A Review on the Nutritional and Hepatoprotective Properties of *Madhuca indica* Flower Extracts

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Abstract— *Mahua (Madhuca indica), a member of the Sapotaceae family, is an important economic tree from India. Mahua flowers were rich in bioactive compounds such as carbohydrates, minerals- calcium,iron, antioxidants, flavonoids, and phenolic acids. Mahua flowers are nutritional and have medicinal properties. The paper reviews the Mahua flower's nutritional qualities and health-protective functions in the paracetamol-induced liver damage in the Wistar rat models. Traditional application records indicated that Mahua flowers have anti-inflammatory, anticancer, and anthelmintic properties, and help against the causative agents like bronchitis, diabetes, eczema, and digestive disorders. Mahua seeds arenutritionally significantas a good source of proteins, fats, fiber, different sugars, carbohydrates, and minerals. Mahua methanol extracts have been proven hepatoprotective and non-toxic and can be used to treat liver diseases.*

Keywords— Mahua flower, Nutritional properties, Health Benefits, and Hepatoprotective properties.

I. INTRODUCTION

The genus Madhuca belongs to the Sapotaceae family and is botanically known as *Madhuca indica J.F. Gmel*. The Mahua or Indian butter tree is a self-growing tree with the name meaning "Madhu" for sweet and "indicus" for India from the Sanskrit language. The Mahua tree grows well in mixed deciduous forests in South Asia, including India, Nepal, and Sri Lanka. The tree has several names depending on the area. This evergreen tree is called Mahwa in Hindi, and other familiar names are Mahua, mahwa, mohwa, mohwra, llupai, honey tree, butter tree [English]; illipe, arbre à beurre, bassie, madhuca [French]. The tree has white, juicy blossoms that eventually turn into rectangular, yellow fruits, which are ripe from March to June annually. Mahua is an essential economic resource because of its use in food, medicine, and various industrial processes, including oil extraction, soap and detergent manufacturing, and cosmetics. These substances support several therapeutic applications, including the management of ulcers, tonsillitis, diarrhea, rheumatism, eczema, bleeding gums, skin conditions, and respiratory ailments[1,2]. Because of its galactogenic, analgesic, and vomiting-inducing properties, mahua seed oil treats piles, skin conditions, and pneumonia. With its use, especially in the nutritional field, mahua proves to be a versatile plant. The Mahua seeds have a high percentage of lipids (between 50 and 61%), with the main fatty acids being stearic, oleic, linoleic, and palmitic acids. The seeds also contain considerable protein (16.3–29.4 %).However, it is underutilized due to a lack of processing and consumption data[3]. Mahua flowers also supply essential minerals, including iron, calcium, magnesium, and potassium, and they are a source of carbohydrates that significantly increase calorie intake. Mahua is used in local cuisines and

is known for its high-energy seeds. Its blossoms and seeds are used in various ways, enhancing the nutritional landscape[4]. Barfi, kheer, [5,6,], butter [7], candy [8], fermented drinks, and milkshake are just a few of the many products that have been developed from Mahua. [9, 10,], Jam jimjam Jam [11], pickle [12], wine/vermouth [13]. Bioethanol [14,15,16]aging and fining agent [17]. Mahua cake is a byproduct that promotes general health and production by providing wholesome feed for animals. Beyond its apparent advantages, Mahua's bioactive components and antioxidant qualities show promise for improving health. The soil and ambient conditions are among the elements that affect the variances in nutritional and bioactive components in Mahua. The nutritional analysis of Mahua guides its successful incorporation into customs and more comprehensive nutritional plans, opening up new study directions in the food and human health domains. Therefore, this review study aims to comprehend the nutritional and functional characteristics, Hepatoprotective properties, and mahua health advantages. The scientific classification is also discussed below in Table 1.

FIGURE 1: Photographs of the *madhuca indica* tree with yellowish flowers

1.1 Taxonomy:

TABLE 1
SCIENTIFIC CLASSIFICATION OF MAHUA PLANT (*Madhuca indica*)

Kingdom	Plantae
Division	Angiosperms
Clade	Asterids
Order	Ericles
Family	Sapotaceae
Genus	Madhuca
Species	*M.longifolia*

1.2 Mahua Flowers in Nutrition:

The Corolla parts of Mahua flowers are edible and form an article of the diet of tribals. Tribes used to consume raw or cooked flowers, make medical decoctions, and make country liquor. Flowers are rich in sugars, varying with the flower habitat source. Flowers are safe for human consumption and non-toxic in the mouse models.

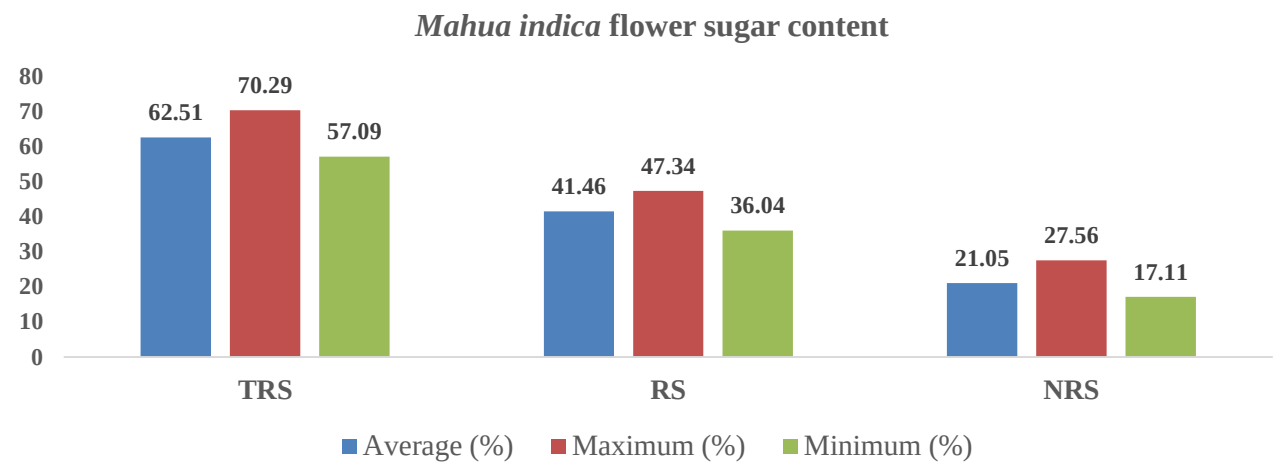

FIGURE 2: Total sugar content in the mahua flowers data collected from suryawanshi & mokat, 2020; trs= total reducing sugar, rs= reducing sugar, nrs =non-reducing sugar.

Flowers have total reducing sugars (TRS), reducing sugars (RS), and non-reducing sugars (NRS). The TRS content ranged from 57.09 to 70.29 %, the RS ranged from 36.04 to 47.34 %, and the NRS ranged from 17.11 to 27.56 % in Mahua flowers.Sugar syrup is prepared by various researchers using dried Mahua flowers that contain sucrose, glucose, fructose, arabinose, maltose, and rhamnose [18].Flowers contain 2-acetyl-1-pyrroline, D-glucose, L-rhamnose, D-xylose, L-arabinose, D-glucuronic acid, stearic acid, lactic acid, myristic acid, arachidic acid, oleic acid, linoleic acid, palmitic acid, as active constituents[19].

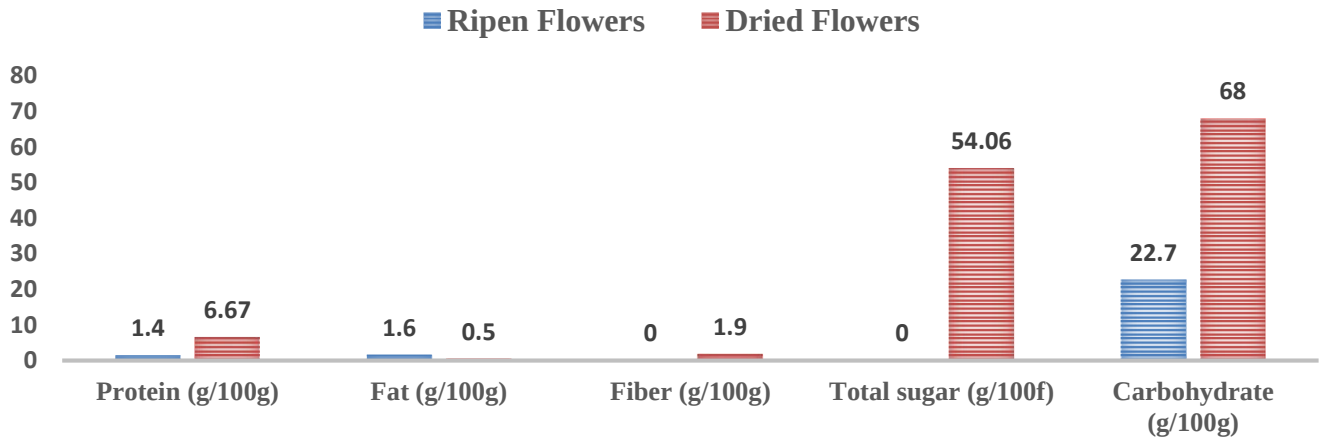

FIGURE 3: Nutritional components in fresh mahua and dried flowers, data collected from [20].

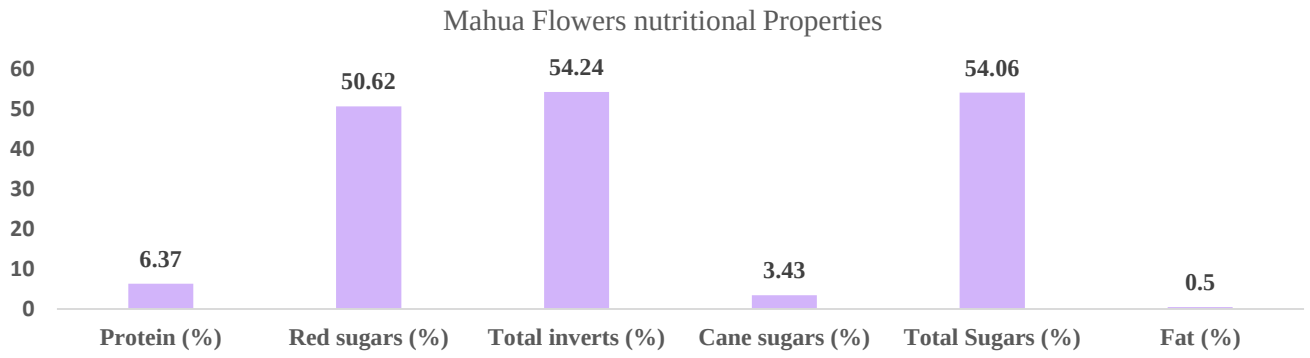

FIGURE 4: Nutritional properties of madhuca longifolia flowers data collected from [21].

II. FUNCTIONAL CHARACTERISTICS:

The mahua tree is regarded as one of the non-timber forest products (NTFP) nutritional powerhouses. All parts of the mahua tree are used to make food goods, make alcohol, make biodiesel, or treat illnesses. The most abundant natural hard fat is mahua fat, which makes chocolate instead of ghee or cocoa butter. Because of its emulsifying qualities, Mahua seed fat is used to make lubricants and laundry soaps. Purification and characteristics of human erythrocyte glutathione peroxidase, Awasthi demonstrate Mahua flowers are rich in nutrients such as reducing and non-reducing sugar, polysaccharides, dietary fibers, protein, fat, minerals, vitamins, enzymes, and other organic acids. It was discovered that dried Mahua flowers have a 40–70% sugar content. The geographical location, flower harvest, and Mahua variety affect the amount of sugar in the blooms [22]. According to Sutaria and Magar, the concentration of reducing and non-reducing sugars varies from 3–18 and 48–57%, respectively. The mahua flower was extracted using both the hydrolyzed and unhydrolyzed extraction methods to extract various polysaccharides [23].

The hydrolyzed extract contained galacturonic acid, maltose, glucose, arabinose, fructose, and rhamnose. There was no sugar in this extract. Polysaccharide structures were also examined after their extraction and separation from the mahua flower. Mahua flowers are used to make fresh juice, and it was found that these flowers are high in sugar and a natural sweetener, namely 1:2.1:2.3 sucrose, glucose, and fructose [24]. The amount of protein and nitrogen fluctuates according to the flower's development stage. Compared to mature flowers, tender flowers are rich in nitrogen content. Protein and nitrogen percentages were found to be 4.4–7% and 0.65–1.1%, respectively. Mahua blooms are high in protein content, and their flowers are high in vital amino acid content [25].

III. FLOWER JUICE UNDER SACCHAROMYCES CEREVISIAE FERMENTATION

Dried mahua flowers are used for alcohol production. The boiled and crushed, de-pulped, and pasteurized flowers were allowed to ferment using *Saccharomyces cerevisiae.* The highest ethanol was produced at 108 hours with 150 rpm purification. Fermentation increased the % alcohol by volume (Fig. 5C) and decreased the total soluble solids (5A), specific gravity (5B), and pH (5D) in the final yield. The sugars fructose, glucose, and sucrose were utilized at different rates during fermentation. The fermented beverage contained flavor compounds of alcohols, terpenes, esters, acids, and ethers [26].

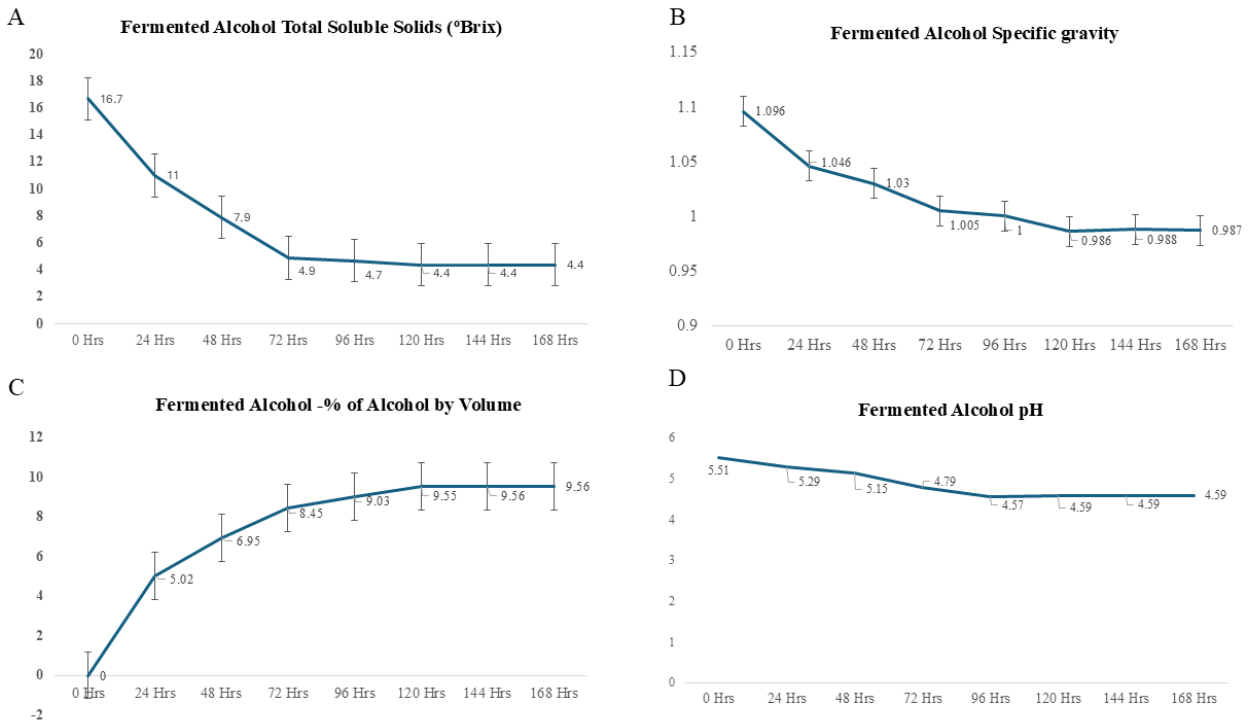

FIGURE 5: Physico-chemical characteristics of fermented alcoholic beverages.

IV. HEALTH BENEFITS OF THE MAHUA PLANT

The Mahua flower (Madhucalongifolia) offers many health benefits (Figure 1), many of which have been traditionally recognized and utilized across generations. Here is a detailed explanation of some of its remarkable therapeutic uses:

- **Bronchitis:** Chronic bronchitis, a disorder characterized by ongoing airway inflammation, can be effectively treated with mahua flowers. Because of its calming qualities, eating the blossoms can help reduce cough and other respiratory problems Orchitis
- **Testis Inflammation:** Madhuca leaves are boiled to treat orchitis by lowering inflammation and accelerating healing. This conventional use demonstrates the plant's possible anti-inflammatory qualities.
- **Rheumatism:** A decoction prepared by boiling the bark in water can be used internally to relieve rheumatic symptoms. Additionally, to relieve pain and inflammation brought on by injured joints or tissues, Madhuca seed oil is administered to the afflicted regions.
- **Diabetes Mellitus:** Madhuca bark decoction has demonstrated promise in controlling blood sugar levels, making it advantageous for diabetics. Frequent ingestion could aid in the natural stabilization of blood glucose levels.
- **Pile:** Madhuca seed oil helps those with persistent constipation and piles by acting as a natural laxative. Its calming properties can aid in bowel regularity and pain reduction.
- **Eczema:** Madhuca leaves can help with eczema when they are cooked and sprayed with sesame oil. Applying the prepared leaves to the afflicted region of the skin aids in wound healing, inflammation reduction, and irritation relief.
- **Gums:** The liquid extract made from Madhuca bark can be gargled after being diluted with water (4 milliliters extract to 300 milliliters). This medication promotes gum health by successfully reducing bleeding, spongy gums, and other dental discomforts.
- **Tonsillitis:** The remedy for gum disease also aids in treating pharyngitis and both acute and chronic tonsillitis. It is a multipurpose treatment that reduces inflammation and soothes sore throats.
- **Burns:** Ghee and leaf ash are administered to the afflicted region to treat burns and scalds. Bark paste is often used to improve healing and lessen irritation.
- **Lactation:** Madhuca seeds and blossoms are thought to help nursing moms produce more milk. Because of this characteristic, it is beneficial for promoting breastfeeding and guaranteeing that babies receive better nutrition.
- A veritable gold mine of health benefits, the mahua plant can help with digestive, skin, and respiratory disorders, among other ailments. Its uses demonstrate the diversity of traditional medicine and the need for more research to support and broaden its application [27].

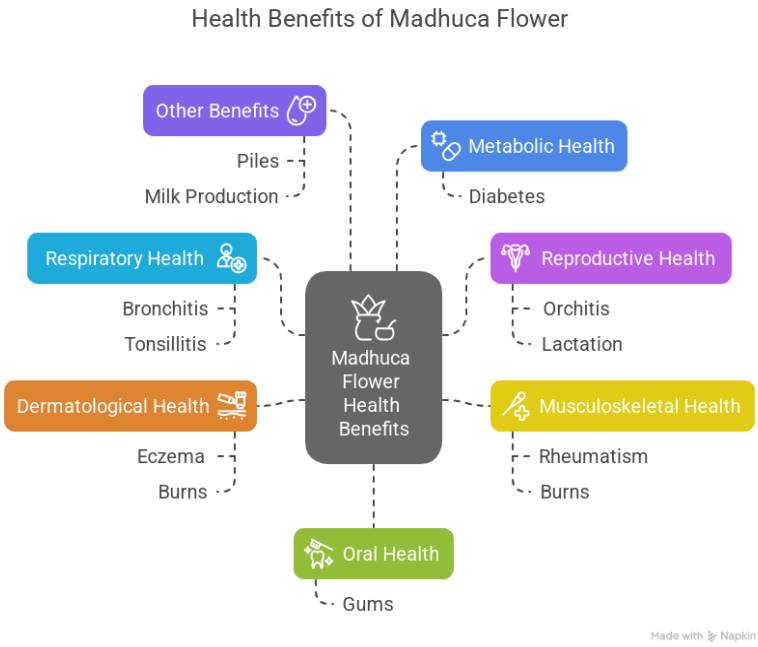

FIGURE 6: Demonstrate the wide health benefits of the mahua flower (*Madhucalongifolia)*

V. MEDICINAL POTENTIAL OF MAHUA FLOWERS

Traditional medicine has long acknowledged the pharmacological qualities of Mahua flowers (Madhucalongifolia), and current research endeavors seek to confirm their therapeutic advantages in various applications.

Anthelmintic properties: Mahua has been investigated extensively, especially regarding how well they work against parasitic worms. The ethanol and methanol extracts of Madhucalongifolia flowers have been shown to have strong worm-killing effects in studies on the Indian earthworm, *Pheretimaposthuma*. The study by Katiyar *et al.* (2011) supported the traditional therapeutic usage of these extracts by confirming their effectiveness against helminthic illnesses. The anthelmintic effects of saponins, flavonoids, alkaloids, and tannins are among the bioactive substances found in mahua flowers. These substances cause paralysis and death in parasites by interfering with their metabolic processes. With encouraging outcomes, the effectiveness of Mahua flower extracts has been contrasted with that of common anthelmintic medications such as piperazine citrate and albendazole [28].

Antioxidant activity: Ethanolic extracts of Madhucasylvestris bark demonstrate the strong antioxidant qualities of mahua flowers. Both in vitro and in vivo methods were used to evaluate the antioxidant activities. The extracts demonstrated strong reducing power and free radical scavenging capabilities against superoxide and hydroxyl radicals in vitro. Reduced lipid peroxidation and elevated tissue glutathione (GSH) levels in vivo validated the extract's antioxidant efficacy. In order to compare the results with ascorbic acid, a well-known natural antioxidant, experiments used techniques such as DPPH free radical scavenging activity, reducing power tests, and superoxide scavenging assays. Additionally, at 500 mg/kg and 750 mg/kg body weight, ethanolic extracts of Madhucasylvestris leaves showed protective properties against acetaminophen-induced toxicity in rats [6].

Anticancer activity: Research also shows that Mahua leaves have cytotoxic properties. Several *in-vitro* cytotoxic tests assessed acetone and ethanol extracts against Ehrlich Ascites Carcinoma (EAC) cell lines. Compared to the acetone extract, the ethanol extract showed more cytotoxic action, suggesting it might be used in cancer treatment. The findings corroborate the anticancer potential of Madhucalongifolia, opening the path for future study into its active components [29].

Analgesic properties: Madhucasylvestris flowers' have been assessed using tail-flick, hot plate, and chemical writing techniques. Studies on rats and mice showed that both alcoholic and aqueous extracts had dose-dependent analgesic effects. Similarly, when examined utilizing an acetic acid-induced nociception response, the crude methanolic extract from *Madhucaindica* aerial portions demonstrated analgesic effectiveness [30].

Cytotoxic properties: A brine shrimp lethality experiment evaluated Madhucalongifolia. When compared to vincristine sulfate as a reference (LC50 = 8.84 µg/ml), the crude extracts, especially those from the leaves and bark, showed considerable cytotoxicity with LC50 values of 17.09 µg/ml and 45.96 µg/ml, respectively [31].

Antiulcer properties: Methanolic extracts of Madhucasylvestris were investigated for their antiulcer properties at different oral dosages (100, 200, and 400 mg/kg) in rat models of pylorus ligation, ethanol-induced, and naproxen-induced stomach ulcers. The results demonstrated that by strengthening the protective mucin layer and lessening the negative effects of pepsin and stomach acid, the methanolic extract from Madhucaindica leaves had potent antiulcer benefits. In rats with pylorus-ligated ulcers, ethanolic extracts of Madhucalongifolia flowers also showed promise. In summary, Mahua flowers have a variety of pharmacological activities, such as anthelmintic, antioxidant, and anticancer qualities that support their traditional ethnomedical uses. These findings highlight the necessity of more research to completely understand this amazing plant's medicinal potential [32].

Hepatoprotective properties: The shade-dried flowers' methanol extract was hepatoprotective in the Wistar Albino rat models. Umadevi et al. (2011) reported that methanol extracts are non-toxic and decrease the paracetamol-induced liver markers, such as serum glutamic oxaloacetic transaminase (SGOT), serum glutamic pyruvic transaminase (SGPT), serum alkaline phosphatase (ALKP), and total bilirubin. Methanol extracts decreased the elevated SGOT (Fig. 6A), SGPT (6B), ALKP (6C), and bilirubin levels (6D) at 200 mg/kg doses in the Wistar rats [33].

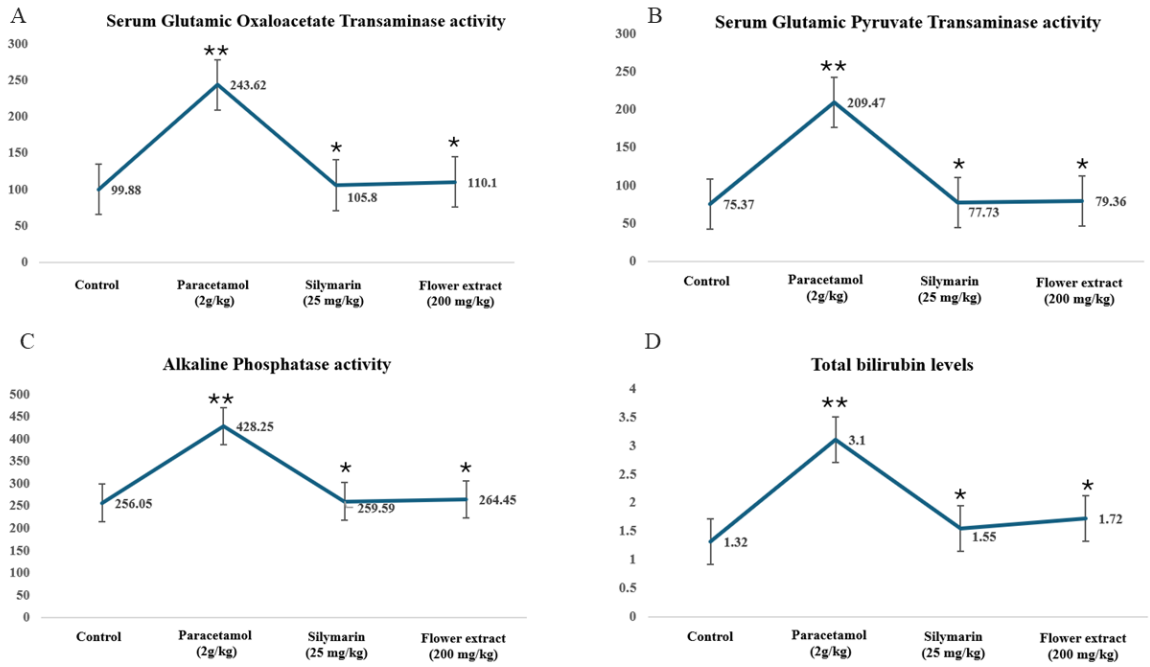

FIGURE 7: Effect of flower extracts on liver markers such as sgot (iu/l), sgpt (iu/l), alkaline phosphatase activity (iu/l), and total bilirubin content (mg/dl); data from (27).

VI. CONCLUSION

The Mahua tree (Madhucaindica) is a unique resource that is neglected while having enormous potential for industrial, medicinal, and nutritional uses. Every component has a special use, from its nutrient-dense seeds and fragrant blooms to its bark and fruits. Rich in bioactive substances, including flavonoids, phenolic acids, and saponins, mahua has pharmacological, anti-inflammatory, and antioxidant qualities, making it useful for treating conditions like eczema, diabetes, and bronchitis. Value-added products from Mahua, such as jams, alcoholic drinks, and baked goods, demonstrate the region's economic potential. Mahua is still underutilized despite its many advantages, and a lack of infrastructure and knowledge hampers its widespread adoption. Mahua offers an incredible chance for sustainable practices and broad growth. Educating people about its nutritional and health advantages through seminars and advertising is essential to maximizing its potential. Product development should concentrate on producing Mahua-based products, including snacks, drinks, and dietary supplements to take advantage of its adaptability. Working with local communities can ensure the preservation of indigenous knowledge while combining conventional wisdom with modern techniques. A significant way to fight hunger and improve food security is to incorporate Mahua into nutrition programs, such as school meals and community projects.Mahua flowers were protective against paracetamol-induced hepatotoxicity. As suggested by the research authors, further experiments are needed to use them on the human population.

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