PHYTOCHEMISTRY, TRADITIONAL USES AND PHARMACOLOGICAL PROPERTIES OF MADHUCA INDICA (SAPOTACEAE): A REVIEW

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ABSTRACT

Madhuca indica L. (Sapotaceae) has been extensively used in traditional medicine for a wide range of ailments of the central nervous system, endocrine system, gastrointestinal tract, reproductive system, and infectious disorders. The aim of the review is to comprehend the fragmented information available on the botany, traditional uses, phytochemistry, pharmacology and toxicology of Madhuca indica to explore its therapeutic potential and future research opportunities. The present study deals with the ethnopharmacological investigation on different parts of Madhuca indica Fam. Sapotaceae. Madhuca indica commonly known as ‘Mahua’, is an important plant used against various disorders in indigenous system of medicine such as hepatoprotective, antipyretics, anti-inflammatory, antiulcer, analgesic, anthelmintic, anti-diabetic and in wound healing activity. Phytochemical research had led to the isolation of phytosterols, amino acids, furanocoumarins, phenolic components, hydrocarbons, aliphatic alcohols, volatile components and few other classes of secondary metabolites from Madhuca indica. Fresh plant materials, crude extracts and isolated components of Madhuca indica showed a wide spectrum of in vitro and in vivo pharmacological activities.

KEYWORDS: Ayurveda, Madhuca indica, phytochemistry, honey tree, traditional uses.

1. INTRODUCTION

Madhuca plants are considered as divine in origin and were worshipped as Mother (Goddess). They have played a significant role in maintaining human health and improving the quality of human life for thousands of years. In the last few years there has been an exponential growth in the field of herbal medicine and these drugs are gaining popularity both in developing and developed countries because of their origin and less side effects. Madhuca indica is highly regarded as a universal panacea in the ayurvedic medicine. Madhuca indica is a large evergreen tree distributed in India, Sri Lanka and Nepal. Madhuca commonly known as mahua or butternut tree, 17m high with a large top. It belongs to the family Sapotaceae. It has a significant place in tribal culture. The bark is yellowish grey to dark brown red in colour and milky inside. Preliminary phytochemical studies of stem bark with ethanol, water and chloroform extract indicated the presence of starch, terpenoids, proteins, mucilage, anthraquinone glycosides, cardiac glycosides, saponins and tannins.

1.1 Scientific classification of Madhuca indica

Family: Sapotaceae
Genus: Madhuca
Species: longifolia, indica

1.2 Vernacular names

English: honey tree, butternut tree
Bengali: mahua, maul
Hindi: mahua, mohwa
Oriya: mahula, moha, modgi
Marathi: mahwa, mohwro
Gujarati: mahuda
Telugu: ippu puvvu, ippe
Kannada: hippe
Tamil: ilupe
Malayalam: poonam, ilupa
Sri Lanka: mi, illuppai, kulilgam, maduragam, mavagam, nattiluppa, tittinnam

1.3 Biological source

The genus Madhuca, belonging to the family of Sapotaceae, is a multipurpose tree with its species, Madhuca indica, M. latifolia, M. longifolia and M. butyracea being the most prevalent. The tree is economically important because of widespread uses of almost every part.
1.4 Distribution and habitat
The species is distributed in northern, central and southern part of peninsular India, Sri Lanka and Burma. Variety longifolia is distributed in Sri Lanka, Southern India extending northwards to Maharashtra and Gujarat; var. latifolia is found in some parts of central and north India and Burma. It is common in dry mixed deciduous forests, dry sal forest and dry teak forests. The tree grows on a wide variety of soils but thrives best on sandy soil. It also grows on shallow, bouldery, clayey and calcareous soils. It is found up to an altitude of 1200m, mean annual maximum temperature 28-50°C, minimum 2-12°C; annual rainfall from 550-1500mm. The species is drought-resistant, strong light demander and readily suppressed under shade. It is not frost-hard.\[^1\]

1.5 Botanical description and identification features
A medium sized to large deciduous tree, usually with a short, hole and large rounded crown found throughout the green forest of India. The bark is thick, dark colored, cracked, inner bark dark red, trunk short, branches numerous. Leaves are 10-30 cm long, thick and leathery most of leaves pointed at the tip, clustersent glabred near end of branches, epileptic or elliptic oblong 7.5 to 23 cm into 3.8 to 11.5 cm. coriaceous pubeand when young almost. Flowers are small and fleshy, dull or pale white in color and in define fascicles near end of branches. Corolla tubular, freshly pale, yellow aromatic and caduceus. Fruits are 2-6 cm long, fleshy and greenish.

2. MACROSCOPICAL CHARACTERS
Leaf: Leaves are clustered at the ends of the branches; young branches, leaves and petiole pubescent or tomentose. Leaves are coriaceous, elliptic or oblong-elliptic, shortly acuminate, base cuneate. Petiole is short and easily fractured.
Flower: Flowers numerous, near the ends of branches, drooping on pedicels. Calyx coriaceous densely clothed rusty tomentum. Corollas are yellowish-white, tube fleshy. Stamens 20-30, usually 24 or 26, anthers are hispid at the back with stiff hair.

Fruits: Fruits are berries, ovoid, fleshy and green
Stem: Stem is cylindrical, decumbent and branched.
Seeds: Seeds are 1-4 and dark brown in colour.\[^5\]

3. MICROSCOPICAL CHARACTER
Stem: The stems of consists thin layered cell cork, cortex, epidermis, xylem, phloem, pith.
Petiole: Petiole consist vascular bundle, xylem, phloem, endodermis, pericycle and pith.
Leaf T.S.: leaf T.S. consist cork, upper and lower epidermis, xylem, phloem and pith.
Trichomes: Leaves consists uniseriate type of trichomes and covering trichomes.
Stomata: Both lower and upper surface consist paracytic stomata.
Powder microscopy of leaves: The powder is dark green in colour, fine, odorless powder with slight bitter taste. Powder microscopy shows paracytic type of stomata, uniseriate and covering trichomes.

![Fig.1. M. indica (A) Transverse section of petiole; (B) Transverse section of leaf; (C) Transverse Section of Stem; (D) Upper epidermis of leaf showing paracytic stomata; (E) Venation Pattern of leaf; (F) Parenchyma; (G) Paracytic Stomata; (H) Fractograms of Vascular Tissue; (I) Covering trichome; (J) Uniseriate Trichome]
Table 1 Quantitative microscopy of *Madhuca indica* leaves.\(^6\)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vein islet number</td>
<td>5-7</td>
</tr>
<tr>
<td>Vein termination number</td>
<td>3.2-5.4</td>
</tr>
<tr>
<td>Stomatal number</td>
<td>10-14</td>
</tr>
<tr>
<td>Stomatal index</td>
<td>17.9-18.8</td>
</tr>
</tbody>
</table>

Table 2 Different plant parts & their use.\(^7\)

<table>
<thead>
<tr>
<th>Plant Part</th>
<th>Used in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf</td>
<td>Enzyma, Wound Healing, Anti Burns, Bone Fracture, Emollient, Rheumatism, Headache, Skin Disease.</td>
</tr>
<tr>
<td>Seed Oil</td>
<td>Laxative, Piles, Hemorrhoids, Emetics, Anti Earthworm, Sweet, Refrigerant, Aphrodisiac, Tonic, Dispepsia.</td>
</tr>
<tr>
<td>Fruit</td>
<td>Bronchitis, Astringent, Anti Ulcer, Acute and Chronic Tonsilitis, Pharyngitis, Rheumatism, Ulcer, Inflammation, Bleeding, Spongy.</td>
</tr>
<tr>
<td>Bark</td>
<td>Gums, Tonsilitis, Diabetes, Stomach ache, Snake Poisoning, Astringents, Emollient, Fracture and Itching.</td>
</tr>
<tr>
<td>Flower</td>
<td>Refrigerant, Liquor, jelly, Sweet Syrup, Expectorant, Increase the production of milk in woman, Stimulant, Diuretics, Anthelmentic</td>
</tr>
</tbody>
</table>

5. PHOTOCHEMISTRY OF *MADHUCA INDICA*

The therapeutic value of the plant depends on the active constituents present inside the different part of the plant, which may be present in the small or large quantity. The secondary metabolites are the important substance responsible for the main medicinal properties in the crude drugs. Many medicinal plants constitute a rich source of bioactive chemicals that are largely free from adverse effects and have excellent pharmacological actions; they could lead to the development of new classes of possibly safer drugs.

Species of Madhuca contain pentacyclic triterpenoid saponins based on an oxygenated oleanolic acid skeleton. Thus, known Madhuca saponins contain protobasic acid (2β, 6β, 28-trihydroxyoleanolic acid), 16α-hydroxyprotobasic acid (2β, 6β, 16α, 28-tetrahydroxyoleanic acid), or their 2-oxo derivatives as aglycones, with sugar residues attached in most case to both C-3 and C-28 to form bidesmidic saponins. New saponins are continuously being isolated and their structures are being determined. However, structural details proposed for some of the isolated saponins are not reliable and it is therefore difficult to conclude about the exact number of known Madhuca saponins.

5.1 Constituents of leaves

The leaves of Mahua contain saponin, alkaloid, and glycoside. Sapogenin and other basic acid are found in the seeds. Various Phytochemical studies on Mahua include characterization of Sapogenin, triterpenoids, steroids, saponin, flavonoids and glycosides. In view of the aides and attributed medicinal properties new components including madhucide (penta cyclic triterpenoids), madhushazone, four new oleanane type triterpene glycosides and madhucosides A and B and the presence of β-carotene and xanthophylls; erthrodiol, palmitic acid, myricetin and its 3-O-arabinoside and 3-O-L-rhamnoside, quercetin and its 3-galactoside; 3β-caproxy and 3β-palmityoxy-olean-12-en-28-ol, oleanolic acid, β-sitosterol and its 3-O-β-D-glucoside, stigmasterol, β-sitosterol- β-D-glucoside, nhexacosanol, 3β-caproyxolcan-12-en-28-ol, β-carotene, n-octacosanol, sitosterol and quercetin.

4. USEFUL PARTS OF PLANTS

Every part of any plant posses some medicinal properties, either in small of large proportion. Different parts of a plant often contain quite different active ingredients, so that one part may be toxic and another one quite harmless. The plant consist of several parts, they may be classified according to the function. They are root, bark, leaves, flowers, fruits, seeds, oil.\(^7\)

5.2 Constituents of Flowers

The fresh flower of Mahua contains 2-acetyl-1-pyrroline, the aroma molecule. They also contain polysaccharide which on hydrolysis give D-galactose, D-glucose, L-arabinose, L-rhamose, D-xyllose, and D-glucuronic acid. Chemical composition of mahua flower reveals its high nutritional value. Apart from being a rich sources of sugar and protein, the flowers also contain essential minerals like Ca, P, Fe, and K. Calcium is a major component of the bone and assists in teeth development and phosphorus is next in importance to calcium as utilization of Ca is closely related to it. Most of the Calcium in the body is deposited as the calcium Phosphate. They also contain a good quantity of sugars, enzymes, yeast and albuminoids.

Total sugar content of 40-70% (on dry weight basis) is reported by different scientist in samples collected from different geographical region. Similarly, reducing sugar 48-57% and non reducing sugar 3-18% has been reported. Paper chromatographic analysis of unhydrolysed mahua extract show the presence of maltose, sucrose, glucose, arabinose, fructose and rhamnose, whereas the hydrolysed extract show the presence of galacturonic acid and absence of sucrose, others being the same. Studies are also reported on the isolation and structure determination of mahua flower polysaccharide. HPLC analysis of the concentrate prepared the juice of fresh flowers shows the presence of...
sucrose, glucose, and fructose in 1:2.1:2.3 ratios. These results show the potential of mahua flower to be used as a novel source of natural sweetener.

Presence of eleven different amino acid such as lysine, arginine, aspartic acid, glutamic acid, theonine, valine, tryptophan, phenylalanine, isoleucine, leucine and proline has also been reported.

The nitrogen content of the flower varies from 0.65-1.1% being apparently higher in the younger than in the well developed flowers. The protein content of the flower varies from 4.4-7%.

5.3 Constituents of Trunk Bark
It contains lupeol acetate, α-amyrin acetate, α-spinasterol, erythrodiol monocaprylate, betulinic acid, oleanolic acid caprylates. It also contains tannins, saponins and sterols. β-amyrin, β-amyrin acetate, β-amyrin cinnamate, β-amyrin decanoate, β-amyrinone, betulinic acid, friedelin, hederagenin, isoarborinol, ursolic acid, α-spinasterol and α-spinasterol-β-D glucoside have been isolated from the bark and timber.

Bark also contains caprylates, xylose, rhamnose, glucose and galactose.

5.4 Constituents of Seed
Seeds of Mahua fruits contain protein and oil. Fatty acid composition of oil included oleic acid, linoleic acid, palmitic acid and stearic acid. Defatted seed meal contained protein and saponins (which are toxic at this level, but could be reduced by isopropanol treatment).

Seed contains semisolid fixed oil which yield oleic acid myristic acid (Shashikant VG, 2005).
Table 3: Nutritional constituents of mahua flower.\textsuperscript{[10]}

<table>
<thead>
<tr>
<th>Per 100 gm</th>
<th>Mahua flower (ripe)</th>
<th>Mahua flower (dry)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture*</td>
<td>73.6</td>
<td>11.61</td>
</tr>
<tr>
<td>Protein*</td>
<td>1.4</td>
<td>6.67</td>
</tr>
<tr>
<td>Fat*</td>
<td>1.6</td>
<td>0.69</td>
</tr>
<tr>
<td>Minerals*</td>
<td>0.4</td>
<td>-</td>
</tr>
<tr>
<td>Fibres*</td>
<td>-</td>
<td>1.9</td>
</tr>
</tbody>
</table>
Table 4 Phytochemical analysis of *Madhuca indica* (leaves).

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Phytochemical</th>
<th>Test</th>
<th>Inference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Alkaloids</td>
<td>Mayer’s reagent</td>
<td>++</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Dragendorff’s reagent</td>
<td>+</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Wagner’s reagent</td>
<td>+</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Hager’s reagent</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>Sterols</td>
<td>Salkowski Test</td>
<td>+</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Lebermann’s Burchard Test</td>
<td>+</td>
</tr>
<tr>
<td>7</td>
<td>Cardiac Glycosides</td>
<td>Legal Test</td>
<td>+</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>Keller Killiani Test</td>
<td>+</td>
</tr>
<tr>
<td>9</td>
<td>Anthraquinone Glycosides</td>
<td>Borntrager’s Test</td>
<td>-</td>
</tr>
<tr>
<td>10</td>
<td>Carbohydrates</td>
<td>Molisch’s reagent</td>
<td>-</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>Fehling Solution</td>
<td>-</td>
</tr>
<tr>
<td>12</td>
<td>Tannins</td>
<td>Lead acetate solution</td>
<td>+</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>Ferric chloride solution</td>
<td>+</td>
</tr>
<tr>
<td>14</td>
<td>Protein &amp; Amino Acids</td>
<td>Biuret test</td>
<td>-</td>
</tr>
<tr>
<td>15</td>
<td>Saponins</td>
<td>Foam Test</td>
<td>+++</td>
</tr>
<tr>
<td>16</td>
<td>Flavonoids</td>
<td>Ammonia test</td>
<td>+</td>
</tr>
<tr>
<td>17</td>
<td></td>
<td>Alkaline reagent test</td>
<td>++</td>
</tr>
<tr>
<td>18</td>
<td>Fixed oil &amp; Fats</td>
<td>Spot test</td>
<td>-</td>
</tr>
</tbody>
</table>

*(g/100g) ** (mg/100g)

6. PRELIMINARY PHYTOCHEMICAL SCREENING

Freshly prepared various extracts of leaves were tested for the presence of phytochemical constituents by using various chemical tests.[11]

7. UTILIZATION

7.1 Nutritional and Medicinal Use

Mahua tree is having lots of nutritional value in it. It produces fruit which is valued for its seed which yield high quantity of fat commercially known as Mahua butter or mowrah butter, many edible and medicinal applications and it is also used as a biodiesel. Its fat has been used as substitute for cocoa butter and ghee. It is one of the single largest sources of natural hard fat. The fat which is thus obtained from Mahua fruit oil is used in cooking, frying and manufacturing chocolates. The seed fat has emulsification property so it mostly used as an emulsifying agent in few pharmaceutical industries. It is generally applied as massage oil in many part of the country, as it is very good to moisturize skin. Besides edible and medicinal uses, Mahua has industrial application as it can be utilized in the manufacture of laundry soaps and lubricants. Moreover, the seed cake is reported to have insecticidal and pesticide property and used as organic manure in crops like rice, sugarcane etc.

The medicinal properties which are seen in this plant are stimulant, demulcent, emollient, galactogogue and laxative. It can also be used in skin disease, rheumatism, headache, piles, and sometimes as astringent and many more.

7.2 Traditional uses

Mahua flower occupied an important position in the life of the tribal in many parts of India. Major quantity of flowers is used in the preparation of the distilled liquors. The freshly prepared liquor has a strong, smoky foetid odour, which disappear on ageing. The most interested thing about the Mahua tree is that it has two fruits in different seasons; the seed oil is extracted from it and used in the several different purposes. The wood of mahua tree is also used in the house hold utility like door and window making.[12]
7.3 Preparation of sugar syrup
There are several reports on preparation of sugar syrup from dry Mahua flowers, as its sweet property is utilized in the fermentation process. The syrup obtained from the flower of Mahua is employed in different purposes, either in the manufacturing of chocolate or as a sweetening agent.[12]

7.4 Industrial use
Research has been carried out from the last several years to produce the new source of diesel which provide the alternative of present fuel. Recently, biodiesel has been receiving increasing attention due to its less polluting nature and because it is a renewable energy resource as against the conventional diesel, which is a fossil fuel leading to a potential exhaustion. Mostly, biodiesel is prepared from oils like soybean, rapeseed, sunflower, safflower, jetropa etc.

7.5 Other uses in tribes
In diarrhoea a cup of infusion of bark is taken orally twice a day by the tribal. Besides the stem bark is used in chronic tonsillitis, leprosy and fever. It is commonly used in the treatment of snakebite as antidote in southern part of Tamilnadu, India. Decoction of stem bark is used to cure skin disease and hydrocoele. Powdered bark is employed for the treatment of scabies. Leaves are expectorant and also used for chronic bronchitis and Cushing’s disease. The leaves are applied as a poultice to relieve eczema.[13]

7.5.1 Stem
Fresh stem pieces are used as toothbrush to remove foul smell from the mouth and to strengthen gums. Decoction of inner bark, about a half cup, is administered twice a day suffering from amenorrhea. Bark flakes are heated gently and then tied on joints to reduce joint ache. A cup of infusion of bark is taken orally twice a day to cure diarrhea.[13]

Long stripes removed from fresh wet wood are used to prepare rings, which are then employed for making fish traps, locally called “Tondya” Milky viscous juice obtained from inner bark of the trunk is applied on logs, which are placed amidst the crops when they are fruiting. Due to fear of sticking to these logs birds avoid visiting these cropped fields. Arrows dipped in juice are also used to kill the birds in the cropped fields. The wood is useful for making agriculture implements, handles or tools, etc. Wood of only old tree is used as a fuel.[14]

7.5.2 Leaves
Jaggery slightly diluted in water is applied on leaves and kept overnight. On the next day, it is licked thrice a day to cure mouth ulcers and practiced till cure. The leaves juice is applied on body to relieve muscular pain.[11]
Leaves are used to thatch roofs of huts or houses and are fed to cattle in times of scarcity only.[5]

7.5.3 Flowers
A handful of dried corollas are heated gently then spread on the abscess and bandaged. A cup decoction of dried petals is given in case of dysuria. Wine prepared from fermented petals is given to ladies during child delivery. It is also administered for cold and cough. It is a favorite drink in all tribal societies.

Petals are eaten fresh, dried or parched. Dried petals are mixed with flour while making bread. In times of scarcity, the grains of corn (Zea mays) or jawar (Sorghum milliflora) are cooked along the Mahua petals. These are crushed thoroughly and this paste is served as food.

7.5.4 Fruits
Ripe fruits are edible; unripe fruits are first boiled and then used as vegetable.

7.5.5 Seeds (Kernels)
Kernels oil is administered to bullocks and buffaloes for better digestion. Seed powder is applied to infants for clear motion if they have constipation trouble. Seed powder is smelt in hysteria and it is homogenized with cow ghee and taken orally for throat infection. Few drops of juice obtained by rubbing the germinated seed in water are dropped into nose for chronic headache.

Oil expressed from the kernels using indigenous oil expellers is used for cooking and illumination purpose in tribal areas only. The cake left after extraction of oil from the kernels is used as cattle feed.[15]

7.5.6 Some cosmetics uses
Mahua butter has a mild, pleasant odor suitable for use in cosmetics and toiletries as it has properties to prevent drying of the skin and may hinder the development of wrinkles and it is also said to reduce degeneration of skin cells and restores skin flexibility. Mahua butter is a soft, solid at room temperature. Butter melts immediately upon the contact with the skin, thus making it great for bath melts, massage bars, whipped butters and body bars. Use from 3% to 100% pure to make a butter like balms. This is a solid at room temperature.

8. PHARMACOLOGICAL PROPERTIES OF MADHUCA INDICA

Pharmacological profile
Madhuca indica, belonging to the family Sapotaceae, is an important economic tree growing throughout India. Traditionally, Madhuca indica bark has been used against diabetes, rheumatism, ulcers, bleeding and tonsillitis. The flowers, seeds and seed oil of Madhuca have great medicinal value. Externally, the seed oil massage is very effective to alleviate pain. In skin diseases, the juice of flowers is rubbed for oleation. It is also beneficial as a nasya (nasal drops) in diseases of the head due to pitta, like sinusitis. The Mahua have several pharmacological potency and it is being used from the tradition. Few of its Pharmacological use are as follows:
8.1 Anti-inflammatory Activity
The reason of the generation of the swelling or inflammation is release of the various chemical mediators from the damaged cell like histamine and serotonin. Inflammation is a defensive mechanism of the body. The most important mechanism of anti-inflammatory drugs is considered to be inhibition of PG synthesis at the site of injury. The anti-inflammatory potency of drugs is corresponds with their potency to inhibit. The *Madhuca indica* is found to be a good remedy for treatment of the inflammation, its aerial parts is utilized for the treatment of inflammation. When extract solution was given to the male vistar rat which was already having inflammation, shown a satisfactory result. Anti inflammatory effect can be measured as the percent inhibition of inflammation and calculated with reference to negative control.16

8.2 Analgesic activity
Analgesics are the agents that relieve the sensation of pain without disturbing consciousness or altering other afferent input. Analgesic activity was evaluated on the acetic acid induced writhing. The methanolic extract of *Madhuca indica* was given orally to the group of 6 animals. The number of writhing during the following 30 min. period was observed after acetic acid injection. Anti analgesia is expressed as the reduction of the number of abdominal constriction between control animal and mice pre-treated with the extract. In other words if the analgesic drug works the abdominal constriction will be the less in numbers. The analgesic activity of the *Madhuca indica* can also be evaluated by the using other method of evaluation like tail flick method or hot plate method in rats. Significant reduction either in the reaction time hot plate, tail flick, gradient heat, abdominal constriction compared with vehicle treated animals was consider as anti nociceptive response.17

8.3 Antipyretic activity
*Madhuca indica* is used to treat the fever in individual, as it is experimented in animals. About 5 groups of 6 rats, each were injected subcutaneously with 10 ml/kg body weight. Firsty the animals were forced to fever by injecting the suspension of the yeast, this increased the body temperature of the experimental animal. Basal rectal temperature of each animal was recorded. About 19 hr. after yeast injection, the rectal temperature was recorded again and animal showing a rise in temperature of <0.6 °C were discarded. Rectal temperature was then recorded at 20-24 hr after yeast injection. After some time interval the reduction in the rectal temperature of rat, was found which shows the antipyretic effect of *Madhuca indica*.18

8.4 Anti-hyperglycemic Activity
The significant hypo-glycemic effects of *Madhuca indica* bark in diabetic rats indicate that this effect can be mediated by stimulation of glucose utilization by peripheral tissues. The results of the present study clearly indicated that the methanolic extract of *Madhuca indica* bark have hypoglycemic effect on STZ induced diabetic rats. In all groups except for glibenclamide, at 30 min of initiating glucose tolerance test, blood glucose concentration was higher than at zero time but decreased significantly from 30 min to 120 min. Methanolic extracts were enhancing glucose utilization, thus the blood glucose level was significantly decreased in glucose loaded rats. Methanolic extract of *Madhuca indica* have significantly decreased the serum glucose level in streptozotocin and STZ-NIC induced diabetic rats. The crude methanolic extract of *Madhuca indica* leaves demonstrated dose-dependent reductions in serum glucose level following administration in glucose-loaded mice. The decreases in serum glucose levels were found to be significantly reduced at doses of 100, 250, and 500 mg extract per kg body weight. At these doses, the extract reduced serum glucose levels.19

8.5 Anti ulcer Activity
Gastro intestinal ulcer is a common disorder of gastrointestinal tract. It is now considered that gastrointestinal ulcer is a disease of multi factorial origin but its detailed etiology is still not clear. Ulcer is a result of the imbalance between the defensive and attacking factors in the GIT. An ulcer is a local defect or excavation of the upper part that is called surface of an organ or the tissue. Anti ulcer activity has been proved in *Madhuca indica* plant when it was tested in the male vistar rat. To evaluate the anti ulcer activity of the Mahua tree, firstly the animal is forced to produce the ulcer by any of suitable method like stress induced ulcer or carrageen induced ulcer, and then the same is treated with the extract of the tested plant materials.20

8.6 Antioxidant Activity
Oxidative stress is produced during normal metabolic process in the body as well as induced by a variety of environmental and chemical factors, which causes a generation of various reactive free radical and subsequent change in DNA and lipids. The reducing property of ethanolic extract of *Madhuca indica* bark implies that it is capable of donating hydrogen atom in a dose dependent manner. The high content of phenolic compounds in the extract may be a contributing factor towards antioxidant activity because the phenolic compounds are known to have direct antioxidant property due to the presence of hydroxyl groups, which can function as hydrogen donor. The reducing capacity of a compound may serve as a significant indicator of its potential antioxidant activity.21

8.7 Anti fertility activity
The percentage of fertile male mice and the number of pregnancies were significantly reduced in atropine induced mice. Among the plant based contraceptives, inhibition of male fertility after administration of natural substances has been related to decrease spermatozoa density. Also for male contraception, it is not necessary to stop spermatogenesis, but rather to eliminate the fertilizing ability of the spermatozoa by causing changes
in the morphology or in the function of the sperm. The decrease in sperm count and the high number of morphologically abnormal sperms indicate interference with testicular spermatogenesis. [22]

8.8 Antibacterial Activity
The flower has an antibacterial activity against the Escherichia coli and resist against rice pest disease. [22]

8.9 Antiepileptic Activity
The anticonvulsant activity of the methanolic extract of heart wood of Madhuca indica was assessed in pentylenetetrazole (PTZ) - induced convulsion in mice with benzodiazepine as standard drug. Mechanistic studies were conducted using flumazenil, a GABA-benzo-diazepine receptor complex site antagonist, and naloxone a non-specific opioid receptor antagonist. Madhuca indica at the dose of 400 mg/kg prolonged the onset time of seizure and decreased the duration of seizures compared to saline group. [23]

8.10 Dermatological Activity
The decoction of the bark is useful in itching and ulceration, the oil is obtained from the seed, which is useful in the several allergic disorders. It is also used as laxative. [15]

8.11 Hepatoprotective Activity
The methanolic extracts of Madhuca indica bark is studied for hepatoprotective activity against albino rats with liver damage induced by carbon tetrachloride (CCl₄). It was found that the methanolic extract of Madhuca indica bark at a dose of 300 mg/kg body weight exhibited moderate protective effect by lowering the serum levels of Glutamate Pyruvate Transaminase (SGPT), Serum Glutamate Oxaloacetate Transaminase (SGOT), Serum bilirubin and Serum alkaline phosphate (SALP) to a significant extent. Present finding demonstrated the methanolic bark extract of Madhuca indica could afford significant dose-dependent protection against CCl₄ induced hepato cellular injury. [24]

8.12 Toxicity Activity
A mixture of saponin isolated from Madhuca indica seed did not reveal any cholinergic activity, although it produced at a higher concentration. The saponin is extremely toxic when administered parentally. LD₅₀ by IP route was one of the same orders as that by the IV route, being 50 to 70 times higher than oral route. In the root of Madhuca indica, higher amount of phenol was observed. These compounds play an important role in the precursor of toxic substance and role in the growth regulation and development of plants. It is also reported that Madhuca indica seed oil contains toxic chemical aflatoxine. [25]

8.13 Wound healing activity
Wound healing activity was observed in animals treated with Ethanolic extracts of bark. Extract treated animals showed a significant reduction in wound area and period of epithelisation. The extract treated animals showed faster epithelisation of wound respectively than the control.

9. CONCLUSION
Plants are the important economical source of a number of well established drugs looking upon wide prospects and potential of Madhuca indica for various purposes; it is worthwhile to cultivate this plant on large scale especially on unproductive and wasteland. This will help in financial support of poor and landless families. Generally this plant Madhuca indica is known only for its liquor making purpose, but one have to come forward to change the thinking of unaware people. The Mahua tree is hidden from the public eyes as its medicinal point of view. As for the better potential, good quality of mahua tree should be cultivated through plant tissue culture by means of micro propagation. The research workers have to come along with the people of rural area so they may have more and valuable knowledge. In coming next generation the importance of plant and mahua tree is going to be increase because of their effectiveness, easy availability, low cost and comparatively being devoid of toxic effect. Madhuca indica has found several of pharmacological activity, yet several other activities have to be finding out.

Scientists have realized an immense potential in natural products from medicinal plants to serve as an alternate source of combating infections in human beings which may also be of lower cost and lesser toxicity. The flowers, seeds, and seed oil of Madhuca have great medicinal value.

REFERENCES