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Original Article

Traditional Uses and Nutritional Properties of Mahua (Madhuca Longifolia): A Multipurpose Tropical Tree Grown by Tribals Of Chhattisgarh State

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ABSTRACT

Chhattisgarh, the "heart of India," is renowned for its agriculture, mineral wealth, and vibrant tribal cultures, which remain a focus of regional and global interest. Indigenous communities rely on local resources like Mahua (Madhuca indica), a vital tree offering medicinal benefits such as hepatoprotective, antimicrobial, and wound-healing properties, along with non-medicinal applications like alcohol fermentation, food production, and soap-making. While some of these uses have been explored, many remain underutilized, presenting opportunities for further research and application. The Mahua (Madhuca longifolia) tree, native to South Asia and abundant in Chhattisgarh State, is a valuable resource for its edible flowers and oil-rich seeds. Taking 10 years to mature and producing for up to 60 years, it yields 60–80 kg of seeds and 100–150 kg of flowers annually per tree.The flowers are consumed fresh, dried, or fermented for liquor, while the seeds produce 35–50% oil used in soaps, candles, pest control, and as a laxative or emollient for skin and rheumatism. Traditional medicinal uses include treating ailments like tuberculosis, arthritis, cholera, snake bites, and infections. Mahua seed cake is a protein-rich pond manure in aquaculture but has reduced palatability due to saponins. Additionally, Mahua oil serves as a sustainable source for biodiesel, and the tree supports soil reclamation and erosion control efforts. Its wide applications make it an integral part of traditional and industrial practices. The genus Madhuca, part of the Sapotaceae family, includes species like Madhuca longifolia and Madhuca butyracea. Madhuca longifolia (Mahua) is a large deciduous tree native to India, valued for its flowers and seeds, which provide a livelihood for rural communities. Mahua seeds are a rich oilseed crop, yielding 20–200 kg per tree annually and contributing to 0.5 million tonnes of annual production in southern India. The seeds are high in vegetable fat, and oil extraction is done using commercial screw press expellers. The residual seed cake contains about 30% protein and, after detoxification, serves as a protein source in food and feed. Protein extraction techniques include alkaline extraction, which modifies protein structure under alkaline conditions, and ultrasound extraction, a safe and eco-friendly method using high-frequency mechanical waves. These approaches enhance protein quality for diverse applications.

Keywords: Medicinal plant; Mahua oil; Antioxidant, bio fuels, Hepatoprotective; nutritional properties and uses

INTRODUCTION

Chhattisgarh, established on 1 November 2000 after its separation from Madhya Pradesh, has emerged as a fast-developing state despite the initial challenges. Its rapid growth can be attributed to two major factors: its naturally favorable environment, which supports farming and offers abundant mineral resources for the production of metals such as aluminum, steel, iron, and tin, and the vibrant culture of its rural and tribal communities. These tribal communities play a significant role in collecting and processing minerals and medicinal plants using traditional knowledge systems. Among the notable trees in Chhattisgarh is the *Mahua* (*Madhuca longifolia*), which serves as an essential source of income for many tribal people. They collect, process, and shell its flowers, fruits, and seeds. This Indian-origin tree, approximately 20 meters tall, grows wildly without any investment and is either evergreen or semi-evergreen. It features short, rounded crowns, thick and clustered pointed leaves measuring 10–30 centimeters, and fragrant, sugar-rich flowers that are small but attract animals like elephants. While *Mahua* has been recognized for its pharmacological properties, such as medicinal uses reported in prior studies, there is limited information

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on its non-medicinal applications. The tree holds immense potential, not only in terms of pharmacology but also as a source for unexplored economic benefits, making it a critical asset for the local communities in Chhattisgarh's green forest regions. *Mahua* (also known as Mahwa or Iluppai), scientifically classified as *Madhuca longifolia*, is a significant tropical tree native to India, widely distributed in the plains and forests of Central and North India, as well as parts of Eastern India such as West Bengal, Bihar, and Jharkhand. This fast-growing tree, reaching heights of about 20 meters, belongs to the family Sapotaceae and thrives in warm, humid regions. Its foliage is either evergreen or semi-evergreen, making it a resilient species.

Historical background

The *Madhuca* tree (*Madhuca longifolia*), commonly known as Mahua, has been a vital resource for both edible products and medicinal uses for generations. Tribals regard the tree as sacred, worshipping it for the welfare it brings through its various parts. The flowers of the Mahua tree are particularly versatile—they serve as flavoring agents in dishes, are used to make pickles, and even act as cattle feed, boosting milk production in lactating mothers. Mahua holds profound cultural significance in tribal traditions, where its sacred status is reflected in rituals and practices involving the tree and its byproducts, including a drink made from its flowers. Growing predominantly under subtropical and dry tropical conditions, Mahua thrives in forests, revenue lands, and private lands. It is distributed across states like Andhra Pradesh, Gujarat, Madhya Pradesh, Odisha, Chhattisgarh, Jharkhand, Bihar, and Uttar Pradesh. The tree is especially valuable to forest dwellers and the underprivileged. The flowers and seeds, often referred to as *tora*, are widely recognized for their medicinal properties. In tribal cultures, Mahua holds both religious and aesthetic value. Trees with the best girths are carefully protected and nurtured by forest dwellers. Traditionally, Mahua trees have been closely associated with specific families or communities. Rights to harvest the flowers and fruits were passed down through generations, often as part of family inheritance. In the absence of male heirs, daughters received harvesting rights as part of their marital arrangements. This tree's economic and social role extends beyond food and medicine—it symbolizes wealth, heritage, and sustainability within tribal communities.

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DESCRIPTION

Madhuca longifolia, commonly known as Mahua or the Butter Nut Tree, belongs to the Sapotaceae family and is highly regarded for its diverse medicinal properties and nutritional benefits. This medium to large deciduous tree thrives in Nepal, India, Sri Lanka, and parts of Asia and Australia. It is particularly common in the deciduous forests of West Bengal, Odisha, Madhya Pradesh, Uttar Pradesh, Bihar, Punjab, and the sub-Himalayan regions.

Chemical Composition and Medicinal Uses: The tree contains valuable compounds such as terpenoids,

proteins, starch, anthraquinone glycosides, phenolic compounds, mucilage, cardiac glycosides, tannins, and saponins, which contribute to its wound-healing, antimicrobial, antioxidant, anti-inflammatory, anticancer, and antidiabetic properties. Its antioxidant activity combats oxidative stress caused by free radicals like superoxide anions.

Specific Uses:

- **Flowers**: Tonic, aphrodisiac, astringent, and cooling. Used to treat acute and chronic tonsillitis, helminths, pharyngitis, and bronchitis. They are edible, rich in reducing sugars, and serve as sweeteners in traditional dishes like halwa, kheer, puri, and burfi.
- **Leaves**: Used as an expectorant and to manage conditions like Cushing's disease, chronic bronchitis, and eczema through poultices.
- **Stem Bark**: Powder strengthens gums when used as tooth powder. Bark infusions treat diarrhea, phlegm, itching, swelling, fractures, snake bites, chronic tonsillitis, leprosy, fever, and rheumatism.
- **Seeds**: Rich in sapogenin and acids, the seeds are useful for medicinal and nutritional purposes.

Culinary and Post-Harvest Challenges: The flowers, integral to the Mahua production belt of India, require traditional sun drying (until 80% moisture is reduced) before storage, highlighting the lack of advanced post-harvest technologies. The Mahua tree continues to be a cornerstone for medicinal, nutritional, and cultural traditions, underscoring its incredible potential for further exploration and innovation.

Cultivation and Collection

In India, Mahua (*Madhuca longifolia*) plays an essential role in employment and economic sustenance for many communities, with an annual seed production of around 0.12 million tons and flower production reaching nearly 1 million tons. The Indian government actively encourages the collection of Mahua seeds and flowers due to their economic significance. Mahua trees can grow naturally or be cultivated, with their flowering season occurring between March and April. Seeds are typically collected during May, June, and July, though flowering often exceeds seed production during this period. The fruits are harvested by villagers using hand-picking methods or bamboo sticks, primarily in the mornings. At peak collection times, up to 15 kilograms of seeds, locally called *tori*, can be gathered in one day. From every kilogram of seeds, approximately 250 ml of oil can be extracted. This oil is extensively used in households and sold after undergoing vacuum purification. Indigenous oil extraction methods are often employed, and the oil is preserved in airtight earthen pots or baskets to prevent fungal spoilage. The seeds are separated from the fruits, while the pulp is used as food. The extracted oil, known as *gully oil*, is a key ingredient in the soap-making industry. Additionally, *Madhuca* products are outlined in The Ayurvedic Pharmacopoeia of India, with a recommended dose of 10–15 g for medicinal use. The Mahua tree remains a vital resource, supporting livelihoods and offering multiple applications in culinary, medicinal, and industrial contexts.

Distribution and Habitat-

Madhuca longifolia is widely distributed across northern, central, and southern parts of peninsular India, including regions like Maharashtra and Gujarat, as well as Sri Lanka and Burma. It is prevalent in dry mixed deciduous forests, dry forests, and dry teak forests, where it thrives under specific climatic and soil conditions. The tree adapts to various soil types, including shallow, boulder-filled, clayey, calcareous, and sandy soils, with sandy soils being the most favorable for its growth. It is commonly found up to altitudes of 1200 meters, in areas where the annual maximum temperature ranges from 28–50°C, the minimum temperature from 2–12°C, and rainfall is between 550–1500 mm. Although not frost-hardy, it is drought-resistant and requires strong sunlight, as it is suppressed when grown in shaded environments. Its ability to adapt to diverse conditions makes *Madhuca longifolia* a valuable species in ecological and agricultural contexts.

Botanical description

Madhuca longifolia is a medium-to-large deciduous tree, commonly found in Nepal, India, and Sri Lanka. It grows to a height of 10–15 meters, featuring a dense, spreading, round, and shady canopy.

1. **Bark**: Rough and brownish to yellowish-grey in color, the bark is fissured and slightly cracked. The inner bark is red and exudes white, milky sap when cut.
2. **Leaves**: Clustered at the ends of branches, they measure 15–25 cm × 8–15 cm, arranged in pairs. The leaves are elliptic, coriaceous, pointed at the tip, with a cuneate base and a thick, hairy texture beneath. They have strong nerves and entire margins that may appear wavy. Tertiary nerves are oblique.
3. **Stalk**: Reddish, 2–4 cm in length.
4. **Flowers**: White, fragrant, fleshy, and approximately 2 cm long. They grow in bunches at the tips of branches, drooping from pedicels.
5. **Fruits**: Ovoid, fleshy, and greenish in color. Each fruit contains 1–4 seeds and measures 2–4 cm across.
6. **Seeds**: Brown, elongate, and shiny, each about 2 cm long.
7. **Calyx**: Densely covered with rusty tomentum and coriaceous in texture.
8. **Corolla**: Yellowish-white and fleshy.
9. **Stamens**: 20–30 in number, often 24 or 26, with hispid anthers bearing stiff hairs on the back.

1 Madhuca longifolia

2 Flower buds

3 Dry flowers

4 Fresh flowers

5 Dry Fruit

6 Seeds

The flowers of *Madhuca longifolia* are highly valued for their diverse medicinal applications. They act as a cooling agent, aphrodisiac, astringent, and demulcent, offering remedies for various ailments such as tonsillitis, helminthiasis, pharyngitis, bronchitis, and impotency. Additionally, the flowers are effective in reducing inflammation, treating eczema, and curing eye diseases. The juice extracted from the flowers is particularly beneficial for addressing skin-related conditions. The bark of the tree also possesses medicinal properties and is traditionally used to treat itching, swelling, and fractures. It has proven effective in managing snake-bite poisoning, making it a significant resource in traditional medicine. These attributes highlight the immense therapeutic potential of the Mahua tree, which has been deeply integrated into traditional healing practices. Let me know if you'd like to explore more about its other uses or related research!

Taxonomy

Botanical profile of Mahua (Madhuca longifolia).

Botanical Name	**Madhuca longifolia**
Family	Sapotaceae
Subfamily	Caesalpinioideae
Tribes	Caesalpinieae
Genus	Madhuca
Species	longifolia
Order	Ericaleae

Synonyms

English	South Indian Mahua
Hindi	Mahva, Mohva
Kannada	Erappe
Telegu	Ippa
Tamil	Iluppai
Sanskrit	Madhukah
Malayam	Irippa

Classical categorisation

The classical categorization outlines the references to Mahua (*Madhuca longifolia*) and related plants in prominent ancient Indian texts and traditional medicinal systems:

1. **Charaka**: Mentioned in *Charak Chikitsa* (Chapter 19), highlighting its therapeutic uses.
2. **Sushruta**: Included in *Sushruta Sutra* (Chapter 46), focusing on its applications in surgery and healing.
3. **Dhanvantri Nighantu**: Categorized under *Aamraadi Varga*, emphasizing its medicinal properties.
4. **Bhavprakash Nighantu**: Listed in *Aamradi Phalavarga*, showcasing its value in the fruit-based classification.
5. **Kaiyadev Nighantu**: Placed in *Aushadhadi Varga*, focusing on its role as a medicinal herb.
6. **Madanapal Nighantu**: Grouped under *Phaladi Varga*, highlighting its fruit applications.
7. **Raj Nighantu**: Classified in *Aamradi Varga*, illustrating its widespread importance in flora categorizations.
8. **Dravyaguna Sangraha**: Located in *Phaladi Varga*, discussing its attributes and medicinal significance.

- The tree is cultivated for its seeds, flowers, and wood. Mature trees produce 20 to 200 kg of seeds annually, which have a high fat content.
- *Mahua* fat, solid at room temperature, is widely used for skin care, as a base in soap and detergent manufacturing, and as vegetable butter. It also serves as fuel oil.
- The residual seed cake from oil extraction acts as an excellent fertilizer, enriching soil and supporting agriculture.
- The flowers, rich in sugars, are used to produce traditional alcoholic beverages in tropical India, though these drinks can have effects on animals consuming them.

The *Mahua* flower holds significant cultural and economic value for tribal communities across India. It serves as a food item, a natural sweetener, and most notably, a key ingredient in the production of an alcoholic drink also called "mahua." This drink is deeply rooted in the cultural heritage of tribes such as the Bastar tribes in Chhattisgarh and Orissa, the Santhals in Jharkhand, and the Koya tribes in Andhra Pradesh, among others. It is a staple during tribal celebrations, prepared using dried *Mahua* flowers and granular molasses (*jhola gur*). The liquor is whitish, mild, aromatic, and inexpensive, with production typically carried out in home stills. Beyond its cultural significance, *Mahua* exhibits medicinal properties. Methanolic and ethanolic extracts of *Mahua* have demonstrated dose-dependent hypoglycemic activity in both normal and streptozotocin-induced diabetic rats. Studies suggest that habitual consumption of *Mahua* drinks may influence diabetes and lipid profiles among tribal populations.

Ayurvedic pharmaco-dynamics

Rasa	Madhura, Kashaya
Hindi	Mahva, Mohva
Guna	Guru, Snigdha
Veerya	Sheeta
Vipaka	Madhura
Doshaghnta	Vatapittashamaka
Karma	Balya, Brimhana,Vrishya
Part Used	Pushpa, Beeja, Taila

Phytochemistry of different parts of mahua

Phytochemistry, as an evolving scientific field, has made substantial progress over the years. It focuses on the study and structural characterization of the diverse and complex molecules synthesized and stored by plants. This discipline is concerned with the identification, analysis, and understanding of a wide range of natural compounds, including alkaloids, flavonoids, terpenoids, phenolic compounds, and glycosides. These bioactive molecules not only play crucial roles in plant growth and defense mechanisms

but also hold immense potential for pharmaceutical, nutraceutical, and industrial applications. Phytochemistry bridges the gap between natural product research and modern science, enabling advancements in areas like drug development, agriculture, and environmental sustainability.

1	Leaves	3- O-βDglucoside, stigmasterol, β-sitosterol- β-D glucoside, nhexacosanol, 3β-caproxyolcan- 12-en-28-ol, β-carotene, noctacosanol, sitosterol, quercetin. 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-palmitoxyolean-12-en-28-ol, oleanolic acid, β-sitosterol
2	Bark	3β-capryloxy oleanolic acid. α- and β- amyrin acetates, α-tocopherol and Ethylcinnamate, sesquiterene alcohol, α-terpeneol, 3βmonocaprylic ester of eythrodiol
3	Fruits	3β-Dglucoside, n-hexacosanol and dihydroquercetin and α- and β- amyrin acetates, quercetin, β-sitosterol
4	Seeds	glycine, isoleucine and leucine, lysine, methionine, proline, serine, threonine, myricetin, quercetin, Mi-saponin A & B and Arachidic, linolelic, oleic, myrisic, palmitic and stearic acids, α-alanine, aspartic acid, cystine
5	Flower	Vitamins A and C
6	Nut –shell	β-sitosterol and its 3β-Dglucoside, n-hexacosanol quercetin and dihyroquercetin

Phytochemical properties of mahua

Phytochemical constituents, naturally occurring compounds in plants, play a crucial role in promoting specific physiological effects on the human body. Based on their functions within plant metabolism, they are classified into two main categories:

1. **Primary Phytochemicals**: These are essential for the basic functions and growth of plants, including compounds like carbohydrates, proteins, and fats. They serve as energy sources and structural components, forming the foundation of plant metabolism.

2. **Secondary Phytochemicals**: These compounds are not directly involved in growth but play significant roles in plant defense mechanisms, interaction with the environment, and reproduction. Examples include alkaloids, flavonoids, tannins, terpenoids, saponins, and glycosides. They often exhibit bioactive properties, contributing to therapeutic, antimicrobial, antioxidant, and anti-inflammatory effects beneficial to human health.

The distinction between primary and secondary phytochemicals underscores their multifaceted contributions, both to plant sustainability and their potential applications in medicine, nutrition, and industry.

Constituents

Phytochemicals are broadly categorized into primary constituents and secondary constituents, each serving distinct roles in plants and providing numerous benefits to humans:

1. **Primary Constituents**: These include essential compounds such as common sugars, amino acids, proteins, and chlorophyll.

   - **Common Sugars**: Serve as vital energy sources for both plants and humans. They are integral to metabolic processes and the storage of energy.

   - **Amino Acids and Proteins**: These are building blocks for the synthesis of enzymes, structural components, and various functional molecules necessary for cellular and physiological functions.

   - **Chlorophyll**: Essential for photosynthesis, it captures sunlight to produce energy in plants, indirectly supporting life by providing oxygen and energy-rich food sources.

2. **Secondary Constituents**: These compounds are not directly involved in growth but are crucial for the plant's defense, survival, and interactions with the environment. They include:

   - **Alkaloids**: Nitrogen-containing compounds with medicinal properties, often used in

pharmaceuticals to treat conditions like pain or infections.

- **Terpenoids**: Contribute to the aromatic properties of plants and exhibit anti-inflammatory, antimicrobial, and anticancer activities.
- **Saponins**: Known for their foaming ability, they provide health benefits such as cholesterol reduction and immune system support.
- **Phenolic Compounds**: Potent antioxidants that protect plants and humans from oxidative damage, reducing the risk of chronic diseases.
- **Flavonoids**: Pigments responsible for vibrant colors in flowers and fruits, these compounds have anti-inflammatory, antioxidant, and cardioprotective effects.
- **Tannins**: Astringent compounds that help in wound healing, reducing inflammation, and protecting plants from herbivores and pathogens.

Both groups of phytochemicals highlight the diverse and vital roles of plant-based compounds in ecology, health, and nutrition, emphasizing their significance for research and practical applications Phytochemical screening provides insights into the types of compounds present in plants, aiding in the discovery of bioactive substances. Plants are tested for phytochemicals to identify constituents or groups linked to therapeutic effectiveness. Preliminary studies on the methanolic extract of *Madhuca longifolia* have revealed the presence of key bioactive compounds, highlighting its medicinal potential.

Table:1 Key bioactive compounds

Alkaloids	+
Tannins	+
Proteins	+
Flavonoids	-
Carbohydrates	+
Amino acids	-
Volatile oils	-

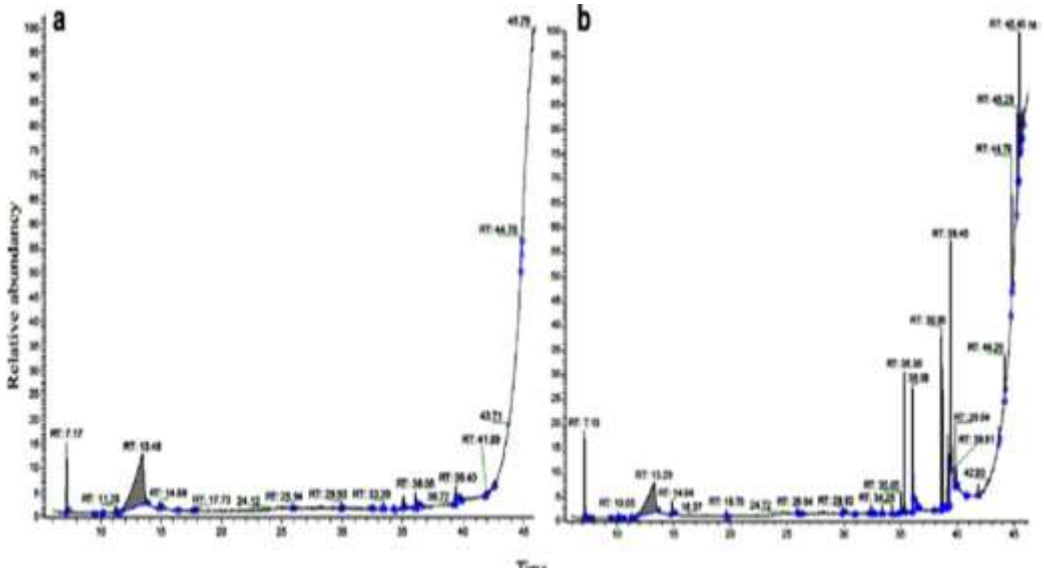

Fig -1Chromatograms-of-the-bioactive-compounds-present-in-a-hot-and-b-cold-acetone-extracts-of mahua

Fig-: 2 Distribution of mahua tree in india

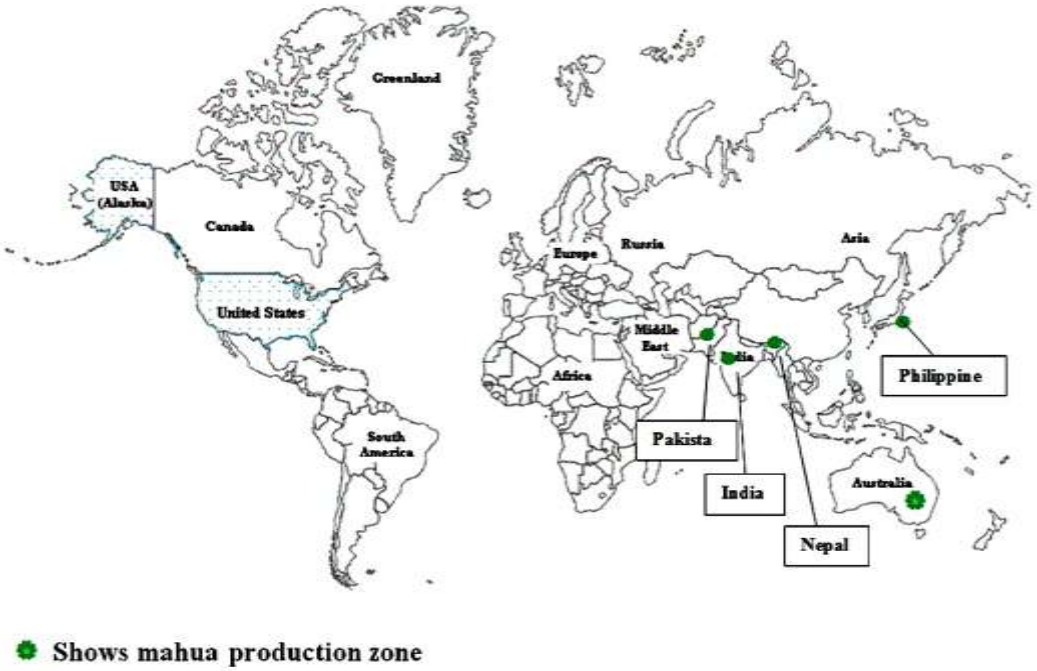

Fig-: 3 Distribution of mahua tree in world.

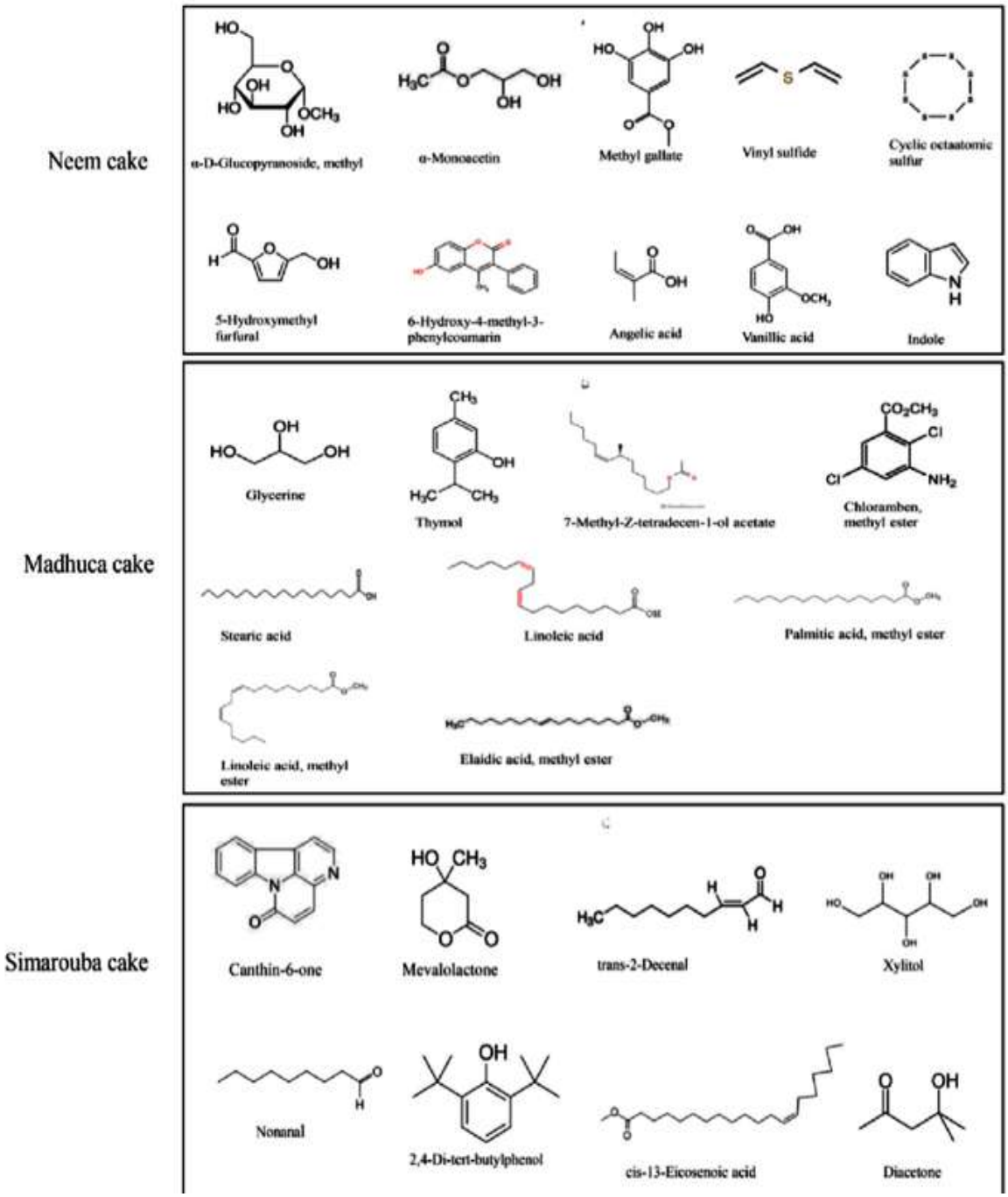

Fig -: 4 Structure of pharmaceutically active phytochemicals of mahua tree

Different species of madhuca

The genus Madhuca belongs to the family Sapotaceae. This genus has various species, some of it are listed below:

1	Madhuca alpinia	47	Madhuca tomentosa
2	Madhuca aristulata	48	Madhuca tubulosa
3	Madhuca macrophylla	49	Madhuca utilis
4	Madhuca magnifolia	50	Madhuca vulcania
5	Madhuca malaccsensis	51	Madhuca vulpina
6	Madhuca microphylla	52	Madhuca woodii
7	Madhuca mindanaiensis	53	Madhuca aspera
8	Madhuca mirandae	54	Madhuca barbata
9	Madhuca montana	55	Madhuca bejaudii

10	Madhuca moonii	56	Madhuca betis
11	Madhuca motleyana	57	Madhuca montana
12	Madhuca multiflora	58	Madhuca burckiana
13	Madhuca multinervia	59	Madhuca calcicola
14	Madhuca neriifolia	60	Madhuca cheogiana
15	Madhuca oblongifolia	61	Madhuca clavata
16	Madhuca obovatifolia	62	Madhuca coriacea
17	Madhuca obtusifolia	63	Madhuca costulata
18	Madhuca ochracea	64	Madhuca crassipes
19	Madhuca orientalis	65	Madhuca cuneata
20	Madhuca ovate	66	Madhuca cuprea
21	Madhuca pachyphylla	67	Madhuca curtisii
22	Madhuca palembanica	68	Madhuca daemonica
23	Madhuca pallida	69	Madhuca decipiens
24	Madhuca pasqueiri	70	Madhuca diplostemon
25	Madhuca penangiana	71	Madhuca dongnaiensis
26	Madhuca penicillata	72	Madhuca dubardii
27	Madhuca pierrei	73	Madhuca elliptica
28	Madhuca platyphylla	74	Madhuca elmeri
29	Madhuca primoplagensis	75	Madhuca endertii
30	Madhuca prolixa	76	Madhuca erythrophylla
31	Madhuca pubicalyx	77	Madhuca esculenta
32	Madhuca punctata	78	Madhuca firma
33	Madhuca ridieyi	79	Madhuca floribunda
34	Madhuca rufa	80	Madhuca fulva
35	Madhuca sandakanensis	81	Madhuca fusca
36	Madhuca sarawakensis	82	Madhuca glabrascens
37	Madhuca sepilokensis	83	Madhuca hainanensis
38	Madhuca stipulacea	84	Madhuca heynei
39	Madhuca stylosa	85	Madhuca hirtiflora
40	Madhuca sessliiflora	86	Madhuca insignis
41	Madhuca sessilis	87	Madhuca kingiana
42	Madhuca silamensis	88	Madhuca klackenbergii
43	Madhuca spectabilis	89	Madhuca korthalsii
44	Madhuca stipulaceae	90	Madhuca krabiensis
45	Madhuca takensis	91	Madhuca kuchingensis
46	Madhuca thorelii	92	Madhuca kunstleri

Common uses of mahua-:

1	Intercropping	M. latifolia can also be raised with agricultural crops.
2	Boundary or barrier or support	It is planted along the boundaries of fields.
3	Ornamental	Madhuca is occasionally planted as avenue tree.
4	Soil improver	The seed cake is used as fertilizer.
5	Nitrogen fixing	It has been observed that madhuca has Vesicular arbuscular mycorrhizal associations and root colonization.
6	Shade or shelter	It provides shade for animals because of its wide spreading crown. Reclamation: Madhuca is planted on wasteland with hard lateritic soils in India
7	Erosion control	Madhuca holds soil together as it has a large spreading superficial root system
8	Timber	The reddish-brown heartwood of *Madhuca longifolia* is strong, hard, durable, and heavy (approximately 929 kg/cu. m). It takes a

		fine finish, making it suitable for construction purposes, such as house building, cartwheels, window frames, and doors.
9	Fodder	Seed cake is also fed to cattle and leaves, flowers and fruits are lopped for goats and sheep.

Nutritonal aspects of mahua-:

1. Madhuca flowers

Mahua flowers are stored by families in quantities based on their specific needs, with poorer families storing more to ensure food security and income during off-seasons. Tribes rely on these stored products as a significant food source during lean periods. However, due to their hygroscopic nature, Mahua flowers absorb atmospheric moisture and are prone to spoilage, limiting their storage time. The flowers hold deep cultural and economic importance. Tribal communities produce *Mahua*, a traditional country liquor, by fermenting the flowers of the *Madhuca* tree. This beverage is considered a vital part of their cultural heritage and is an integral feature of celebrations and social activities. Tribal men and women from Bastar in Chhattisgarh, Odisha, the Santhal communities of Jharkhand, and North Maharashtra cherish Mahua drink as an essential aspect of their daily lives and festive gatherings. The widespread use of Mahua flowers as a resource reflects their role in supporting livelihoods, preserving cultural identity, and contributing to the economy of tribal regions. Their significance extends beyond sustenance, embodying a connection between people, nature, and tradition

SN	Constituents	Flower
1	Moisture	18.7 %
2	Protein	6.9 %
3	Fat	0.5 %
4	Reducing Sugar	50.62 %
5	Total Inverts	53.20 %
6	Cane Sugar	3.43 %
7	Total Sugar	52.06 %
8	Ash	4.36 %

3. Mahua seed oil

Mahua seeds are rich in semi-solid fat, constituting about 40% of their composition. The oil extracted from these seeds, known as Mahua Butter, accounts for 33–43% of the kernel's weight. This oil is highly valued among tribal communities across Odisha, Chhattisgarh, and Maharashtra, who use it as a cooking oil despite its yellow color and somewhat unpleasant taste. Mahua Butter has versatile applications beyond culinary uses. It is utilized in the manufacture of soaps, especially laundry chips, due to its cleansing properties. In rural areas near production centers, the oil serves as an illuminant and is widely used as hair oil for its emollient qualities. Furthermore, it is included as an ingredient in hydrogenated Vanaspati, showcasing its industrial significance. The production and utilization of Mahua seed oil reflect its importance as a sustainable and multipurpose resource for both traditional and modern applications.

SN	Properties	Value
1	Refractive index	1.2-1.62
2	Saponification value	187-197
3	Iodine value	50-70
4	Unsaponifiable matter (%)	2-5
5	Palmitic C 16:0 (%)	20.5
6	Stearic Acid C 18:0 (%)	22.7
7	Oleic Acid C C18:0 (%)	37.0
8	Linolic Acid C18:2 (%)	14.3

Traditional uses of madhuca longifolia

Place, Country	Part(s) Used	Ethnomedicinal Uses	Preparation(s)	Reference(s)
India	Seeds cake	Anti-inflammatory, anti-ulcer, and hypoglycaemic activity	Ethanolic & crude alkaloid extract	Seshagiri M. et al 2007
India	Bark	Antidiabetic Activity	Methanol, water, & petroleum ether	K Pavan Kumar et al 2011
India	Bark	Antihyperglycemic and antioxidant	Ethanolic extrac	Srirangam Prashanth et al 2010
India	Flowers	Analgesic Activity	Aqueous and alcoholic extracts	Dinesh Chandra et al 2001
India	Leaves & Bark	Wound healing activity	Ethanolic extract	Smita Sharma et al 2010
India	Leaves	Nephro and hepato protective activity	Ethanolic extract	S. Palani et al 2010
India	Leaves	Antioxidant Activity	Ethanolic extract	S. Palani et al 2010
India	Leaves	Cytotoxic Activity	Petroleum ether, chloroform, ethanol acetone and water	Saluja. M.S. et al 2011
India	Bark	Antibacterial activity	acetone and water	acetone and water
India	Leaves & Stem Bark	Antimicrobial activity	Hexane, ethanol chloroform,	Mangesh Khond et al. 2009
India	Bark	Rheumatism, bleeding	ND	Y. Vaghasiya et al
India	Fruits	Asthma and phthisis	Roasted flowers	S. Palani et al 2010

Health benefits of madhuca

The *Madhuca longifolia* tree offers remarkable health benefits through its various parts, utilized in traditional medicine:

1. **Bronchitis**: The flowers are commonly used to treat cough and chronic bronchitis, providing relief from respiratory issues.
2. **Orchitis (Testis Inflammation)**: Boiled *Madhuca* leaves serve as a soothing remedy for orchitis, reducing inflammation and discomfort.
3. **Rheumatism**: For relief from rheumatism, a decoction made from boiling the bark in water is consumed internally. Additionally, seed oil, applied topically to affected areas, aids in reducing pain and inflammation.
4. **Diabetes**: The bark decoction is effective in managing diabetes, showcasing its potential in blood sugar regulation.
5. **Piles and Constipation**: The oil extracted from seeds acts as a natural laxative, helping to alleviate chronic constipation and piles, making it a valuable resource for digestive health.
6. **Eczema:** Madhuca leaves, coated with sesame oil and heated over a fire, are applied to affected areas for relief from eczema.
7. **Gums:** To address spongy and bleeding gums, 4 ml of bark liquid extract is diluted with 300 ml of water and used as a gargle.
8. **Tonsillitis:** The same gargling preparation used for gum treatment is effective for managing chronic and acute tonsillitis and pharyngitis.
9. **Burns:** Bark paste, applied locally, helps relieve itching, while ash from the leaves mixed with ghee is used to treat scalds and burns.
10. **Lactation:** The flowers and seeds of *Madhuca* possess lactation-enhancing properties, making them valuable for boosting milk production in feeding mothers.

The multifaceted use of *Madhuca* highlights its role as an important medicinal plant in traditional healing practices.

Pharmacological uses of madhuca

Antioxidant Activity of *Madhuca longifolia* Free radicals, including active nitrogen and reactive oxygen species, are major contributors to cellular damage, leading to pathological changes and various diseases. Studies have demonstrated that extracts from the *Madhuca longifolia* tree exhibit substantial antioxidant potential, helping to mitigate such damage.

- **Ethanolic Bark Extract**: Research by Roy et al. and Agrawal et al. highlights the significant antioxidant properties of the ethanolic extract of *Madhuca* bark. It effectively prevents lipid peroxidation during in-vivo assessments, which is a critical marker of oxidative damage.
- **Leaf Extract**: The in-vitro free radical scavenging ability of *Madhuca* leaves was studied by Palani et al., followed by in-vivo antioxidant evaluation through glutathione. Glutathione, a natural antioxidant in the body, plays a crucial role in reducing oxidative stress, and the extract enhances this protective activity.

These findings underscore the potential of *Madhuca longifolia* as a natural antioxidant, capable of combating oxidative stress and promoting cellular health. Its applications in reducing free radical damage could pave the way for advancements in therapies for various oxidative stress-related disorders.

Anti-Inflammatory Activity of *Madhuca longifolia*

Inflammation represents a complex biological response to external stimuli, during which inflammatory leukocytes produce excessive free radicals. These radicals disrupt cellular functions and can lead to organ damage, ultimately promoting and initiating various diseases.
Extensive research has established the anti-inflammatory potential of *Madhuca longifolia* extracts:

- **Ethanolic Extracts**: Studies by Agrawal et al. and Gaikwad et al. confirm that crude ethanolic extracts, along with methanolic bark extracts and saponin mixtures, effectively reduce inflammation.
- **Carrageenan-Induced Inflammation**: These extracts demonstrated significant anti-inflammatory effects in experimental models of carrageenan-induced swelling, showcasing their ability to counteract inflammation.

This evidence highlights the medicinal potential of *Madhuca longifolia* as a natural anti-inflammatory agent, valuable for the prevention and treatment of inflammation-related disorders.

Analgesic Activity of *Madhuca longifolia*

Madhuca longifolia exhibits significant analgesic properties, mediated through both central and peripheral mechanisms:

- **Central Analgesic Activity**: Research by Chandra demonstrated that the alcoholic extract of *Madhuca* flowers shows good analgesic activity using the hot plate and tail flick methods. These studies indicated a dose-dependent efficacy, with remarkable improvement observed at doses ranging from 4–64 mg/kg across all nociceptive methods.
- **Peripheral Analgesic Activity**: The methanolic extract of *Madhuca* flowers was found to significantly reduce acetic acid-induced pain in experimental models. At doses of 50–200 mg/kg administered intraperitoneally (i.p.), the extract exhibited potent pain-relief effects in a dose-dependent manner, confirming its peripheral analgesic properties.

These findings underline the potential of *Madhuca longifolia* as a natural analgesic, providing relief from pain through complementary mechanisms. I

Antipyretic Activity of *Madhuca longifolia*

Pyrexia, the abnormal elevation of body temperature, is a condition where *Madhuca longifolia* demonstrates febrifuge (fever-reducing) properties. Studies have shown that the methanolic extract of the aerial parts of *Madhuca* effectively inhibits the rise in body temperature. In experimental models using Brewer's yeast-induced pyrexia, the extract exhibited

significant antipyretic activity in a dose-dependent manner. This suggests that *Madhuca* could serve as a natural remedy for fever, providing an alternative to synthetic antipyretic medications.

Anti-Ulcer Activity of *Madhuca longifolia*

Peptic ulcers, characterized by sores in the stomach and duodenum lining, are chronic inflammatory conditions. Experimental studies highlight the anti-ulcer potential of *Madhuca longifolia*:

- **Ethanolic Bark Extract**: Research by Kalaivani and Jegadeesan demonstrated significant anti-ulcer effects.
- **Aqueous Leaf Extract**: Mohod and Bodhankar proved its efficacy in reducing ulcers.
- **Ethanolic Seed Extract**: It showed notable protective effects in pylorus ligation-induced gastric ulcer models, significantly lowering the ulcer index.
- **Immunosuppression by *Madhuca longifolia***
- The methanolic extract of *Madhuca longifolia* has demonstrated immunosuppressant activity in murine models. It significantly decreased total WBC and spleen leukocyte counts, indicating suppression of the nonspecific immune system. A notable reduction in relative spleen and thymus weight was also observed, suggesting its potential in managing unwanted immune responses, such as those seen in autoimmune diseases and transplant rejection.

Anti-Hyperglycaemic Activity of *Madhuca longifolia*

Madhuca longifolia has shown promising potential for managing diabetes, as demonstrated by several studies:

- **Methanolic Bark Extract**: Dahake et al. and Seshgiri et al. reported its antidiabetic effects, likely linked to improved glucose utilization.
- **Ethanolic Bark Extract**: Prashanth et al. confirmed its dose-dependent activity (100–200 mg/kg) against streptozotocin-induced diabetes in rats.
- **Hydroethanolic Leaf Extract**: Ghosh et al. highlighted its effectiveness in alloxan-induced diabetic rats.
- **Methanolic and Ethanolic Seed Extracts**: Seshgiri et al. found these extracts to exhibit antidiabetic properties.

These effects are thought to stem from altered glucose utilization, improved insulin levels, and interactions with intestinal enzymes, as indicated by in-vitro studies.

Neuropharmacological Activity of *Madhuca longifolia*

Madhuca longifolia has shown significant neuropharmacological potential, particularly in its anticonvulsant properties. Studies have revealed that administering its active constituent at a dose of 400 mg/kg results in a notable prolongation of seizure onset and a reduction in seizure duration. This suggests its potential utility in the treatment or management of absence seizures. The anticonvulsant activity is thought to be mediated by specific bioactive compounds inherent to the plant. Additionally, its traditional use as an anti-epileptic agent has been scientifically validated through in-vivo experiments that highlight its efficacy in controlling seizures. These findings confirm the medicinal value of *Madhuca longifolia* in addressing neurological conditions, specifically in mitigating convulsive disorders.

Anti-Neoplastic Activity of *Madhuca longifolia*

Madhuca longifolia exhibits notable anti-neoplastic properties, contributing to cancer prevention and management. Chemoprevention, the use of natural or pharmacological agents to reverse, block, or delay cancer onset, is a key feature of *Madhuca's* therapeutic potential, with minimal adverse effects aiding in the reduction of cancer-related mortality.
Scientific investigations have demonstrated its chemopreventive action on human cancer cell lines, along with its cytotoxic potential against carcinoma cells. In-vitro cytotoxic assays have confirmed its anticancer efficacy, particularly against Ehrlich ascites and carcinoma cell lines. The crude acetone and ethanolic extracts of *Madhuca* stem and leaves, at a dose of 200 µg/mL, showed significant cytotoxic effects during in-vitro studies conducted at varying

doses. These findings underscore the promise of *Madhuca longifolia* as a natural agent in cancer prevention and treatment, paving the way for further research and development in oncology.

Antihelminthic Activity of *Madhuca longifolia*

The antihelminthic properties of *Madhuca longifolia* have been demonstrated through studies involving its extracts:

- **Alcoholic Leaf Extract**: When incubated with *Ascaridia galli*, the extract exhibited significant efficacy.
- **Methanolic Extract**: Akhil et al. found its anthelmintic activity comparable to the standard drug Piperazine at a dose of 60 mg/mL.

Mechanistically, the extract inhibits glucose uptake, reduces lactic acid content, and lowers glycogen levels in parasites, disrupting their energy metabolism and ATP production. This leads to a loss of motility and eventual elimination of the parasites, showcasing *Madhuca longifolia* as a promising natural remedy for helminth infections

Hepatoprotective and Nephroprotective Activity of *Madhuca longifolia*

Madhuca longifolia exhibits significant hepatoprotective effects, particularly demonstrated in studies using its ethanolic bark extract on D-galactosamine-induced liver hepatitis. The extract significantly reduced serum markers such as glutamic-oxaloacetic transaminase, glutamic pyruvic transaminase, alkaline phosphatase, and bilirubin levels, indicating its protective action. This hepatoprotective activity is thought to arise from its ability to prevent cellular leakage and maintain the functional integrity of hepatocyte cell membranes, showcasing its therapeutic potential in managing liver conditions. In nephroprotective studies, *Madhuca* has been explored for its ability to safeguard kidney function, though detailed mechanisms are likely related to similar protective properties against oxidative stress or cellular damage.

Wound Healing Properties of *Madhuca longifolia*

Madhuca longifolia demonstrates remarkable wound healing potential, as highlighted by Sharma et al. in their investigation. Compared to standard betadine, the plant's efficacy in promoting wound healing is attributed to its bioactive constituents. In their study, the use of ether-benzene-95% crude ethanolic extracts of *Madhuca* leaves and bark significantly accelerated the rate of wound closure and epithelialization. The treated group exhibited a marked reduction in wound healing time compared to the control group in excision wound models. These findings suggest that *Madhuca* plays a crucial role in enhancing tissue repair, making it a promising natural alternative for wound management.

Anti-Fertility Activity of *Madhuca longifolia*

Madhuca longifolia demonstrates significant anti-fertility potential, as observed in experimental studies on male albino rats. The administration of crude seed extracts led to a marked reduction in plasma testosterone levels, which, in turn, resulted in a decrease in the weights of reproductive organs, including the testis, epididymis, seminal vesicle, vasa deferens, and ventral prostate. This reduction also extended to the accessory sex organs, where atrophy of glandular tissue and secretory cells was evident, further highlighting the diminished testosterone levels. These observations underscore the effectiveness of *Madhuca* seed extracts in exhibiting anti-fertility effects, suggesting its potential applications in reproductive health research or contraceptive developments.

Toxicity Profile of *Madhuca longifolia*

The assessment of *Madhuca longifolia's* toxicity is crucial due to its use in direct or formulated drug applications. Here's an extended summary:

- **Saponins**: While saponins exhibit high toxicity upon parenteral administration, they are less harmful when taken orally. The median lethal dose (LD50) for oral administration was determined to be 1000 mg/kg in mice.
- **Ethanolic Leaves Extract**: Morphological and histopathological changes were observed in male Wistar rats after administering 175 mg/kg for 14 days. However, no toxic effects on liver and kidney were noted up to doses of 2000 mg/kg.
- **Methanolic Bark Extract**: Reported to be safe up to 2000 mg/kg without causing toxicity.

- **Mahua Oil**: Studies by the European Food Safety Association indicate that excessive doses may lead to antifertility effects, including testicular atrophy and degenerative changes in rats.
- **Genetic Toxicity**: To date, no mutagenic or genetic toxicity has been reported in the literature.

This toxicity evaluation highlights the importance of dose management to minimize risks and ensure safe use of *Madhuca longifolia.*

Non-Medical and Commercial Uses of *Madhuca longifolia*

Madhuca longifolia is recognized for its versatile applications beyond medicinal purposes:

1. **Adsorbent Properties**: Leaves of *Madhuca* have been proven to effectively adsorb cadmium and lead from water when used along with polyaniline, showcasing their potential in water purification.
2. **Anticorrosive Nature**: The leaves protect mild steel from corrosion in 1 mol/L HCl solution, offering utility in industrial applications.
3. **Tassar Silk Production**: The leaves are used as feed for moth *Antheraea paphia*, which produces Tassar silk, a commercially valuable wild silk.
4. **Distilled Liquor**: Flowers are utilized for preparing distilled liquor, reflecting their traditional and cultural significance.
5. **Mahua Oil**: Extracted from seed kernels, Mahua oil is used for cooking and as a fuel, showcasing its importance in daily and industrial use.

These non-medical uses highlight the economic and practical significance of *Madhuca longifolia* across various domains.

Preclinical and Clinical Studies on *Madhuca longifolia*

Madhuca longifolia has been extensively studied in both preclinical and clinical settings to explore its efficacy and safety in various applications:

1. **Clinical Trial on Oligospermia**: An open clinical trial was conducted on 40 subjects to evaluate the efficacy and safety of Chandrakanthi Chooram, a formulation containing *Madhuca* flowers among its 25 ingredients. The study focused on improving sperm count, morphology, and motility, with significant outcomes observed.
2. **Santhal Tribes Studies**: Clinical investigations and surveys on *Madhuca* among the Santhal tribes revealed its anti-venom activity and benefits in managing dyslipidemia. Regular consumption of *Madhuca* drink improved blood sugar and lipid profiles in this population.
3. **Preclinical Pharmacological Studies**: Different parts of *Madhuca* have been preclinically tested for numerous pharmacological activities, including hepatoprotective, anti-epileptic, antimicrobial, analgesic, and anti-diabetic effects, showcasing its broad therapeutic potential.
4. **Kutajarista Research**: Kutajarista, an Ayurvedic product containing *Madhuca*, is used to treat amoebiasis, bacterial dysentery, and blood diarrhea. Preclinical studies on male Sprague Dawley rats, administering Kutajarista at 40 mL/kg, indicated alterations in biochemical profiles when taken in higher doses over extended periods.

These findings highlight the medicinal promise of *Madhuca longifolia* and its integration into traditional formulations like Chandrakanthi Chooram and Kutajarista, paving the way for further clinical advancements.

RESULT AND DISCUSSION RESULT AND DISCUSSION RESULT AND DISCUSSION

The formulation of Mahua Flower Enriched Wheat-Based Laddoo was optimized using CCRD experimental design and analyzed with a 9-point hedonic scale. Various proportions of dried mahua flower, sugar, germinated wheat flour, millet flour, and ghee were tested across six trials. Sensory attributes like color, texture, flavor, taste, and overall acceptability were evaluated. A quadratic model identified the ideal combination, with T3 containing 9% dried mahua flower and 21% sugar, achieving the best sensory scores. This formulation was finalized for the development of the wheat-based laddoo enriched with mahua flower The Mahua Flower

Enriched Wheat-Based Laddoo, prepared using optimized parameters, underwent profiling for physico-chemical, vitamin, mineral, and microbiological properties. The analysis revealed its high nutritional value with moisture (10.36%), protein (13.74%), fat (12.09%), carbohydrates (46.36%), ash (3.09%), crude fiber (2.08%), total sugar (41.29%), and reducing sugar (37.74%). The laddoo's hardness was 175.22 N, showcasing its well-balanced texture and nutrient richness, making it a highly nutritious product The Mahua Flower Enriched Wheat-Based Laddoo was analyzed for vitamin and mineral content, revealing high levels of calcium, iron, and phosphorus. These nutrients make the laddoo particularly beneficial for pregnant and lactating women due to their essential role in supporting health and development.

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CONCLUSION

Madhuca longifolia is an underutilized yet highly versatile plant with significant medicinal and commercial potential. Its flowers are widely used for liquor production, food preparation, and medicinal purposes. Despite its immense nutritional value and therapeutic properties, inadequate knowledge and practices have limited its broader applications.Constituents**:** Contains sapogenins, triterpenoids, steroids, saponins, flavonoids, and glycosides.Medicinal Uses: Exhibits antibacterial, anticancer, hepatoprotective, antihyperglycemic, analgesic, spasmogenic, oxytocic, anti-implantation, anti-progestational, antiestrogenic, and uterotonic properties.

Traditional Applications**:** Flowers are used as vegetables, in cakes, as liquor ingredients, and in treating various ailments.Potential and Future DirectionsThe development of modern drugs from *Madhuca longifolia* is essential, as the shift towards nontoxic plant-based products aligns with its therapeutic and commercial promise. This could enhance employment opportunities and income generation while addressing knowledge gaps through further research into its unexplored pharmacological activities

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