sup>41</sup>.
- ✓ Cationic Bio sorbent / Leaves: Study evaluated the efficacy of unfertilizable fruiting buds of the mango plant as biomass for bio sorbent for the removal of lead, copper, zinc, and nickel metal ions. Results showed the non-living biomass of *Mangifera indica* present comparable bio sorption capacity for lead, copper, zinc, and nickel metal ions and is effective in removing metal ions from single metal solutions<sup>42</sup>.
- ✓ Immuno-stimulatory / Stem Bark: Study evaluated the immuno-stimulatory effect of an ethanolic extract of *M. indica* stem bark in dexamethasone induced immuno-suppressed male albino rats relative to immuno-boosting effect of levamisole. Results showed a hepato-protective effect, cholesterol lowering effect, and a stabilizing tendency on the alanine aminotransferase concentrations<sup>43</sup>.
- ✓ Anti-inflammatory / Colitis Model: Study evaluated an aqueous extract of *Mangifera indica* on dextran sulfate sodium (DSS) induced colitis in rats. Results showed anti-inflammatory properties with improvement of clinical signs, reduction of ulceration, and reduced MPO activity when administered before DSS<sup>44</sup>.
- ✓ Anti-Gouty Arthritis: Study evaluated the therapeutic effects of ethanol extract of *M. indica* in rat with monosodium urate (MSU) crystals-induced gouty arthritis. Treatment reversed pretreatment ankle swelling,

- TNF- $\alpha$ , IL-1 $\beta$  mRNA and protein levels. The beneficial anti-gouty effect may be mediated, at least in part, by the inhibition of TNF- $\alpha$  and IL-1 $\beta$  expression in synovial tissue<sup>45</sup>.
- ✓ Activated Carbon from Pyrolysis of Seed: Study reports of the preparation of activated carbons (ACs) by pyrolysis of *Mangifera indica* seeds in presence of sodium and potassium hydroxide (chemical activities). Variable adsorption capacities and porosity distributions can be achieved depending on the activating agent selected. KOH produces AC with narrower microspore distributions than those prepared by NaOH<sup>46</sup>.
  - ✓ Acute Toxicity Study / Seed Kernel: Study reports the seed kernel of *Mangifera indica* is practically non-toxic drug and reports on its safety. SKMI powders in dose up to 5 g/kg did not show any variations in mice, so 500 mg/kg body weight (1/10th part of 5 g/kg) can be used for experimental study for longer duration<sup>47</sup>.
  - ✓ Acute and Sub-Chronic Toxicity Study / Mangiferin / Stem Bark: Study evaluated acute and 28-day sub chronic studies on mangiferin, a glucosyl xanthone isolated from *M. indica* stem bark. Results showed a low level of toxicity for orally administered mangiferin to rodents in acute and sub chronic studies. Although there were some toxicity signs in repetitive dose assay, there is a wide margin of safety for oral administration under the experimental conditions<sup>48</sup>.
  - ✓ Hypoglycemic / Leaves / Type 2 Diabetes: Clinical study evaluated the hypoglycemic effect of leaves of *M. indica* in type-2 diabetes mellitus. Results showed significant hypoglycemic activity in high dose and can be successfully combined with oral hypoglycemic agents in type-2 diabetic patients not controlled by these agents<sup>49</sup>.
  - ✓ Antibacterial / Fruit and Seed: Study evaluated the difference in antimicrobial activity of ripe and unripe seed and fruit extracts of *Mangifera indica* against *Staphylococcus aureus* and *Pseudomonas aeruginosa*. Statistical analysis showed a significant difference. Ripe fruit extracts showed no activity against *P. aeruginosa* while ripe and unripe seed extracts showed antibacterial activity, with the ripe seed extract showing highest inhibitory action<sup>50</sup>.
  - ✓ Herbal Finish / Prevention of Bed Sore: Study evaluated the development of a functional herbal finish to produce a bedsore preventing fabric using two herbal extracts viz. *Mangifera indica* and Triphala dried fruits in 1:2 and 2:1 ratios with and without binder (chitosan). Results showed fabric dyed with *Mangifera indica* and Triphala dried fruits in 2:1 ratios with chitosan was the most promising candidate<sup>51</sup>.
  - ✓ Hypoglycemic Potential / In-Vitro Enzyme Inhibition / Leaves: Study evaluated the comparative hypoglycemic properties of aqueous methanolic extracts of mature and tender leaves of *M. indica* var. Totapuri in glucose loaded Wistar albino rats and in-vitro  $\alpha$ -glucosidase and  $\alpha$ -amylase inhibition bioassays. Significant hypoglycemic activity was observed with both extracts. Extracts showed inhibition of rat intestinal  $\alpha$ -glucosidase, as well as porcine pancreatic  $\alpha$ -amylase. Activity may be due to inhibition of carbohydrate digesting enzymes by polyphenols, flavonoids and saponins in the extracts<sup>52</sup>.
  - ✓ Wound Healing / Leaves: Study evaluated the wound healing property of *M. indica* leaf crude extract on *Rattus norvegicus* (Sprague-Dawley). Results showed significant wound healing activity ( $p < 0.05$ ). The wound healing property was attributed to phyto-chemical constituents, mainly tannins, which can facilitate healing by increasing collagen formation and epithelization<sup>53</sup>.
  - ✓ Effect on Liver Function / Hepato-protective / Leaves: Study evaluated the hepato-protective activity of ethanol extract of *M. indica* dried leaves against CCl<sub>4</sub> induced acute liver damage on albino rats. Results showed potential therapeutic values in CCl<sub>4</sub> induced hepatic damage attributed to antioxidant principles<sup>54</sup>.
  - ✓ Comparative Study / Leaf Mouthwash on Plaque, Gingival Inflammation and Salivary Streptococcal Growth: Study compared the efficacy of *Mangifera indica* leaf mouthwash with chlorhexidine on plaque status, gingival inflammation, and salivary *Streptococcus* mutants count. Results showed significant reduction in microbial count, improved plaque control and gingival health in both groups. There was higher reduction in microbial count, better plaque control and gingival health in the chlorhexidine group. Results suggest a safe and alternative mode of treatment<sup>55</sup>.
  - ✓ Antimicrobial in Cream and Ointment Formulations / Seeds: Study evaluated the seed ointment and cream formulation for antimicrobial activity. Formulated ointments containing oleaginous-base showed the best formulation compared to emulsion water in oil type. The formulation of *Mangifera indica* was found to be safe and efficient carriers, with potent antimicrobial activity<sup>56</sup>.
  - ✓ Pancreatic Lipase Inhibitory Activity / Leaves: Study evaluated the pancreatic lipase inhibitory ingredients of mango leaves. A methanolic extract of old dark green *Mangifera indica* leaves showed porcine pancreatic lipase inhibitory activity. Activity was attributed to 3-C- $\beta$ -D-glucosyl-2,4,4',6-tetrahydroxybenzophenone (1) and mangiferin (2). While the pancreatic lipase inhibitory activity of young mango leaf extract was superior to old leaf extract, the amount of leaves obtained from pruning old dark green leaves may be a reasonable natural source for the preparation of ingredients with lipase inhibitory activity<sup>57</sup>.
  - ✓ Antibacterial activity against Gastro-intestinal Diseases caused by Gram Negative Bacteria, Leaves of *Mangifera indica*: Study evaluated the effects of aqueous extracts of *Mangifera indica* young leaves against

- different gram negative organisms (*E. coli*, *S. typhi*, *V. cholera*, *S. sonnei*) causing gastrointestinal disorders. Results showed dose dependent inhibition of all tested organisms<sup>58</sup>.
- ✓ Immuno-stimulant / Bark Oil: Study evaluated *M. indica* bark oil for phyto-constituents and immuno-stimulant activity in rats and mice models by determining neutrophil adhesion to nylon threads and phagocytic index. Results showed significant increase in percent neutrophil adhesion ( $p < 0.01$ ). Haemagglutination antibody (HA) titer ( $p < 0.01$ ) and phagocytic index ( $p < 0.001$ ) were also significantly increased. Results suggest the bark oil has potent immuno-modulatory activity and therapeutic potential for prevention of autoimmune and infectious diseases<sup>59</sup>.
  - ✓ Antimicrobial / Ant tubercular Activity / Flowers: GC-MS analysis of flower extracts of *Mangifera indica* identified seven constituents: Icosanedioic acid monomethyl ester (1), nonadec-16-enyl-benzene (2) 1, 9 diphenyl nonane (3), icosane (4), octadecane (5), dodecanoic acid butyl ester (6), and tetracosyl- benzene (7). On testing against human and plant pathogenic bacteria, an ethanol extract inhibited almost all tested pathogenic bacteria and showed anti-tubercular activities at various concentrations<sup>60</sup>.
  - ✓ Absorption Study / Cobalt / Bark: Co (II) in wastewater is highly toxic. Study reports on a very simple, eco-friendly, and cost-effective method for the removal of Co (II) by *M. indica* bark substrate. Absorption increased with increasing doses of the substrate<sup>61</sup>.
  - ✓ Primary Metabolites in Unripe Mango: Study evaluated the nutrients present in unripe mango and seed and compared it with ripe mango. Results showed protein and vitamin C were found high in the unripe fruit, while water, ash, total sugar, lipid, vitamin A, vitamin B-complex were less<sup>62</sup>.
  - ✓ Reno-modulatory / Carbon Tetrachloride Induced Toxicity / Stem-Bark: Study evaluated the Reno-modulatory effect of aqueous stem bark extract of *Mangifera indica* against CCl<sub>4</sub>-induced renal damage. The extract significantly ( $p < 0.05$ ) attenuated the increase in serum electrolytes, urea, and creatinine, and significantly ( $p < 0.05$ ) attenuated the decrease in SOD, CAT, and GSH. Results suggest *M. indica* has potential for drug development in the management of kidney diseases caused by lipid peroxidation<sup>63</sup>.
  - ✓ Anxiolytic / Leaves: Study evaluated the anxiolytic activity of aqueous extract of *M. indica* leaves using elevated plus maze (EPM) model in rat and staircase model in mice using 250 mg/kg and 500 mg/kg doses. Results significant anxiolytic activity at both dose levels comparable with standard anxiolytic diazepam<sup>64</sup>.
  - ✓ Effect on Biochemical and Hematological Parameters / Immuno-stimulatory / Stem Bark: Study evaluated an aqueous ethanolic extract of *M. indica* stem bark on biochemical and haemato-logical indices of adult albino Wistar rats. Results suggest the stem bark may have immuno-stimulating properties and may also stimulate the haemato-poietic system via increase rate of erythropoiesis and reduce oxidative damage of RBC membranes<sup>65</sup>.
  - ✓ Alpha Amylase Inhibitory Activity / Lowering of Postprandial Hyperglycemia: In a study of ten plants for in vitro alpha amylase inhibitory activity, the ethanol extracts of *Mangifera indica*, *Azadirachta indica* and petroleum ether extract of *Murraya koenigii* showed maximum percentage inhibition with IC<sub>50</sub> values of  $37.86 \pm 0.32$  µg/ml,  $62.99 \pm 1.20$  µg/mL and  $59.0 \pm 0.51$  µg/ml, respectively, compared to acarbose with IC<sub>50</sub> of  $83.33 \pm 0.75$  µg/ml. Results suggest the three plants may be effective in lowering postprandial hyperglycemia<sup>66</sup>.
  - ✓ Aqueous Extract of Leaves as Functional Food: Study evaluated the effect of aqueous *Mangifera indica* leaves on alloxan-induced diabetic rats. Results showed significant improvement in biochemical parameters with best results seen with 70 mg extract. The extract was found rich in total phenols and total flavonoids suggesting use as antioxidant, nutraceutical, functional foods or dietary supplement with antidiabetic and hypoglycemic effect<sup>67</sup>.
  - ✓ Analgesic / Antimicrobial / Leaves: Study evaluated the analgesic, anti-inflammatory and an antimicrobial property of ethanol leaves extract of *M. indica*. Results showed moderate activity against Gram positive bacteria and low activity against Gram negative bacteria. There was significant inhibition ( $p < 0.01$ ) of acetic acid writhing response of mice, suggesting potential analgesic activity. There was no significant anti-edematogenic effect in carrageenan induced paw edema testing; suggesting *M. indica* has no significant anti-inflammatory activity<sup>68</sup>.
  - ✓ Anti-Inflammatory / Essential Oils / Leaves: GC-MS analysis of two Brazilian *M. indica* varieties (espada and coracao-de-boi) yielded twenty-three volatile compounds in two essential oils from the leaves. Both varieties showed anti-edematogenic action against inflammatory agent carrageenan, in addition to reducing MPO activity in the experimental model of inflammation. The results may be attributed to the presence of major compounds, such as caryophyllene and  $\alpha$ -humulene<sup>69</sup>.
  - ✓ Mangifera indica Gum as Tablet Binder: Study evaluated the gum of *Mangifera indica* as tablet binder with paracetamol as model drug. Results showed *M. indica* gum could be used as binding agent in the formulation of tablet-dosage forms. The binding efficacy is comparable with tablets prepared using 5% w/w gum acacia as tablet binder<sup>70</sup>.

- ✓ Effect on Reproductive Functions in Female Rats / Leaves: Study evaluated the reproductive impact of oral administration of aqueous leaf extract of *M. indica* at dose of 500 mg/kg on gravid and non-gravid rat models. Results showed significant disruption of estrous cycling of matured female rats by alteration of hormonal profile responsible for synergy between phases of the estrous cycle and ovulation. There was also significant reduction of maternal weight and litter birth weight, with no significant effect on duration of pregnancy<sup>71</sup>.
- ✓ Bio sorption of Zinc / Peel Powder: Study showed *M. indica* peel was an effective bio sorbent for removing zinc ions from aqueous solution. Results suggest it can be applied as a low cost material with potential biosorptive capacity in wastewater treatments of remediation of heavy metal contamination<sup>72</sup>.
- ✓ Antiplasmodial / Antipyretic / Stem Bark: Stem bark extract of *M. indica* was evaluated for antiplasmodial activity against Plasmodium yoelii nigeriensis and antipyretic activity in yeast-induced hyperpyrexia. The extract exhibited a schizontocidal effect during early infection along with a repository activity. A chloroform: methanol (1:1) extract showed good activity against P. falcifarum in vitro with growth inhibition of 50.4% at 20 µg/ml. Extract also produced a reduction in yeast-induced hyperpyrexia<sup>73</sup>.
- ✓ Antiprogesteric and Estrogenic Effect: Study evaluated the effect of methanol extract of *M. indica* on female sex hormones and ovary in Chinchilla rabbits. Results showed significant increase in serum concentration of estradiol in a dose dependent manner ( $p < 0.005$ ) along with insignificant decreases in serum concentration of progesterone in treated groups C and D ( $p > 0.05$ ). Study suggests the effect on estradiol can be exploited to treat infertility from decrease estrogen concentration in females. However, a high dose of extract may results in ovarian cysts<sup>74</sup>.
- ✓ Anticancer / Antibacterial / Larvicidal / Leaves: GC-MS study of five leaf extracts yielded ten constituents. A hexane ethyl acetate extract showed antimicrobial activity against all human and plant pathogenic bacteria tested. *Mangifera indica* showed 100% larvicide activity. Various concentrations of hexane-EA extract showed cytotoxic activity on L929 cell lines<sup>75</sup>.
- ✓ Antibacterial / Antityphoid / Acute Toxicity Study / Stem Bark: Study evaluated the acute toxicity and antibacterial activity of aqueous stem bark extract of *M. indica* on Salmonella typhi and six other bacteria. No sign of toxicity or death was recorded even at 5000 mg/kg dose, with no statistically significant changes ( $p < 0.05$ ) in hematological parameters. The extract was found active against all test bacteria except for Streptococcus faecalis<sup>76</sup>.
- ✓ Analgesic / Leaves: Study evaluated the analgesic activity of *M. indica* leaves by hot plate method and acetic acid induced writhing in rats, using tramadol and diclofenac as standard drugs for the two models, respectively. Results showed significant ( $p < 0.001$ ) increase in reaction time in the hot plate method and significant ( $p < 0.001$ ) decrease in number of writhes in the acetic acid induced writhing test<sup>77</sup>.
- ✓ Antidepressant / Anxiolytic / Stem Bark: Study evaluated the antidepressant- and anxiolytic-like effect of a hydroalcoholic stem bark extract of *M. indica* in mice. Results showed significant reduction in immobility time in forced swim test and tail suspension test. The antidepressant-like effect may be through interaction with 5-HT<sub>2</sub> receptor,  $\alpha$ 2-adrenoceptor and dopamine D<sub>2</sub>-receptors. The anxiolytic effect may be through affinity for 5-HT<sub>2</sub> and benzodiazepine receptors. Results suggest a potential therapeutic agent in the treatment of mixed anxiety-depressive illnesses<sup>78</sup>.
- ✓ Antioxidant / Antiglycation: Study evaluated the total phenolic contents, antioxidant, and antiglycation activities of leaves, barks, roots, and kernels from two cultivars of *M. indica*. All extracts showed high level of total phenols and potent antioxidant activities. Kernel extracts showed the highest total phenol contents and DPPH radical scavenging activities. Extracts also exhibited potent inhibitory effects against formation of AGE (antiglycation end) products, with IC<sub>50</sub>s lower than standard aminoguanidine. Results suggest potential in aging, diabetic, and oxidative stress related diseases<sup>79</sup>.
- ✓ Protection against UVB-Induced Skin Aging: Study evaluated the protective effect of *M. indica* extract against UVB-induced skin aging in hairless mice. Results showed significantly improvement in the mean length of wrinkles in UVB-treated mice, as evidenced by significant inhibition in the increase in epidermal thickness and epidermal hypertrophy ( $p < 0.05$ ), along with marked increase in collagen bundles<sup>80</sup>.
- ✓ Antibacterial against Staphylococcus aureus / Stem Bark: Study evaluated the antibacterial activity of *M. indica* stem bark extracts. Results showed antimicrobial activity against *S. aureus* with a methanol extract showing highest inhibition zone (25mm). Extract was bacteriostatic at low concentration. Phytochemical screening yielded alkaloids and tannins which are known to inhibit bacterial growth in mechanisms different from synthetic drugs<sup>81</sup>.
- ✓ Hypoglycemic activity / effect on Vascular Reactivity / Leaves: Study of aqueous *M. indica* leaves extract showed significant hypoglycemic effect in diabetic rats and improved diabetes induced changes in vascular reactivity<sup>82</sup>.
- ✓ Antifungal / Essential Oil / Leaves: Study evaluated leaf essential oil from *Mangifera indica* cultivars for anti-Candida spp. activity against strains isolated from dogs. The essential oils of the four *M. indica* cultivars

showed good in vitro antifungal activity against *Candida* species and suggests a potential source of antifungal compounds for veterinary medicine<sup>83</sup>.

- ✓ Wound Healing / Ethosomal Gel / Leaves: Study reports on the development and characterization of an ethosomal gel from a methanol leaf extract of *M. indica* and its wound healing effect on excision wound healing models in rats. Results showed the ethosomal gel applied topically possess wound healing ability as evidenced by significant reduction in percentage wound area and period of epithelization<sup>84</sup>.
- ✓ Inhibition of Quorum Sensing / Leaves: Quorum sensing is a gene regulatory mechanism in bacteria for various traits including virulence factors. Disabling QS is a potential strategy to prevent bacterial infection. Study evaluated the efficacy of a leaf extract of *M. indica* on QS-regulated virulence factors and biofilm formation in gram-negative pathogens. In vitro evaluation of anti-QS activity against *Chromobacterium violaceum* showed dose-dependent inhibition of violacein production. QS Inhibitory activity was also evidenced by reduction in elastase, total protease, procyanin, chitinase, and swarming motility. Biofilm formation by *P. aeruginosa* and *A. hydrophila* was considerably reduced<sup>85</sup>.
- ✓ *M. indica* Gum as Sustained Release Polymer in Matrix Tablets: Study evaluated *M. indica* gum as sustain release polymer in glibenclamide matrix tablets using various formulations. The best sustained release formulation of 10.89% was achieved with F1 formulation, indicating that the drug release from the matrix tablets was dependent on gum concentration, with effective results even at very low concentrations (below 1%)<sup>86</sup>.
- ✓ Antidiabetic / Anticancer / Leaves: Study evaluated the antidiabetic and anticancer activities of the ethanolic leaf extract of *M. indica*. Okrong and its active compound, mangiferin. The mango extract and mangiferin exhibited dose dependent inhibition against yeast  $\alpha$ -glucosidase with IC50s of 0.0503 and 0.5813 mg/ml, respectively, and against rat  $\alpha$ -glucosidase with IC50 1.4528 and 0.4333 mg/ml, respectively. The extract showed cytotoxic potential against all five human cancer cell lines tested<sup>87</sup>.
- ✓ Virucidal: Study evaluated the antiviral activity against Newcastle disease (NDV) and IBD viruses using leaves of *Prosopis spicigera* and *Mangifera indica*. Results showed significant antimicrobial activity against PBMC, TNF $\alpha$  production, and CD14 monocyte surface marker. Results showed potential for aqueous extracts of leaves in the treatment of various viral diseases<sup>88</sup>.
- ✓ Effect on Testes / Reproductive Parameters of Male Rats / Leaves: Study evaluated the effect an aqueous leaf extract of *M. indica* on reproductive parameters of male Wistar rats. An oral dose of 10 mg/kg for six weeks resulted in drastic reduction in weight of animals, distortion of the tunica albuginea and basement membrane of the seminiferous tubule, reduction of sertoli cells and spermatogenic cells. Results suggest adverse effects on some male reproductive parameters<sup>89</sup>.
- ✓ Anticarcinogenic / Polyphenolic Extracts: Study evaluated the anticancer properties of polyphenolic extracts from several mango varieties in cancer cell lines, including Molt-4 leukemia, A-549 lung, MDA- MB-231 breast, Ln Cap prostate, and SW-480 colon cancer cells and noncancer colon cell line CCD-18Co. Results showed the polyphenolics from the mango varieties exerted anticancer effects<sup>90</sup>.
- ✓ Immunosuppressive / Cytotoxic / Flavonoids / Leaves: Study isolated flavonoids from the leaves of three medicinal plants i.e., *Mitragyna parvifolia*, *Mangifera indica* and *Aegle marmelos* and evaluated there in vitro effect on human peripheral blood mononuclear cells (PBMC) using hepatitis B vaccine containing surface antigen. Results showed immunosuppressive activity against HBsAg and suggested the crude flavonoids have potential for development as immunosuppressive and cytotoxic agent<sup>91</sup>.
- ✓ Antileishmanial / Leaves: Study evaluated various extracts of *M. indica* for antileishmanial activity using *Leishmania donovani* (strain AG83) promastigotes by in vitro promastigote cell toxicity assay. All the test extracts markedly inhibited the growth of *L. donovani* promastigotes in a dose dependent manner. The methanol extract was most active<sup>92</sup>.

**Availability:** Wild crafted.  
Small and large-scale cultivation.

### 3. CONCLUSION

*Mangifera indica* is an easily available plant. The plant belongs to family Anacardiaceae, which has given us many important medicinal plants like- *M. amba* Forssk, *M. anjsoadora* Blanco, *M. austroyunnanensis* Hu, *M. balba* Crevos & Lemarje, *M. cambodiana* (Pierre) Anon, *M. domestica* Gaerth, *M. gladiata* Bojer, *M. kukuku* Blume, *M. laxiflora* Desr, *M. linnaei* Korth.ex Hassk. *M. maritime* Lechaume, *M. indica* etc. Hence it not is wrong to state that still a lot has to be worked upon this important plant. Apart from this, old traditional texts like Unani, Ayurveda, mention the protective role of *Mangifera indica* on important body organ like kidney, heart, skin & digestive etc, many of which are scientifically proven. It contains almost all the properties of pharmaceutical care designed like antibacterial, anti-inflammatory, analgesic, hypoglycemic, immunostimulatory, antioxidant, anti-diarrheal, anti-asthmatic, anti-hyperlipidemic, anti-gouty arthritis, anti-

ulcerogenic, wound healing, anti-helminthc, properties etc. In developing countries like India, one must fully explore this important medicinal plant which might provide us some important “leads” in near future.

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