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A BRIEF STUDY ON MANILKARA HEXANDRA (KHIRNI) AND ITS PHARMACOLOGICAL ACTIVITIES – A REVIEW

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ABSTRACT

The primary goal of this review paper is to provide comprehensive information about Manilkara hexandra. In India's most tropical areas, it is used as a Khirni or Rayan. It is native to India, mainly distributed as a wild tree in the southern part and North-central part of India. It is widely spread in Gujarat, Rajasthan, Madhya Pradesh, Andhra Pradesh, Kerala and Maharashtra our efforts are to collect valuable information with respect to morphology, microscopy, phytoconstituents and pharmacological aspect of the plant. The plant contains significant phytoconstituents such as protobasic acid, 16-alphaspinasterol, betasitosterol, beta D-glucoside, quercitol, and quercetin, Ursolic acid and its dihydro derivatives. The entire plant is used as an astringent, refrigerant, and aphrodisiac, Alexipharmic, stomachic. used to treat fever, flatulence, colic, dyspepsia, helminthiasis, hyperdipsia, and burning sensation. All of these compounds are claimed to have unique pharmacological properties such as antioxidant, antiulcer, anti-inflammatory, antidiuretic, and anthelmintic activity. The fruit of this tree can be suitable for eating and available in market. The leaves are used to treat asthma. The bark is sold in markets and is used to treat fever, flatulence, stomach disorders.

Keywords: Manilkara hexandra, Rayan/Khirni, Phytoconstituents, Ethnopharmacology, Pharmacological activity.

1.INTRODUCTION

Manilkara hexandra (milk tree) is a sapotaceae family evergreen tree with small fruits containing 1-2 hard seeds.[1]The plant grows abundantly in the tropical forests of central and western India, as well as other humid countries. The tree is also known as 'Khirni,' 'Raina,' and 'Rayan' in states such as Rajasthan, Madhya Pradesh, Maharashtra, and Gujarat. [2,3]

This plant's fruits are high in sugars, carbohydrates, protein, vitamin A, and minerals like calcium, phosphorus, and iron.[3,5]The bark is highly regarded for its aphrodisiac properties and also used as a stomachic. Furthermore, it's had refrigerant and astringent properties. The bark is used to treat burning sensations because it contains saponins, flavonoids, and procyanidins, the bark has anthelminthic properties and is commonly given to lactating mothers.[6]The plant is thought to be a good blood purifier and can help with swelling in rheumatism, gout, toxicosis, and abdominal colic. Commercially, it is an important mineral reservoir and source of income for the local tribal population.[7] For many years, the bark and fruits have been widely used to treat dyspepsia, ulcer, bronchitis, corneal opacity, urethrorrhea, and leprosy.[8]

Tannins extracted from the bark are used to treat fevers, whereas oil extracted from the seed has emollient and demulcent properties and is used in cooking. Lactiferous cell secretions have remained an excellent treatment option for dental diseases.[9]

The plant's diverse potential, the current review has been compiled to present the entire data in an updated form related to botanical aspects, ethnopharmacology, phytochemistry, pharmacological properties, and medicinal efficacy. The current review provides a detailed description of the plant as well as its extraordinary benefits, including anti-SARS-covid virus effect.

2.BOTANICAL ASPECTS

Manilkara hexandra belonged to the sapotaceae family. It is found in north, south, and central India, as well as the tropical forests of Sri Lanka, Cambodia, Thailand, Myanmar, and Vietnam.

TABLE 1: SCIENTIFIC CLASSIFICATION OF MANILKARA HEXANDRA[10]

Kingdom	Plantae (Plants)
Subkingdom	Tracheobionta (Vascular plants)
Infrakingdom	Streptophyta (land plants)
Class	Magnoliopsida
Order	Ericales
Family	Sapotaceae
Genus	Manilkara
Species	Manilkara hexandra

PLANT DESCRIPTION [10]

Manilkara hexandra (Khirni) is a small to medium-sized, slow-growing but fairly large glabrous evergreen tree that typically grows to be 12 to 25 metres tall with a trunk circumference of one to three metres. It can be found in both tropical and temperate forests.

LEAVES[10]

The leaves are smooth on both surfaces, 7- 10 cm long, obovate, elliptic and oblong, apex emarginate and dark green in colour with prominent midribs.

FIGURE 1: LEAVES OF MANILKARA HEXANDRA

Flowers

Flowers are white with 6-lobed sepals and petals, 6 stamens, hirsute ovary with multiple loci arranged in axile placentatio and a simple stigma. Staminodes are narrow with 6-8 stamens alternated with staminodes that are shorter than the stamen. Anthers are more acute and longer than filaments.[13]

FIGURE 2:FLOWERS OF MANILKARA HEXANDRA

Fruits and Seeds

Fruits are yellow, obovoid-oblong to ellipsoid in shape, with 1-2 seeded berries that are endospermic (thick endosperm) and oily, Where the hilum is elongated.[8]

The seeds are oblique to ovoid in shape, slightly compressed, shinning, and radish brown and covered by hard testa, with a distinctive odour and bitter taste due to the presence of 25% edible oil.[14]

An exploration study on plant germplasm collection with various parameters of fruits and seed from different villages in Rajasthan's Ali district was recently reported. Fruit length, fruit weight (33.49%), fruit width, pulp weight (43.54%), seed width, seed length (19.48%) was all recorded.[15]

FIGURE 3: FRUITS OF MANILKARA HEXANDRA

TABLE 2:VERNACULAR NAMES OF MANILKARA HEXANDRA

Sr. No	Plant name/Synonym	Language
1.	Khirni, Ceylon iron wood, Milky tree	English
2.	Rayan, Drirh	Hindi
3.	Rajadnah	Sanskrit
4.	Patla, Pola, and Khirni	Telugu
5.	Ulakkaippalai and Palai	Tamil
6.	Hale hannu	Kannada
7.	Palamunpala	Malayalam
8.	Palai maram	Irula
9.	Rayani,Karani,Ranjana	Marathi
10.	Tukhm Khirni	Urdu

3.Phytochemistry

Manilkara hexandra is well known for extensive variety of chemical constituents like flavonoids, saponins and phenolic compounds as shown in table 3.

The acetone fraction of seeds for determination of saponin contents that resulted in the isolation of two new saponins and three phenolic compounds namely gallic acid, quercetin and myricetin which was identified for the first time, along with other known constituents. Confirmations for the same had been made possible with the help of spectrophotometric techniques including UV, 13C NMR, 1H NMR and MS. [16]

The methanolic extract of the leaf displayed better free radical scavenging potential along with inhibition of α-amylase activities compared to the reported ones.[17]

The presence of significant amounts of phenolic contents, tannins, alkaloids, flavonoids, terpenoids, phlobatannins, anthraquinones, saponins, and terpenoids, reducing sugars, steroids, glycosides, and carbohydrates was discovered during phytochemical screening procedures for the methanolic extract of leaf and bark.

Methanolic extract of the leaves was discovered to be a better source of antioxidants than one obtained from the fruit.

Various studies' findings confirmed the presence of various types of phytocomponents in various parts of the plant, including stem, bark, and leaf, indicating specific medicinal uses when extracted with a variety of solvents, including ethyl acetate, acetone, methanol, ethanol, hexane, petroleum ether, chloroform, and double distilled water.

A clear demarcation was seen in terms of chemical constituents contained by the plants, as the stem primarily consisted of alkaloids and saponins, whereas the leaves were significantly rich in flavonoid, and the bark contained significant amounts of terpenoids, tannins, and phenols.

Through phytochemical screening, one study that was conducted to learn about the hypoglycaemic properties of the natural polymer extracted from the stem of M. hexandra confirmed the presence of alkaloids, flavonoids, amino acids, proteins, saponins, carbohydrates, tannins, gum, fixed oil, and fats.

Some researchers reported the presence of volatile oils, tannins, and sterols in the leaves, which was confirmed by phytochemical screening of alcoholic and aqueous leaf extracts.

Cinnamic acid, taraxerol, quercitol, and hentriacontane were also isolated from the leaves of

M. hexandra. A study found cinnamic acid, taraxerol, α-spinasterol, quercitol, and esters of and amyrins in plant root extract.[19],[20],[21]

TABLE 3: CHEMICAL CONSTITUENTS OF MANILKARA HEXANDRA [21]

Parts of plant	Phytochemical components
Leaves	Taraxerol, Terpenic hydrocarbon, Triterpene ketone, cinnamic acid, hentriacontane, 4-methylbenzaldehyde, p-coumaric acid, Rutin, myricetin, quercetin, gallic acid
Flowers	D-Quercitol, ethyl nicotinate
Fruit mesocarp	α-amyrin acetate, Ursolic acid, β-amyrin acetate, gallic acid, kaempferol, quercetin, tetra-hydroxy alcohol, monohydroxy monocarboxylic acid
Seeds	Quercetin, sterol, quercitol, arabinose, rhamnose, glucose, gallic acid, myricetin, vanillic acid, dihydroquercetin, xylose
Bark	Xerol, α-amyrin cinnamate, α-spinasterol, triterpenoid acid, β-sitosterol, taraxeryl acetate, 7,9-di-tert-butyl-1oxaspiro [4.5] deca-6,9- diene-2,8-dione,
	flavan-3-ol, Trigonelline, Rutin

4. Qualitative analysis of manilkara hexandra[18]

To find new sources of compounds with therapeutic and commercial value, phytochemical analysis is crucial.

In the current study, Manilkara hexandra leaf, stem, and bark were used to qualitatively analyse primary and secondary metabolites in a variety of increasing polarity solvents, including petroleum ether, hexane, chloroform, ethyl acetate, ethanol, methanol, and aqueous, using the cold percolation method.

The results of the phytochemical analysis of the obtained compounds (alkaloids, anthocyanin, anthraquinone, carbohydrates, coumarins, emodin, oils and fat, flavonoids, glycosides, gum, saponin, tannin, and terpenoid) are shown in Table 4.

TABLE 4: QUALITATIVE SCREENING OF MANILKARAHEXANDRA [19]

Sr. No	Phyto compounds	P. E			H			C			E. A			E			M			D.D H2O		
	Parts of Plants	L	S	B	L	S	B	L	S	B	L	S	B	L	S	B	L	S	B	L	S	B
1.	Alkaloid	E	-	E	G	G	P	G	E	P	-	G	P	G	E	E	E	E	E	G	P	P
2.	Amino acid	-	-	-	-	-	-	-	P	-	-	-	P	G	E	G	-	E	P	-	-	-
3.	Anthocyanin	P	P	P	P	P	P	-	G	P	G	P	P	P	P	E	P	-	P	-	-	P
4.	Anthraquinone	G	G	G	G	G	G	G	P	P	P	G	E	G	G	E	P	G	P	P	P	P
5.	Carbohydrates	E	G	E	G	E	P	E	G	G	G	E	G	G	E	E	G	E	G	G	E	G
6.	Coumarins	P	P	P	G	P	P	G	G	E	P	P	P	G	P	G	P	P	P	-	-	E
7.	Emodin	G	P	P	P	G	G	P	G	G	P	P	P	P	E	G	-	G	E	-	P	-
8.	Fixed oils & Fats	P	E	E	G	G	G	-	E	E	P	E	G	G	E	E	P	P	P	-	-	-
9.	Flavonoids	G	-	-	-	-	-	-	G	G	G	E	G	G	E	E	E	G	G	G	E	P
10.	Glycosides	E	P	-	P	G	-	G	E	G	E	E	E	E	E	E	P	G	E	E	G	P
11.	Gum & Mucilage	E	E	G	E	G	E	-	E	E	P	E	E	E	E	G	G		E	P	E	P
12.	Phlobatannin	-	-	-	-	-	-	-	G	-	-	P	P	E	E	E	P	E	G	G	P	P
13.	Protein	G	-	-	P	P	P	G	G	E	P	P	G	E	E	E	G	E	G	P	E	G
14.	Quinone	P	-	-	-	P	-	-	P	G	P	G	G	G	E	E	P	E	E	P	P	E
15.	Resin	P	G	E	P	G	E	P	E	G	G	E	E	G	E	E	G	E	G	P	P	G

16.	Saponin	-	-	-	E	E	E	G	E	E	-	G	-	E	E	E	G	E	E	G	E	E
17.	Steroids	P	-	-	G	G	-	G	E	G	E	E	E	E	E	E	G	G	E	G	G	G
18.	Tannin	P	P	-	G	E	-	-	E	E	E	E	P	E	E	E	P	E	G	E	E	E
19.	Terpenoids	-	-	-	G	E	E	G	E	E	G	E	E	E	E	E	G	E	G	G	E	E
20.	Xanthoprotein	P	-	-	P	-	-	-	-	-	E	E	-	E	E	E	E	E	E	P	E	P

P.E= Petroleum ether, H=Hexane, C= Chloroform, E.A= Ethyl acetate, E= Ethanol, M= Methanol, DD= Double distilled water.

[E = Abundant, G = Good, P = Slightly present, - = Absent]

Quantitative Analysis of manilkara hexandra [19]

The alkaloids, flavonoids, terpenoids, and saponins in Manilkara hexandra leaf, stem, and bark were measured by using a standard procedure in Table 5.

The quantitative outcomes for various phytochemicals including alkaloids, flavonoids, saponin, terpenoids, phenol, and tannin, were evaluated as shown in Table 6.

TABLE 5:COMPARATIVE REPORT OF PHYTOCHEMICALS OF PLANT PART

Phytocompounds	**Ascending Order of plant parts**
Alkaloids and Saponin	B < L < S
Terpenoids, Phenol, and Tannin	L < S < B
Flavonoids	B < S < L

[L - Leaf, S - Stem, B - Bark.]

TABLE 6:QUANTITATIVE ANALYSIS

Sr.No.	Phytochemicals	Weight(mg/g)		
		Leaf	**Stem**	**Bark**
1.	Alkaloids	119.2 ±37.8	153.8 ± 45.8	69 ± 28
2.	Flavonoids	144.2 ± 3.16	128 ± 14.66	29.7 ± 3.2
3.	Saponins	205.2 ± 50	211 ± 70.4	115.6 ± 12
4.	Terpenoids	10 ± 1.3	18.45 ± 0.75	34.0000 ± 4.10
5.	Phenols	1.34 ± 0.02	6.51 ± 0.0162	9.48 ± 0.02
6.	Tannins	42.63 ± 0.019	74.15 ± 6.0	79.03 ± 0.02

4.Ethnopharmacology

Traditionally utilised the stem decoction to treat diarrhoea, stomach infection, and to decrease elevated body temperatures. The bark exhibited astringent qualities, whilst powdered seeds, when mixed with honey, demonstrated its utility in reducing eye irritation.[18]

The stem bark has been used to cure burning sensations, adenopathy, hallucination, as an astringent, anthelmintic, febrifuge, and in gastrointestinal issues.[19]

Dysuria was treated with stem and root bark powder, while conjunctivitis and insanity were treated with bark paste applied to the forehead.[22]

Fresh and dried fruits are high in vitamins and minerals, they have been used as a tonic, to treat vomiting, and as an aperitif.[23]

Mashed fruits have traditionally been used to treat arthritis and jaundice. Locals in Nawargaon village and Maharashtra utilised it for heat burn therapy, vermicide, and blood purification.[24]

The Irulas medicinal utility of the flora in the Kodiakarai Reserve Forest (KRE) indicated that the tree latex was utilised in the treatment of toothache by applying it to the gums and teeth.[25]

Andhra Pradesh's tribal community used M. hexandra leaf extract to treat asthma.[26]

In the Andhra Pradesh region of Paderu, root extract was successfully employed for headache alleviationand in Khammam district a decoction of M. hexandra stem bark was used to treat dysentery and diarrhoea. [27,28]

It was boiled in water to relieve bodily aches in the Bhil tribe of Madhya Pradesh, while the stem bark extract was consumed as a tonic in the Gond tribe.[29]

In Tamil Nadu's Pudukkottai area, a decoction of mashed fruits and bark was used to treat hallucination and fever.[30]

TABLE 7: PROVIDED AN OVERVIEW OF M. HEXANDRA ETHNOPHARMACOLOGY

Plant parts Used	Preparation	Ethnomedical uses	City/Place
Stem Bark	Decoction	diarrhoea, stomach infection	Andhra Pradesh (Khammam)
Stem Bark	Decoction, Infusion	Tonic	Madhya Pradesh
Stem Bark	Boiled	Body ache	Madhya Pradesh
Stem Bark	Infusion	galactagogue	Tamil Nadu
Stem Bark, Fruit	Decoction, Mashed	Fever, Hallucination	Tamil Nadu

Stem Bark, Fruit	Decoction, Mashed	Fever, Jaundice	Rajasthan
Stem Bark, Fruit	Decoction, Mashed	Bronchitis	Madhya Pradesh
Stem Bark, Fruit	Decoction, Mashed	Alimentary disorder	Maharashtra, Gujarat
Stem Bark, Leaves	Infusion	Infertility,vetirinary	Tamil Nadu
Stem Bark, Root	Mashed	Dysuria	Madhya Pradesh
Leaves	Decoction, Infusion	Asthma	Andhra Pradesh
Fruit	Mashed	Burning, Digestive disorder,Arthritis,Blood purifier	Maharashtra
Root	Decoction/Infusion	Headache	Andhra Pradesh
Latex	Applied directly	Toothache	Kodiakarai
Seed	Mashed	Eye irritation	Maharashtra

5. Pharmacological Activities of manilkara hexandra

A wide range of biological qualities including anti-inflammatory, anti-diabetic, antioxidant, anti-ulcer, anti-arthritic, anti-diabetic and immunostimatory activity have been documented from various portions of the plant in numerous Indian states.

Antioxidant Activity [31,32]

Several studies have demonstrated that fruits and seeds have substantial antioxidant capabilities of the plant, which represented the health benefits of the entire fruit. This

could be attributed to the presence of more phenolic chemicals in the harvest the total phenols and flavonoids content of the fruits were determined.

Phenolic substances were tested utilising six separate assays including ferric reducing antioxidant power, radical scavenging activity, 1,1-diphenyl-2-picrylhydrazyl radical scavenging activity test, 2,2 azino-bis (3ethylbenzothiazoline-6-sulfonic acid) diammonium salt radical scavenging activity and hydroxyl radical scavenging activity (HRSA), but in seeds this was validated by nitric oxide radical activity.

The study's findings revealed that methanol extract of M. hexandra Fruits have a high percentage of flavonoids and phenolic content 485.56 mgRE/100 g fresh weight and 811.3 mg GAE/100 g fresh weight, with a total of the seeds' phenolic and flavonoid contents were determined to be 190.19 mg.

There are eleven new phenolic chemicals were extracted from M. hexandra using gallic acid, where the primary phenolic components are kaempferol and quercetin, and their LCMS analysis was used to confirm the antioxidant activity.

Anti-Microbial Activity

A number of research have been reported with impressive antibacterial activities demonstrated by various stems, seeds, fruits, and leaves, as well as various formulations such as gels, Creams.

Herbal gel combining methanolic and hydroalcoholic leaf extracts, as well as Carbopol 934, at various concentrations, had substantial antibacterial activity against Enterobacter aerogenes, Escherichia coli, Klebsiella, Proteus mirabilis, and Proteus vulgaris pneumoniae, 1 percent gelling agent and 2.5 percent plant extract were included in the formulation.[33],[34]

The extract was found to be relatively stable and was tested for Colour, homogeneity, pH, and spreadibility co-efficient. According to the findings, the flavonoids 7,9-di-tert-butyl1-oxasipro (4.5), deca-6,9-diene-2, and 8-dione obtained from the plant extract displayed potent antibacterial properties at concentration of 30-150 µg/ml.

Fruits were also tested for antibacterial activity at various phases of growth and ripening, one of the findings revealed substantial antibacterial capabilities. Methanolic extract of fruits demonstrated this, which was validated by MIC values (1 mg/mL) and measuring zone of inhibition against a variety of pathogens such as Escherichia coli, Enterobacter, E. coli, Staphylococcus epidermidis, Salmonella Para typhi, Salmonella typhi aerogenes, Proteus mirabilis, Proteus vulgaris, and Klebsiella pneumoniae.[35]

In one investigation, several leaf extracts such as acetone extract, petroleum ether extract, and Soxhlet extraction procedure were used to prepare methanol extracts, which were then tested for the antibacterial characteristics against various strains such as 7 yeast, 4 mould, and 14 gram-negative bacteria and 9 gram-positive bacteria at two doses using the agar disc diffusion method Specifically, 250 and 500 g/disc.

Methanolic extract was discovered to be strong in antibacterial activity in comparison to typical antibiotics. The findings of the study confirmed that the plant's MIC range was 250-32,000 g/mL.[36]

Anti-ulcer Activity

Methanolic extract of bark was tested for ulcer healing in male rats with acetic acid induced peptic ulcers, and the mechanism of action involved was also investigated.

Plant extract at 100 and 200 mg/kg concentrations improved the gastric lesions caused by acetic acid in male rats while decreasing the levels of lipid peroxidation (LPO), oxidised glutathione (GSSG), reduced glutathione (GSH), the ratio of GSH/GSSG and superoxide dismutase (SOD), catalase (CAT), glutathione reductase (GR) enzyme, glutathione peroxidase (GP) in the same study, trigonelline (30 mg/kg) revoked Manilkara hexandra ulcer healing effect in acetic acid-treated rats.Trigonelline was also reported to reduce their effect on LPO, GSH, CAT, SOD, GSSG, GP, and other enzymes, indicating their antagonistic properties.[37]

In another study, an orally administered ethyl acetate extract of bark (high in flavonoids) inhibited the formation of gastric lesions caused by ethanol and pylorus ligation. It also decreased lipid peroxidation in animals. Pre-treatment with ethyl

acetate extract improved mucus and glycoprotein content. In another experiment, orally administered ethyl acetate extract was proven to be an ulcer protective against aspirin-induced gastric ulcer and cysteine-induced duodenal ulcer in a dose dependent manner against cimetidine as reference drug.[38]

Anti-Diabetic Activity

Ethanolic bark extract was tested for its ability to lower blood glucose levels in rat plasma.

Streptozotocin (60 mg/kg) was injected intraperitoneally into an overnight fasted rat to induce non-insulin-dependent diabetes mellitus. 250 and 500 mg/kg body weight of 50% ethanolic extract were administered orally once daily for 21 days, and blood glucose was measured with a glucometer.

The study's findings concluded that the extract had a significant effect on lowering the concentrations of triglycerides, cholesterol, LDL, HDL, and blood glucose in rats.[17]

Immunostimulatory activity

Polysaccharides found in the bark have been shown to stimulate immune response by improving macrophage function.

Polysaccharides at doses of 250 and 500 mg/kg were administered to the experimental animal for seven days before blood samples were collected from the retro orbital plexus for analysis using four methods: cellular immune response, humoral immune response, phagocytic index, and white blood cell count.

A comparison with septilin was made, and the significant modulation of immune responses was confirmed.[39]

Anti-Arthritic properties

Proteinase inhibition and protein denaturation methods were used to test the antiarthritic properties of methanolic and hydroalcoholic leaf extracts in vitro.

In comparison to the standard diclofenac sodium, leaf extracts at 50, 100, 200, 250, and 500 g/mL inhibited proteinase and protein denaturation significantly.

Furthermore, hydroalcoholic extract inhibited protein denaturation and proteinase at MICs of 305 and 312 g/mL respectively, when compared to the standard values of 235 and 230 g/mL. [33]

Another study found that a hydroalcoholic extract of the plant at a concentration of 250 mg/kg caused a significant reduction in parameters such as paw volume (84.5%), body weight, paw diameter (80.4%), arthritic index, and haematological parameters when compared to aspirin, when used against complete Freund's adjuvant induced and formaldehyde induced arthritis.[40]

Protease Inhibitor for SARS-CoV-2

Researchers used methanolic extract of leaves and ethyl acetate extract of bark, extracted variety of phytoconstituents from it. Among them flavones, triterpenes, flavanol glycosides were the main constituents extracted. Molecular docking results revealed the significant interaction of rutin, ministering, quercetin 3-O-β-D-glucoside and myricitrin with the SARS-CoV-2 protease.[41]

Anti-Inflammatory Properties

The acetone percentage of seeds produced seven new saponins as well as some recognised chemicals such as gallic acid, Quercetin, followed by chemical structural analysis using UV, 1H, and 13C.

The existence of a crude mixture of saponins that demonstrated NMR and MS Significantly inhibited LPS-induced nitric oxide production by 60% and 20% respectively.

In the nitric oxide assay technique, when compared to the LPS-stimulated and control groups, which also had considerable anti-inflammatory properties. Likewise, acetone and DPPH was used to test methanolic fractions for antioxidant and cytotoxic activity.

They were also evaluated against human cancer cell lines such as HCT116 (colon carcinoma), MCF-7 (breast cancer cell lines), and HPG (hepatocellular carcinoma) however, the data revealed no significant difference.[42]

TABLE 8:SUMMARY OF PHYTOCONSTITUENTS AND BIOLOGICAL ACTIVITIES EXHIBITED BY DIFFERENT PARTS OF M. HEXANDRA.

Plant part used	Extract	Chemical constituents	Biological activity	References
Leaf	Methanolic and hydroalcoholic extract	Phenolic compounds, flavonoids, 7, 9-di-tertbutyl-1- oxasipro (4.5) deca-6,9-diene-2, 8-dione	Anti-bacterial activity	[34]
Leaf	Methanolic extract	Phenolic compounds	Anti-microbial	[36]
Leaf	Methanolic and hydroalcoholic extract	N/A	Anti-arthritic activity	[33]
Leaves and Bark	Methanolic and ethyl-acetate extract	Flavanol glycosides, Rutin	Anti-viral activity	[41]
Fruit	Methanolic extract	Phenols, flavonoids like kaempferol, gallic acid	Antioxidant activity	[32]
Seeds	Methanolic extract	Phenols, flavonoids like gallic acid, quercetin and vanillic acid	Antioxidant and nitric oxide free radical scavenger	[32]
Seeds	Acetone fraction	Seven new saponins, gallic caid, kaempferol	Anti-inflammatory potential	[16]

Stem	Methanolic	Quercetin, Trigonelline	Antiulcer properties	[37]
bark	extract			
Stem bark	Ethyl acetate extract	Flavonoids	Antiulcer properties	[6]
Bark	Aqueous and Ethanolic Extract	Polysaccharides	Immunostimulant	[39]

6. Conclusion

M. hexandra has tremendous potential for use as a research tool for evaluating a variety of pharmacological actions. The compounds found in plants can be used as chemical or biomarkers, as well as reference compounds, in various phytochemical and standardisation procedures for evaluating and controlling the quality of natural products obtained. The plant's diverse biological activities are sufficient to make it a leading candidate for the new drug development programme and to allow the incorporation of other suitable compounds from different systems of medicine, thus broadening the therapeutic zones shared by the plant.

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