



Madhuca indica (Mahua) - Pharmaceutical, Nutraceutical and Economical Importance for Tribal People of Chhattisgarh State

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ABSTRACT

Chhattisgarh state is located at the central part of India, thus considered as the heart of the country. This state is well known for its agriculture and mineral sources. Apart from these specialties the state is also known for its culture, tradition, and the lifestyle of tribal people. In the interior part of Chhattisgarh, there is a little rare known civilization. Their lifestyle and culture is still a subject of interest for many regional and global researchers. One thing that makes a difference in their life is the availability of some potential trees and minerals with pharmaceutical and nutraceutical benefits that indigenous people were used to collecting beneficial parts of them, for instance; Mahua (*Madhuca indica*) which is one of the most important trees, providing several medicinal and non-medicinal products, which is vital for them from health and wealth point of view. In this review we have discussed the medicinal properties like hepatoprotectivity, antimicrobial, wound healing, skin protectivity, bone joining potentials and some non-medicinal properties like nutraceutical; alcohol fermentation and preparation of food, soap, oil, and candy. Although in conclusion, few properties of these plants have been identified, various types of them have been yet to be utilized.

Key Words: Medicinal plant; Mahua oil; Mahua candy; Hepatoprotective; Nutrition, *Madhuca Indica*.

eIJPPR 2019; 9(3):16-28

HOW TO CITE THIS ARTICLE: Vandana Janghel, Pushpendra Kumar Patel, Saket Singh Chandel, Jyoti Sahu (2019). "*Madhuca indica* (Mahua) - Pharmaceutical, Nutraceutical and Economical Importance for Tribal People of Chhattisgarh State", International Journal of Pharmaceutical and Phytopharmacological Research, 9(3), pp.16-28.

INTRODUCTION

Chhattisgarh state was formed on 01 November 2000 and it was carved out of Madhya Pradesh state. Once this state got separated it had lots of to-do lists to be performed, and this state really came out from such difficulties in a quite comfortable way. If we would like to find the answer for why this state appeared as a fast developing state then we will get the answers in just 2 main points: (1) The natural built of this state which provides all suitable environmental favours for farming as well as in the rich availability of minerals which helps in production of various metals like Aluminium, Steel, Iron, Tin, etc. (2) The culture or tradition of people who are living in the far rural part of Chhattisgarh. This is because these tribal people help in the collection and processing of natural minerals along with the collection of rarely known medicinal plants, which were only known for them due to

their traditional information system.

Mahua is one of the most common trees available in the Chhattisgarh region, and many tribal people earn their employment by collection, processing and shelling the flowers, fruits, and seeds of this plant. Mahua is an Indian origin plant which has several undiscovered marvelous properties. Few pharmacological properties have been established and reported earlier by researchers, although a limited data and survey has been documented regarding non-medicinal utilization of Mahua. This is a wild plant, generally grown without investing anything, this tree is approximately 20 meters in height and is evergreen or semi-evergreen in nature. It has short, whole and large rounded crown throughout the green forest part of India. Leaves are 10-30 centimeters long, thick, pointed clustered glared near the end of branches. Flowers are small, with a soothing smell, and rich in sugar contents, and for this reason, all elephants come to this tree to eat

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Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Received: 12 January 2019; **Revised:** 21 May 2019; **Accepted:** 27 May 2019



the flower during flowering session [1]. People of tribal are used to clean the ground below Mahua so that the flowers, falling down may easily be collected and sold to the local market and they got their employment. Although this flowering season is for a short duration, after that, the fruits start to get mature and are collected by tribal people.

In this review, we collected all the possible information related to Mahua (*Madhuca indica*) either as medicinal properties, nutraceutical properties or economical supportive properties. To understand all properties and uses of Mahua, we classified its properties into 3 main categories for review, as given in table 1.

Table 1. Medicinal, Nutraceutical, and Economical properties of *Madhuca indica* [2-4]

Properties	Descriptions
Medicinal Properties	Hepatoprotective, Wound healing, Antburns, Bone healing, Emollient, Skin disease, Rheumatism, Headache, Laxative, Anti-Haemorrhoids, Bronchitis, Anti-ulcer, Astringent, Tonsillitis, Swelling gum, Diabetes, Stomach-ache, Anti snake bite, Increasing milk production in lactating women, Diuretic, Etc.
Nutraceutical Properties	Increase Immunity, Facilitate digestion, Antioxidant, Stimulant, Tonic, Energetic, Glucose booster, Etc.
Economical Properties	In Alcohol production, Jelly, Sweet candy, Chocolate, Jam, Vegetable, Biodiesel, Fuel production, Oil production, Fertilizer, Animal food, Etc.

Plant Profile

Botanical Name: *Madhuca indica*

Common Name: Mahua, Mohwa, Mauwa, Mahwa, Maul, Mahwla, Madhuca, Ippa, Illupei, Poonam, etc [5].

Geographical Sources: In India Mahua plant is wildy found in the region of Chhattisgarh, Madhya Pradesh, Odisha, West Bengal, and Maharashtra. In Chhattisgarh, this tree is easily available in the district of Raigarh, Ambikapur, Dantewada, Bilaspur, Mahasamund, Durg, Janjgir, Champa, etc.

Cultivation and Collection: This is a wild tree so at present it is not cultivated intentionally and naturally found in nature, but nowadays there is a strong need to cultivate this plant and make necessary changes in its genetic structure to make it more useful for commercial purpose. The application of scientific knowledge and agriculture tools is much needed to make this plant more disease resistant and more flowering along with the enhancement of chemical constituents [6]. The cultivation of Mahua should be done on either wildland for better availability of constituents and its seeds should be spread in the farming areas for the future collection of flower, unripe, and ripe fruits may become easier. Cultivation is

generally done in the month of July to September and generally, flowering takes place in March and April. After this time, the flower converts into fruit which is also useful in both unripe and ripe conditions. Although every part of Mahua plant is useful, flower, fruit, seeds oil, and seed cake are more important. Table 2 gives detail about the present phytoconstituents and their amount in percentage

Table 2. Phytochemical screening and nutritional properties of Mahua (*Madhuca indica*) [7]

Phytoconstituents	Presence (+/-)	Other constituents	Percentage (%)
Volatile oil	Absent (-)	Moisture	19.8
Tannins	Present (+)	Protein	06.37
Proteins	Present (+)	Calcium	8
Carbohydrate	Present (+)	Cane Sugar	3.43
Amino acids	Absent (-)	Total Sugar	54.06
Alkaloids	Present (+)	Total Invert	54.24
Flavonoids	Absent (-)	Reducing Sugar	50.62

- = Negative, + = Positive

Medicinal Uses

- 1. Anti-Inflammatory Effect:** Inflammation is a result of the defensive mechanism of our immune system. When any foreign particle enters into our body, the defensive mechanism starts working, and this initiates with the migration of WBC towards the injury site, and phagocytic action takes place [8]. The inflammation is a stepwise process which starts with phosphide which forms arachidonic acid followed by the production of prostaglandin which starts pain. Almost all anti-inflammatory drugs in nature act by inhibiting the COX, either selectively or non-selectively. The anti-inflammatory action of Mahua has been proved by a few researchers [9, 10]. They induced inflammation in the hind paw of the rat using carrageenan and formaldehyde, and the extract of *Madhuca indica* seed in petroleum ether as a solvent was compared with the standard drug, diclofenac sodium in response to inflammation. The overall test was performed and evaluated in the plethysmograph apparatus.
- 2. Antidiabetic Activity:** *Madhuca indica* has also shown its effectiveness as an antidiabetic. Methanolic extract of the leaves and bark of this plant has been studied in streptozotocin-induced diabetes in male albino Wistar rat, and the result was compared with the standard insulin-treated rat. After 30 days of evaluation periods, the result showed a markedly decrease in blood sugar level of the rat who had received the

extract, orally. This result confirms the anti-diabetic activity of *Madhuca indica* [11-13].

3. **Anthelmintic Activity:** The anthelmintic activity of the ethanolic extract of the flower and bark of this plant has been proved by a few researchers. They used the ethanolic and methanolic extracts of *Madhuca indica* and compared their anthelmintic activity by *in vivo* method and used metronidazole as the standard drug. It was considered that the anthelmintic activity may be because of the presence of tannins. The ethanolic, methanolic and hydroalcoholic extracts of *Madhuca indica* have tannins as one of the phytoconstituents with anthelmintic activity [14].
4. **Antimicrobial Activity:** In many regions of Chhattisgarh tribal people were used to use the leaves and bark of Mahua (*Madhuca indica*) to

treat their wounds [15]. They firstly crush the fresh and young leaves and once their active constituents come out they apply this juice cum extract on their wounds, and after regular interval of application of the extract, they find a good result and the wound started to heal and thus the activity of Mahua as an antimicrobial came into light. Several investigators performed this activity in the laboratory using aqueous, ethanolic and methanolic solution to extract the phytoconstituents of leaves and bark parts of Mahua (*Madhuca indica*) by using cup plate methods [16-24]. They have taken ampicillin as a standard drug and after comparison; they found satisfactory response against *Staphylococcus* and *Escherichia coli* as a sample bacteria. Figure 1 shows the antibacterial activity of *Madhuca indica* by cup plate method.

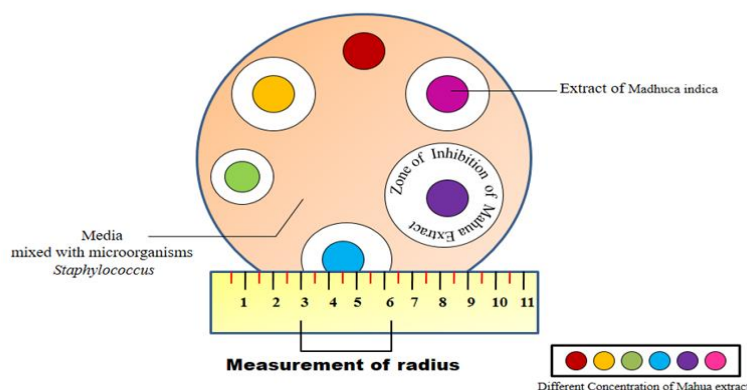


Figure 1: Zone of inhibition of *Madhuca indica* (Methanolic extract) by cup plate methods

5. **Hepatoprotective Activity:** Nowadays, the liver problem is one of the serious problems due to an unhealthy lifestyle and consumption of several medicines such as NSAIDs, Paracetamol, Indomethacin, Diclofenac, etc [25]. The hepatoprotective activity of *Madhuca indica* is one of its vital properties. The various extracts like ethanolic, aqueous and hydroalcoholic extracts of the plant were used for evaluation of its hepatoprotective activity and the result was found satisfactory [26-28]. For the assessment of hepatoprotective activity of Mahua, Albino Wistar rats were used and their liver damage was caused by the Paracetamol, carbon tetrachloride, oral and intraperitoneal injection, respectively [29-31]. The standard drug was silymarin and the test drug was various doses of *Madhuca indica* extract. After 15 days of the experiment, animals were sacrificed and various biochemical and histopathological tests were done and the

result was comparatively positive especially with hydroalcoholic extract of Mahua [1, 32].

6. **Antiepileptic Activity:** The experiment was performed on the female ICR mice with the extraction of the heartwood part of Mahua in Soxhlet apparatus using methanol as a solvent. The epilepsy was induced in the mice by using Pentylenetetrazol-induced seizures (PTZ) into a group of 10 mice. Then the methanolic extract of Mahua bark was given to the mice at different doses. The standard drug was diazepam. In their experiment, the researchers tried to demonstrate the possible mechanism of action for the methanolic extract of Mahua bark, so they made a good experimental protocol, in which they tried to antagonize the possible mechanism of Mahua extract (Expecting that there is involvement of benzodiazepine and opioid receptor) with the Flumazenil and Naloxone [33, 34]. See Figure 2 for the possible mechanism of

Madhuca indica methanolic extract as an antiepileptic.

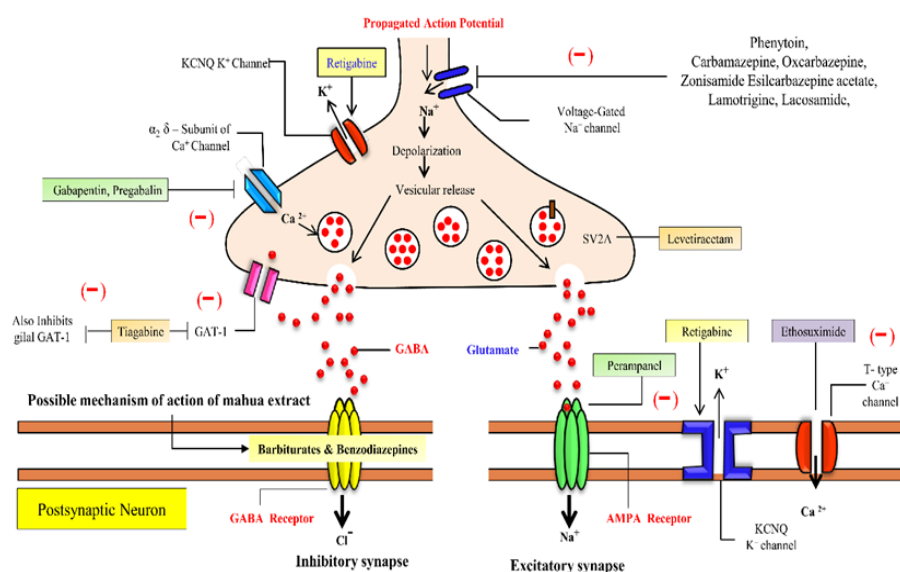


Figure 2: Possible mechanism and site of action of *Madhuca indica* methanolic extract.

7. Anti-ulcer Property: The alcoholic extract of the fresh flower of *Madhuca indica* was used to evaluate its anti-ulcer (Peptic ulcer) property [35, 36]. To conduct ulcer protective efficacy of *Madhuca indica*, various groups of rats were used and they were kept in overnight fasting condition, although the water was supplied in sufficient quantity. This experiment was based on the pylorus ligation method, and ranitidine was used as the standard drug. After administration of mild anesthesia, the abdomen was opened and a small incision was made to expose the pyloric portion of the stomach which was slightly twisted up by side and placed it in

back to the stomach. The alcoholic extract of *Madhuca indica* and standard drug ranitidine were given two times a day simultaneously to a different group of rats before two days of pylorus ligation and in the last day, the gastric contents were titrated to measure the quantity of gastric acid juice and then ulcer score were calculated. The alcoholic extract of *Madhuca indica* reduces the increased effect of gastric acid juice in stomach and it could be due to inhibition of histamine release which usually exaggerates acid release [37-39]. See figure 3 for the possible mechanism of action of *Madhuca indica* as anti-ulcer protective.

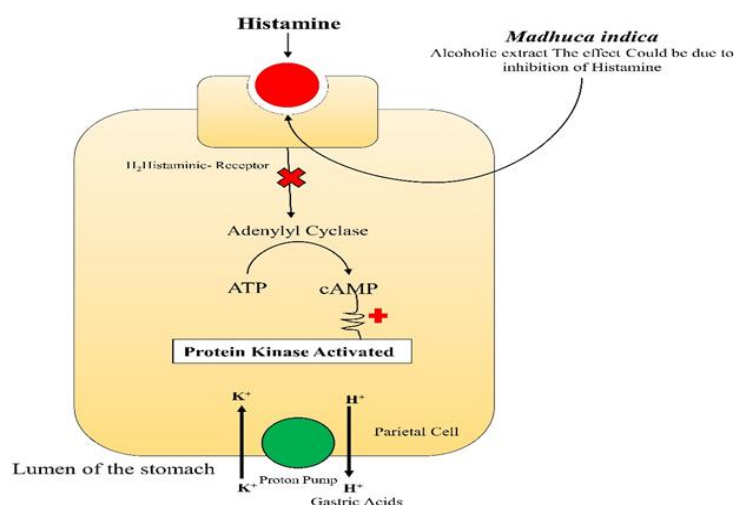


Figure 3: Possible mechanism of action for the antiepileptic activity of *Madhuca indica* as anti-ulcer protective

8. Immunological Property: The immunological property of *Madhuca indica* has been established from the Ayurveda time. The leaves, bark, flowers, and fruits of the plant have been utilized to improve the immune system of any individuals. The tribal people of Chhattisgarh use these parts to improve life vitality by boosting the immune system. The immunological property of Mahua had been studied and documented by a few investigators. They prepared the ethanolic extract of all dried parts like- leaves, bark, flowers, and fruits and evaluated them via oral routes in sheep blood cells (SRBC) antigen for a 7-day immunization period. Levamisole and cyclophosphamide were taken as standard drugs. The extract showed a good efficacy thus considered for further study to make it more relevant [40, 41].

9. Neuropharmacological Activity: Apart from normal peripheral effects the methanolic,

ethanolic and petroleum ether extract of Mahua leaves showed a promising antianxiety activity when evaluated in Swiss albino male mice. The standard drugs used were Tramadol hydrochloride, Diazepam, and Chlorpromazine. The activity was measured via Phenobarbitone sodium-induced sleep and their antagonistic regaining righting effects by Mahua extract. The researchers also performed spontaneous motor activity by using actophotometer. Both the evaluation parameters, Phenobarbitone induced sleeping time and motor activity on Actophotometer showed effective responses by decreasing sleeping time and reduction in spontaneous motor activity [42]. Evaluation of the neuropharmacological activity of mahua extracts by using actophotometer is shown in Figure 4.

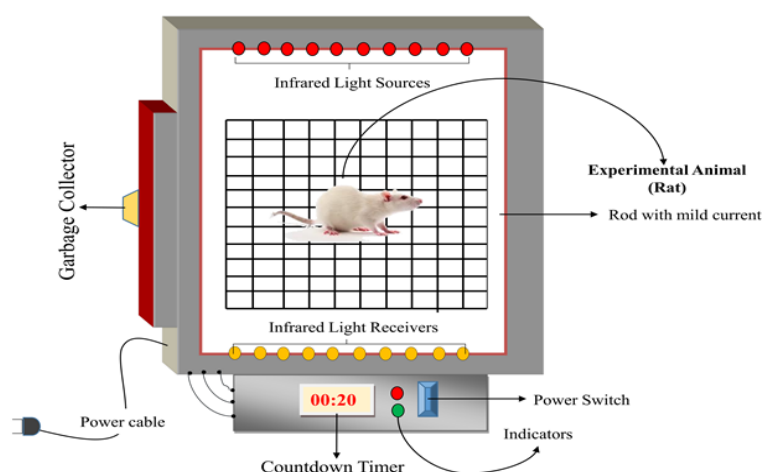


Figure 4: Evaluation of the neuropharmacological activity of Mahua extracts by using actophotometer.

10. Anti-nociceptive Activity: This activity is one of the most important activities shown by *Madhuca indica* analgesic activity which had been proved by many postgraduate and undergraduate students as this activity is very easy to perform because it does not require any sophisticated instruments [43]. The test was performed by using the alcoholic and aqueous extract of the flower part of *Madhuca indica* by

using tail flick, hot plate, and acetic acid-induced abdominal constriction, radiant heat, and tail clip (Not flick) methods. The obtained results were significantly found to reduce pain after taking an average reading from all possible methods [9, 10, 44, 45]. The diagram of hot-plate analgesimeter for evaluation of the analgesic activity of *madhuca indica* given is shown in figure 5.

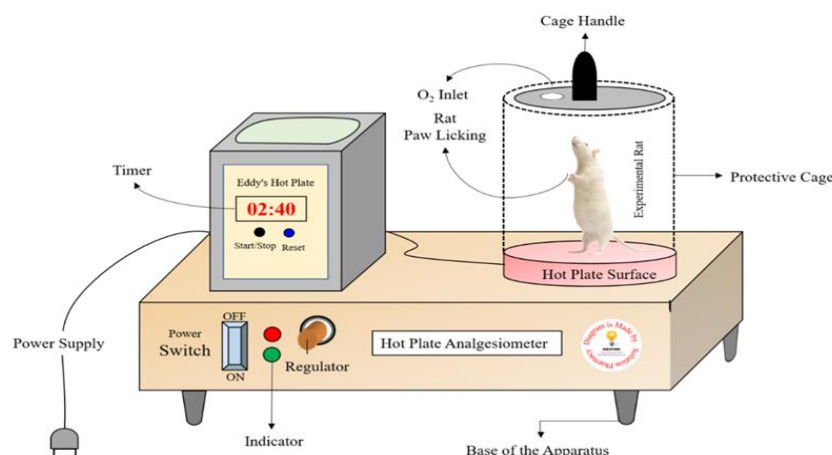


Figure 5: Hot-Plate Analgesiometer for evaluation of the analgesic activity of *Madhuca indica*.

11. **Antipyretic Activity:** The aerial parts including the flowers and few parts of bark were used for the treatment of fever in the traditional system and gave a satisfactory result. The aerial part of *Madhuca indica* was extracted by using ethanol as an extractive solvent. albino Wistar male rats were used to evaluate the antipyretic activity of Mahua extract. To induce fever in rats, a yeast solution was used by injecting it subcutaneously and then the body temperature was recorded by inserting the thermometer in their rectal route. The average and cumulative temperatures were then compared between the group who had taken the extract of *Madhuca indica* as a test drug and Paracetamol as a standard drug. Data significantly showed the antipyretic activity with the plant extract [1, 3, 9].
12. **Antioxidant Property:** Antioxidant property of Mahua plant is very useful as this property may combine with other pharmacological activities and increase their efficacy. Antioxidant boosts the hepatoprotective activity along with immunomodulation activity. This activity has been proved by scavenging activities of DPPH, ABTS, Nitric oxide radical, Hydrogen peroxide, etc. The researchers extracted the shade dried leaves and bark of Mahua using ethanol and hydroalcoholic as a solvent. The antioxidant property of Mahua can also inhibit the chances of asthma and other cell damages [46, 47].
13. **Rheumatic Arthritis:** The arthritis is an inflammatory disorder, caused by the dried friction of joint bone due to loss of synovial fluid. Synovial fluid provides lubrication to the joint, thus prevents excessive erosion of bone at joint. Due to the loss of this lubrication, there is a severe pain which causes swelling. It is well known in Ayurveda and traditional information

that the oil of Mahua is applied to the joint of the leg on a regular basis to get relieved from the pain as well as to increase lubrication between joints [1, 8-10].

14. **Nephroprotective Activity:** Kidney is a vital organ of the human body, which serves the filtration process and eliminates water-soluble toxic chemicals via urine. Mahua is also reported as having a nephroprotective action. The leaves of Mahua plant were dried in shade, ground and then filtered through a sieve. Then the plant was extracted in a Soxhlet apparatus using ethanol as solvent. The experiment was carried out in albino Wistar rats and nephrotoxicity was induced by using Paracetamol as a causing agent. After 14 days of experiments, rats were sacrificed and evaluated for the nephroprotective activity of the extract by biochemical and histopathological parameters. The obtained results were good and provided a chance for further detailed study [48].
15. **Cytotoxic Activity:** Cancer is the uncontrolled and excessive growth of cells. Nowadays there are several reported cases of various types of cancer. This disease is controlled or treated by chemotherapy, which are the agents that inhibit or suppress unwanted cell proliferation, but they have several toxic and side effects, too. Mahua flower was found to have a cytotoxic activity as an anticancer agent. For experiments, the researchers collected fresh flowers of Mahua and extracted by cold extraction method by continuously shaking it in an orbital shaker. After 24 hours the extract was filtered and the residue was again extracted using methanol for one week in an orbital shaker. The rat liver cell line culture was used for the cytotoxic study.

They concluded the positive outcome of Mahua flower as a cytotoxic or anticancer agent [49].

16. DNA damage preventive Property:

Experiments on albino Wistar rat have been performed to check the DNA damage prevention activity of Mahua by using plasmid. The irradiation technique was used to visualize DNA damage. The plasmid was mixed in various extracts of Mahua and then radiations were applied to each of them. The result was evaluated using gel electrophoresis and was good enough to provide an opportunity for further working on it. MDA assay was used to measure the level of NO, salicylic acid test, histopathological studies, and statically studies [50].

17. Permeation enhancer: Mahua not only possesses pharmacological or nutraceutical properties but also it has many other pharmaceutical properties. The oil of Mahua plant shows a good response as a permeation enhancer. The permeation enhancer activity was demonstrated by the researchers after determining the values of acid, saponification, iodine, pH, viscosity, spreadability, and extrudability, and irritation test, determination of content, diffusion study and accelerated study. The oil of Mahua also showed a good emulsifier activity in W/O cream formulations [51, 52].

18. Skin-related disease: In Chhattisgarh state, the parts and oil of Mahua tree are used for multipurpose remedies. Tribal people of Chhattisgarh use Mahua oil for external application on their skin to get relief from itching and pain. They apply the viscous oil throughout their skin to get relief from rashes caused by insect biting and roughness. The smell

of oil is pungent so it also acts as a mosquito repellent. There is a need to do more works on the formulation so that it can be accepted by the global market by reducing its characteristic smell to convert into a pleasant aroma [1, 4, 25].

19. Constipation Treatment: Constipation is a condition of lack of water in the stool so that it become thigh and difficult to excretion. There are many natural medicines which give relief from constipation by many mechanisms. Dried Mahua flower is believed to work as a bulk laxative and when it is consumed at night it adsorbs water from stomach and get swelled and propel the digested food contents towards the rectal route [53, 54]. The Mahua flower's richness in fiber contents justifies its medicinal use as a laxative. The oil is also used as a laxative because it reduces the stool stiffness and facilitates its passage.

20. Spasmolytic Activity: Spasm is an unpleasant feeling in the stomach due to the small intestine twisting. It may or may not be bearable and often gives discomfort. The antispasmodic activity of Mahua has been discovered by a few researchers. They concluded that saponin exists in the leaves and seeds of *Madhuca indica* which gives an antispasmodic activity [8, 20, 55]. So they performed the experimental activity of *Madhuca indica* isolates on guinea pig ileum using student organ bath. Student organ bath is mainly used to evaluate the contraction and relaxation activity of any drugs or chemicals on the isolated tissue that is also called as *in vitro* studies. The significant relaxation of ileum parts justified their results. Evaluation of the antispasmodic activity of mahua in Student organ bath shown in figure 6.

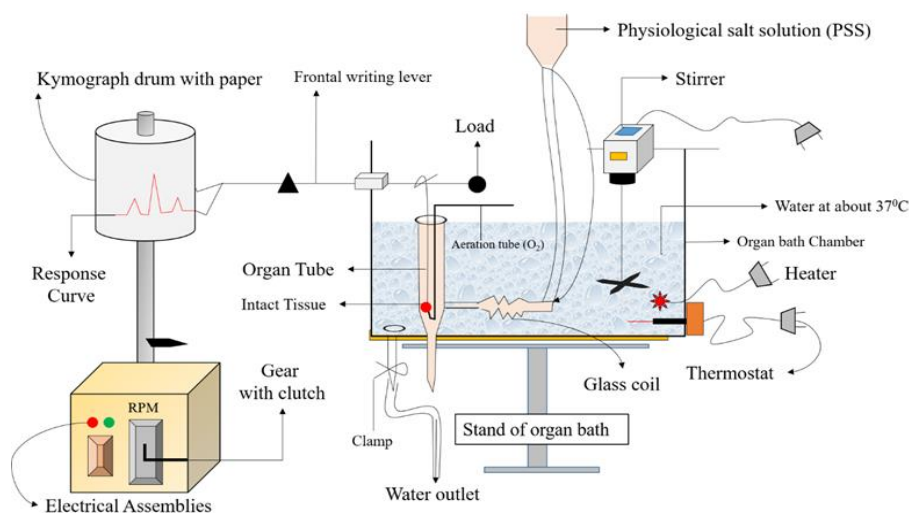


Figure 6- Evaluation of the antispasmodic activity of Mahua in a Student organ bath.

Nutraceutical Properties and Traditional uses of Mahua (*Madhuca indica*)

1. Saturated sugar solution (Syrup): Flowers of Mahua tree contain many minerals, water, and sugars. This sugar content is used for many purposes like- making sugar syrup, eating as such in raw form or by drying in shade [1, 7, 56]. Making sugar syrup from Mahua is a very easy and useful process, so that, the fresh flower of Mahua is dried under the shade, thus the water gets evaporated and sugar got concentrated. This is then soaked in water and extracted. The color obtained is not so good, it looks like a semi to dark black color, which is then treated by using activated charcoal or lime before making its concentrated.

2. Production of alcoholic products: The flower of Mahua tree is very rich in sugar content and after drying the collected flowers under the shade become more concentrated, and this concentrated dried flower is further used as the sources of sugar in making alcoholic products by the following fermentation procedure. In fermentation, the microorganisms use this glucose as their energy source and breakdown sugar into ethanol and carbon dioxide. This is one of the most adopted methods and source of economy for the tribal people in India especially in Chhattisgarh, Orissa and other regions. The products obtained after this process are wine, brandy, ethanol, acetone and lactic acids [1, 56-60]. Figure 7 gives the layout of the utilization of Mahua in liquor preparation.

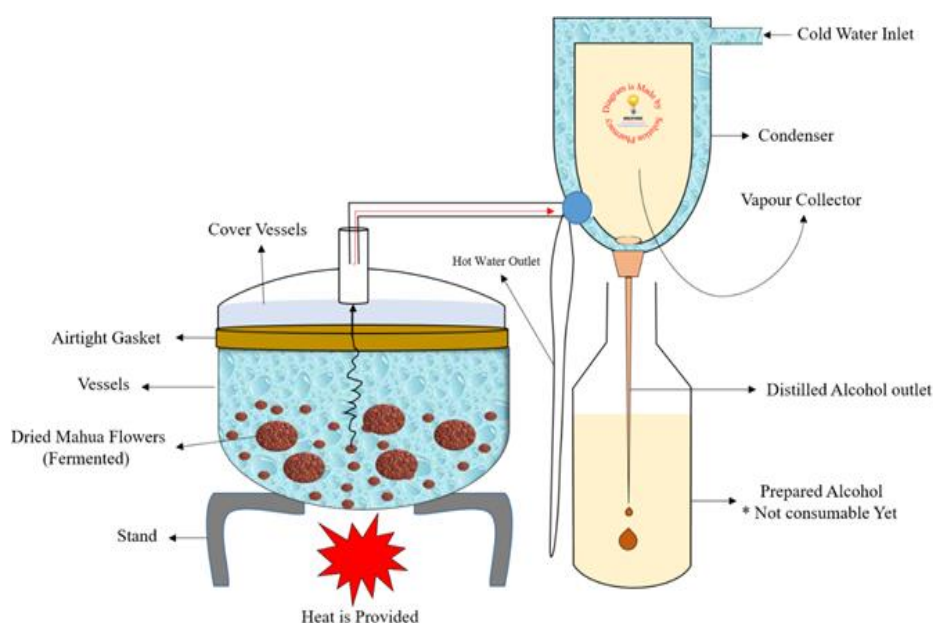


Figure 7- Utilization of Mahua in preparation of country liquor.

3. Preparation of Sweet Dishes: Mahua is very likely used in the preparation of sweet dishes in the tribal area of India, especially in Chhattisgarh. In Baster, Raigarh, Ambikapur, and Dantewada this is quite common among all tribal people called "Aadiwasi Kabila". They prepare it from the dried flower which they have collected and after thoroughly washing, they fry them using "Desi Ghee" or butter and then a pinch of sugar is added to it (because sugar is already present in Mahua flower) and so they prepare Mahua's sugary and juicy dish. It is considered that eating fried Mahua in Ghee increases the production of milk in pregnant and lactating women [1, 55, 56, 60].

4. Jam Preparation: In the state of Bihar after prohibition in liquor production and selling, the people found a new way to use the Mahua flower.

They started to make jam and jelly from it. To prepare jelly, firstly the flowers are washed and soaked into water for overnight, flowers are swelled and then after they are removed from the water and placed it in a new vessel above the fire to be heated and then mashed with the fruit masher. Then pectin and sugar are added to it till the formation of jelly [1, 55, 56, 60].

5. Biofertilizer Property: After the process of alcohol production by fermentation process, the remaining pulp and other ingredients were checked for the biofertilizer property. The researchers were explained how they carried out this activity. They had mixed the remaining mass of Mahua flower pulp with normal sand and then planted a simple plant using this sand plus Mahua pulp mixture with another normal sand plant. After the specified

time of the experiment, they found that Mahua and sand mixture work as good fertilizer and after XRD studies the presence of nitrogen, phosphorus, and potassium (NPK) along with calcium was confirmed. So it is a boon for the farmers and tribal people. After making alcohol or other fermented products they may use these as biofertilizers [55, 56, 60].

6. **Cattle food:** In various research and review articles it was mentioned that the seed cake and flower pulp of Mahua after fermentation can be used as cattle food to provide nutrition. It was evident that flower residue act as per reported but a few researchers suggested that after removing oil, the seed cake may be a little toxic for some kinds of animals. So the seed cake should be tested for its chemical properties before giving to any animal as a cattle food [56].
7. **Household oil production:** The flower of Mahua is converted into fruits and then seeds. The seed is of great importance and rich in oily content so the tribal people used to collect the seed after the ending the flower season [1, 56, 57] and sell it to the local market. Few people of the same area take it to the oil extractor and they collect the oil. This oil is also called "Dori oil" as the fruit is called "Dori". This oil is very useful in many medicinal, non-medicinal, nutraceutical, economical and other purposes. It is believed that the importance of this oil is equal to cow ghee during the season of Diwali in India.
8. **Biodiesel:** This is the advantage use of Mahua in the automobile sector as well as in the petroleum field. The overall concentration of Indian government and Chhattisgarh state government is on alternative production of diesel and petrol. There are a few options available for the production of biological petroleum by using plant-based materials [61-66]. Mahua is one of those shortlisted plants. Ripen, healthy and dried seed of

Mahua plant is crushed in pestle mortar and then the oil is collected by the Soxhlet extraction process. The collected oil was thus mixed with commercial diesel and used as an energy source.

9. **Source of employment:** After explaining all possible medicinal and non-medicinal uses of Mahua, we can easily conclude that this plant is serving by tribal people of Chhattisgarh and other states, providing an open opportunity for them. They can collect every part of Mahua tree like flower, fruits, seed, and leaves and easily sell to the local markets. In return, they will get some money and this creates employment for them [67, 68]. Although they get money in exchange for Mahua product in the current situation, the amount is not so sufficient for them. The government should provide some motivational scheme to all those who collect the Mahua as 'Tendu Patta' collectors.

DISCUSSION

This review was based on the data available on various sources including- online research and review articles, standard books and most importantly on a survey among tribal people of- Raigarh, Champa, Mungeli, Bilaspur, Baster, Ambikapur districts of Chhattisgarh. We have gathered relevant information by meeting most senior people available in that area. After summarizing all above-cited information we can easily conclude that only 20% to 30% of Mahua (*Madhuca indica*) properties has been identified or documented and a large portion of its properties is still in the dark side. It is a strong demand for nature to find out its hidden potentials. Mahua has a perfect balance and fully harmonized plant which gives- Medicinal, Nutraceutical, and Economical benefits. Many research indicated the possibility of its neurological importance, which should be more highlighted. Figure 8 gives the graphical representation about the research possibilities on Mahua plant.

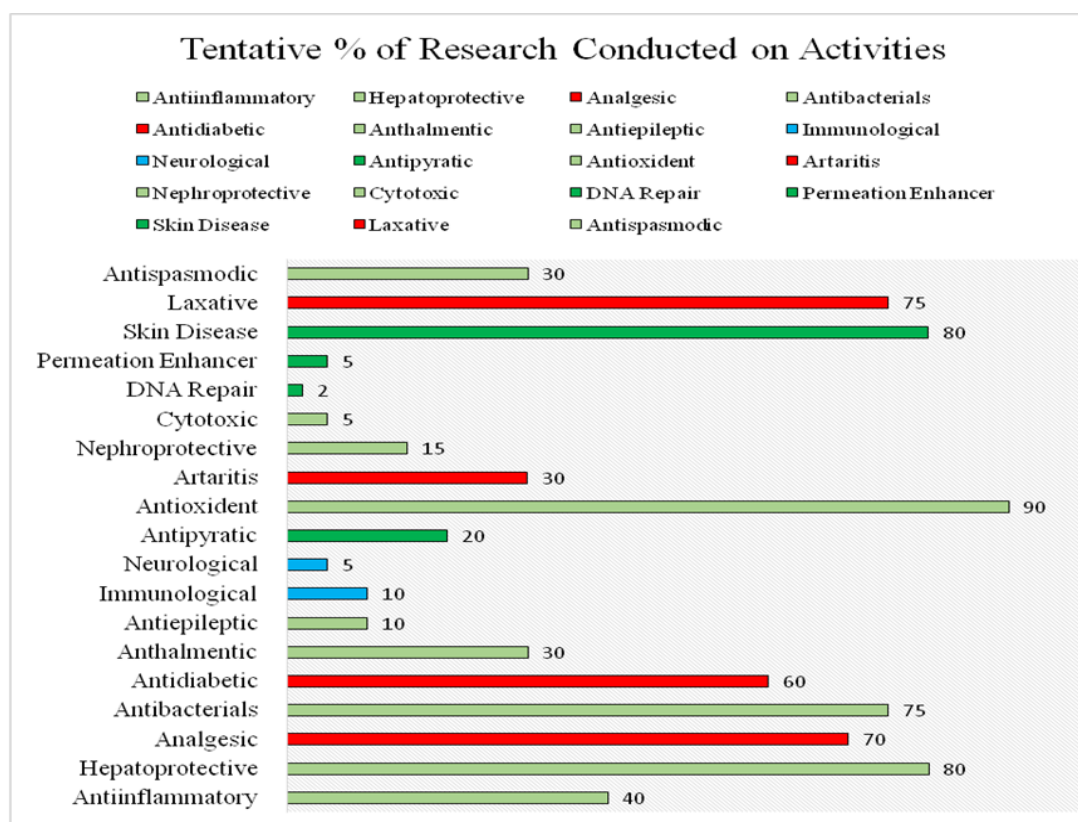


Figure 8- Research possibilities for Mahua plant

List of Abbreviation

1. COX- Cyclooxygenase
2. NSAID- Nonsteroidal anti-inflammatory drugs
3. PTZ- Pentylene tetrazol
4. SRBC- Sheep blood cells
5. DPPH- 2,2- diphenyl-1-picryldrazyl
6. ABTS- 3-ethylbenzothiazoline-6-sulphonic acid
7. MDA- Malondialdehyde
8. DNA- Deoxyribose Nucleic Acids
9. W/O- Water in Oil
10. XRD- X-ray Diffraction

ACKNOWLEDGMENT

I am thankful to my Institute, Siddhi Vinayaka Institute of Technology & Sciences, Bilaspur Chhattisgarh for providing working platforms.

Conflict of Interest

No conflict of Interest

Financial Support

No funding or financial support for this review.

REFERENCES

- [1] Patel PK, Prajapati NK, Dubey BK. *Madhuca indica* A review of its medicinal properties. *Int J Pharm Sci Res* 2017; 3: 942-50.
- [2] Sunita M, Sarojini P. *Madhuca Longifolia* (Sapotaceae): a review of its traditional uses and nutritional properties. *International Journal of Humanities and Social Science Invention*. 2013;2(5):30-6.
- [3] Jha D, Majumder PM. Biological, chemical and pharmacological aspect of *Madhuca Longifolia*. *Asian Pac J Trop Med* 2018 Jan 1;11(1):9.
- [4] Patel PK, Sahu J, Prajapati NK, Dubey BK, Alia A. Hepatoprotective effect of ethanolic and hydro alcoholic extract of *Madhuca indica* in carbon tetrachloride intoxicated rat. *Res J Pharmacokinet Pharmacodyn* 2012 Sep 1;4(5):6.
- [5] Khare P, Kishore K, Sharma DK. A study on standardization parameter of *Madhuca Longifolia*. *Asian J Pharm Clin Res* 2017; 10: 318-21.
- [6] Shrirao AV, Kochar NI, Chandewar AV. *Madhuca Longifolia* (Sapotaceae): A review of its traditional properties and phytopharmacological profile. *Res Chron Health Sci* 2017; 3(4): 45-50.
- [7] Sinha J, Singh V, Singh J, Rai AK. Phytochemistry, Ethanomedical use and future prospect of *Mahua Madhuca Longifolia* as a food: A review. *J Nutri Food Sci* 2017; 7: 573.
- [8] Gaikwad KD, Ahmed ML, Khalid MS, Swamy P. Anti-inflammatory activity of *Madhuca Longifolia* seed saponin mixture. *Pharm Bio* 2009 Jul 1;47(7):592-7.

- [9] Shekhawat N, Vijayvergia R. Investigation of anti-inflammatory, analgesic and antipyretic activity of *Madhuca indica* GMEL. *Euro J Inflam* 2010 Sep;8(3):165-71.
- [10] Vijayabhaskar K. ANTI-INFLAMMATORY AND ANALGESIC ACTIVITIES ON LEAVES METHANOLIC EXTRACT OF MADHUCA INDICA LINN IN WISTER ALBINO RATS. *International Journal of Pharmaceutical, Chemical & Biological Sciences*. 2014 Apr 1;4(2).
- [11] Kumar KP, Vidyasagar G, Ramakrishna D, Reddy IM, Atyam VSSSG RC. Screening of *madhuca indica* for anti-diabetic activity in Streptozotocin-Nicotinamide induced diabetic rats. *Int J PharmaTech Res* 2011 Apr;3(2):1073-7.
- [12] Ganapaty S, Nandeesh R, Veerapur VP, Thippeswamy BS, Shivasharan D. In vivo and In vitro Anti-diabetic effects of *Madhuca indica* Roxb, in Alloxan induced diabetic in rats. *Int J Adv Pharm Bio Chem* 2013; 2: 282-90.
- [13] Dahake AP, Chakma CS, Chakma RC, Bagherwal P. Antihyperglycemic activity of methanolic extract of *Madhuca Longifolia* bark. *Diabetol Croatica*. 2010 Mar 1;39(1):3-8.
- [14] Katiyar S, Tendon M, Chandekar A, Upmanyu N. Pharmacognostic standardization, phytochemical investigation and the anthelmintic evaluation of the extract of *Madhuca indica* J.F GMEL flowers. *Pharmacologyonline* 2011; 3:892-903.
- [15] Sharma SK, Reddy AS, Akhil M, Sankar S. Phytochemical and antimicrobial activity of whole plant of *Madhuca indica*. *IJRPC*. 2013;3(1):15-9.
- [16] Kathuria N, Singh KP. Antibacterial activities of leaves extracts of Indian butter tree (*Madhuca indica*). *Int Res J Pharm* 2015; 6(12): 805-07.
- [17] Purnima.M S, Swarnalatha. Invitro antimicrobial activity of *Madhuca Longifolia* leaf extract. *Int J Eng Sci* 2018; 7: 9-12.
- [18] Pandey B, Agrawal S. Study of antimicrobial activity of *Madhuca Longifolia* and its against various microorganisms. *Environ Sci Toxicol Food Technol*. 2015;1(2):10-5.
- [19] Kalaivani M, Jegadessan M. Antimicrobial activity of ethanolic extract of leaves and flowers of *Madhuca Longifolia*. *Inter J Sci Res Publ* 2013; 3(5): 2250-3153.
- [20] Bulbul JI, Begum Y. Antibacterial, cytotoxic and antioxidant activities of *Madhuca indica*. *Sci Res J* 2014; 2(4): 15-20.
- [21] Krishnamoorthy S, Raj GA, Chandrasekaran M. Antifungal activity of different crude extract of leaves of *Madhuca indica*. *Inter J Nat Prod Res* 2014; 4: 88-95.
- [22] Nimbekar T, Bais Y, Katolkar P, Wanjari B, Chaudhary S. Antibacterial activity of the dried inner bark of the *Madhuca indica* JF. *JMEL. Bull Env Pharmacol Life Sci* 2012; 1: 26-29.
- [23] Chakma Chirantan S, Antimicrobial activity of fruit-seeds *Madhuca Longifolia* (Koenig). *Inter Res J Phar* 2011; 2: 192-93.
- [24] Jayaweera, TSP & Bandara, GMPJ & Udawaththa, UNN & Ruwanjith, HAD & Ruwandeepika, Darshane. (2018). Antibacterial and Antioxidant Activity of Herbal Extracts of *Curcuma longa* L., *Careya arborea* Roxb., *Madhuca longifolia* (Koenig) Macbr. and *Punica granatum* L.. *journal of advances in microbiology*. 10.
- [25] Patel PK, Prajapati NK, Dubey BK. Hepatotoxicity: Causes, symptoms and herbal remedies. *Res J Pharmacog Phytochem* 2012; 4: 104-11.
- [26] Roy SP, Kannadasan T, Gupta R. Screening of hepatoprotective activity of *Madhuca Longifolia* bark on D-Galactosamine induced hepatotoxicity in rat. *Biomed Res* 2015; 26: 365-69.
- [27] Patel PK, Sahu J, Prajapati NK, Dubey BK. Comparison of ethanolic and hydro alcoholic leaf extract of *Madhuca indica* in treatment of hepatotoxicity. *J Pharm Res* 2012; 5: 4871-74.
- [28] Inganakal TS, Inganakal S. In vitro and in vivo Hepatoprotective activity of *Madhuca Longifolia* L leaves on carbon tetrachloride induced rats. *IOSR J Pharm Biol Sci* 2018; 13: 18-24.
- [29] Patel PK, Sahu J, Prajapati NK, Dubey BK. Prevention of hepatotoxicity by *Madhuca indica* hydro-alcoholic and ethanolic leave extract in paracetamol induced rat. *Int J Pharm Sci Rev Res* 2012; 16: 47-51.
- [30] Choudhry A, Bhandari A, Pandurangan A. Hepatoprotective activity of methanolic extract of *Madhuca indica* on carbon tetrachloride induced hepatotoxicity in rat. *Pharmacol online* 2011; 01: 873-80.
- [31] Datta A, Pal A, Bandyopadhyay A. A study on the effect of habitual consumption of *Madhuca Longifolia* drinks on the prevalence of diabetes and dyslipidemia among santhal tribals. *Int J Basic Clin Pharmacol* 2016; 5: 1108-11.
- [32] Roy SP, Shirode D, Patel T, Sastri CS, Gheewala N, Sonara G, et al. Antioxidant and hepatoprotective of *Madhuca Longifolia* (Koenig) bark against CCl₄ induced hepatic injury in rat: In vivo and invitro studies. *Res J Pharm Bio Chem Sci* 2010; 1: 1-10.
- [33] Shri Rao AV, Kochar NI, Chandewar AV. *Madhuca Longifolia* (Sapotaceae) A review of its

- traditional use and phytopharmacological profile. Res Chron Health Sci 2017; 3: 45-50.
- [34] Patel S, Patel S, Patel V. Investigation into mechanism of action of *Madhuca Longifolia* for its anti-epileptic activity. Pharmacogn Comm 2011; 1:18-22.
- [35] Kalaivani M, Jegadeesan M. Evaluation of anti-ulcer activity of ethanolic extract of *Madhuca Longifolia* flower in experimental rats. Int J Sci Res Publ 2013; 3: 1-7.
- [36] Seshagiri M, Gaikwad RD, Parmajyothi S, Jyothi KS, Ramachandra S. Anti-inflammatory, anti-ulcer and hypoglycaemic activity of ethanolic and crude alkaloid extract of *Madhuca indica* (Koenig) Gmelin seed cake. Ori Pharm Exp Med 2007; 7: 1-9.
- [37] Mohod SM, Bodhankar SL. Anti-ulcer activity of aqueous extract of leaves of *Madhuca indica* J.F Gmel against naproxen induced gastric mucosal injury in rats. J Acute Dis 2013; 127-133.
- [38] Patel N, Kumar P, Rai S, Singh MP, Pandey R, Shukla SS, Saraf S et. al. Gastric ulcer protective effect of *Madhuca Latifolia* Roxb bark in wistar rats. Int J Pharm Sci Res 2014; 5: 4051-55.
- [39] Mohod SM, Bodhankar SL. Anti-ulcer activity of petroleum ether extract of leaves of *Madhuca indica* J.F Gmel against pylorus ligation and naproxen induced gastric mucosal injury in rats. Der Pharmacia Lettre 2013; 5: 205-11.
- [40] Purohit R, Singh SK, Shaban A, Nautiyal R, Purohit MC, Verma SK. Immunomodulatory activity of *Madhuca longifolia*. Der Pharmacia Sinica. 2012;3:153-5.
- [41] Shrivastava M, Dhingra N, Dwivedi LK. Immunomodulatory activity of ethanolic extract of *Madhuca Longifolia* in mice. Int J Pharm Tech 2014; 5: 6094-6103.
- [42] Inganakal TS, Ahmed M, Swamy P. Neuropharmacological potential of methanolic extract and a triterpene isolated from *Madhuca longifolia* L leaves in mice.
- [43] Patel PK, Sahu J, Chandel SS. A detailed review on nociceptive models for the screening of analgesic activity in experimental animals. Int J Neutri Phys Therapy 2016; 2: 44-50.
- [44] Patel MP, Chakma CS. Pharmacological screening of isolated compound from *Madhuca Longifolia* seeds give significant analgesic effects. Int Res J of P 2011; 2: 43-45.
- [45] Chandra D. Analgesic effect of aqueous and alcoholic extract of *Madhuca Longifolia* (Koenig). Ind J Pharmacol 2001; 33: 108-11.
- [46] Agrawal S, Kulkarni GT, Sharma VN. A comparative study on the antioxidant activity of methanolic extracts of *Terminalia paniculata* and *Madhuca longifolia*. Free Radicals and Antioxidants. 2011 Oct 1;1(4):62-8.
- [47] Khan Y, Nasreen S. Screening for antioxidant potential in methanolic leaf extract of *Madhuca Indica* L. IJAR. 2016;2(9):849-51.
- [48] Palani S, Raja S, Karthi S, Selvi A, Kumar BS. In vivo analysis of nephro and hepatoprotective effect and antioxidant activity of *Madhuca Longifolia* against acetaminophen induced toxicity and oxidative stress. J Pharm Res 2010; 3:13-16.
- [49] Indu S, Annika D. Cytotoxic and antioxidant potential of *Madhuca indica* flowers. World J Pharm Pharm Sci 2014; 3: 2108-14.
- [50] K V, Muddappa VS, Barangi S, Kumari N S, Sanjeev G, Pradeepa, Rao V, et al. DNA damage protective and anti-inflammatory activity of *Madhuca indica* against electron beam radiation. World J Pharm Pharm Sci 2015; 4: 737-48.
- [51] Mahajan UN, Mahapatra DK, Mahajan NM, Kazi FS, Baghel N. Mahua Oil, an Ayurvedic Product Demonstrated Permeation Enhancing Attribute in Topical Gel Formulations. J. Nat. Prod. Plant Resour. 2017;7(3):8-14.
- [52] Mahajan UN, Mahapatra DK, Mahajan NM, Kazi FS, Baghel N. Exploring the role of mahua oil as a potent emulsifier in cream formulations. Int J Herb Med 2017; 5: 93-97.
- [53] Devi N, Sangeetha R. *Madhuca Longifolia* (Sapotaceae) A review of its phytochemical and pharmacological profile. Int J Pharm Bio Sci 2016; 7: 106-114.
- [54] Yadav P, Singh D, Mallik A, Nayak S. *Madhuca Longifolia* (Sapotaceae). A review of its traditional use, Phytochemistry, and pharmacology. Int J Biomed Res 2012; 3: 291-305.
- [55] Kumar A, Singh BK, Trivedi N, Aggarwal A. *Madhuca Longifolia*- A review. Pharmacoaerena 2015; 1: 75-91.
- [56] Pinakin DJ, Kumar V, Kumar A, Gat Y, Suri S. Mahua: A boon for pharmacy and food industry. Current Res Nutr Food Sci 2018; 6: 371-81.
- [57] Deep P, Singh AK, Dubey S, Srivastava Swarnim. Phytochemistry, Traditional use and pharmacological properties of *Madhuca indica* (Sapotaceae): A review. Eur J Biomed Pharm Sci 2016; 3:169-78.
- [58] Singh R, Mishra BK, Shukla KB, Jain NK, Sharma KC, Kumar S et al. Fermentation process for alcoholic beverage production from mahua (*Madhuca indica*, J.F. Mel.) Flowers. African J Biotech 2013; 12:5771-77.
- [59] Kamal A. Analysis of country made mahua liquor. Inter J Current Res 2015; 7: 23453-55.

- [60] Jha S, Vaibhav V, Suneetha V. A culinary mahua (*Madhuca indica*) flower from Bihar, India- A potential in production of jam, alcohol for pharmacological benefits with fertilizer value. *Inter J Drug Develop Res* 2013; 5:362-67.
- [61] Ariharan VN, Devi VN, Parameswaran NK, Prasad PN. *Madhuca indica* J.F. Gmel (Mahua) An alternative source for biodiesel industrial in future. *Inter J Pharma Sci Review Res* 2015; 32: 69-72.
- [62] Kulkarni PS, Sharanappa G, Ramesh MR. Mahua (*Madhuca indica*) as a source of biodiesel in India. *Inter J Sci Engg Res* 2013; 4: 2319-2329.
- [63] Padhi SK, Singh RK. Optimization of esterification and Trans esterification of Mahua (*Madhuca indica*) oil for production of biodiesel. *J Chem Pharm Res* 2010; 2: 599-608.
- [64] Patil RS, Doddabasawa BS, Naik GR. Biodiesel production from *Madhuca indica*- A potential species for semi-arid lands of Hyderabad-Karnataka region. *J Pharmacog Phytochem* 2017; 6(3): 390-93.
- [65] Yadav A, Dugala NS. Production of methyl ester of mahua (*Madhuca* Biodiesel) for improving its cold flow characteristics. *Indian J Sci Tech* 2018; 11: 1-7.
- [66] Prajapati KP, Shilpkar P, Shah MC. Suitability of Trans esterified mahua (*Madhuca indica*) oil as a diesel fuel. *J Sci Indus Res* 2015; 74: 494-98.
- [67] Patel M, Naik SN. Flowers of *Madhuca indica* J.F. Gmel- present status and future prospective. *Indian J Nat Prod Res* 2010; 1:438-43.
- [68] Jain JB, Kumane SC, Bhattacharya S. Medicinal Flora of Madhya Pradesh and Chhattisgarh- A review. *Ind J Trad Know* 2006; 5: 237-42.