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A Review of Recent and Current Research Studies on the Biological and Pharmalogical Activities of Sapindus Mukorossi

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Abstract: **Sapindus mukorossi is an extremely valuable cultivated medicinal plant which is mostly found in hilly regions of India. It is commonly called as Soap nut or reetha belongs to Sapindaceae family, distributed in tropical and sub-tropical regions of Asia. They wide spread in plant species and are distributed throughout the bark, leaves, stems, roots and flowers. In recent years, the use of this plant promoted considerable attention because of their various biological and pharmalogical activities. Therefore the aim of the present review is to discuss the salient features of plants in various field. And highlights its different activities based on recent studies.**

Keywords: **Sapindus mukorossi, chemical content, Pharmacology, biological activity.**

I. INTRODUCTION

Medicinal plants are very important in nature because of its curement of various human ailments. *Sapindus mukorossi* belongs to family Sapindaceae, is commonly called by several names such as soapnut, soapberry, washnut, reetha, aritha, dodan and doadni. It is an attractive medium sized deciduous tree found in diverse geographical provinces like Gangetic Plains, Western Ghats, and Deccan Plateau in India. The Tree is about 8m to 10 m large, stands with gray, smooth bark and pinnate leaves. The tree bears leaves in 510 Pairs, with large drupes. The trunk of the tree is straight and cylindrical, going 1316 ft. in height and has an umbrella like hemisphere measuring about 16 ft. in diameter. The tree is ever growing and in 70 years of existence, it can attain a height of up to 82 ft. and a girth of up to 916 ft. The size of the leaflets tapers towards the tip of the rachis. The flowers on Reetha plant grow during the summer season and are about 5 mm across, small, terminal, polygamous, greenish in colour , subsessile, numerous, mostly bisexual. The fruit appears in July and August and ripens by the months of November and December. This ripened fruit is then either sold in the market as soap nut or collected for seeds, as they tend to germinate easily. The dried fruit has a soapy texture and is used to prepare quality shampoos, detergents and a substitute for washing hands. Moreover, the plant is soft and Green when it is fresh.

The fruit is commonly known as saponins which contains upto 56.5% of the drupe which is recognized for inhibiting tumour cell growth. Saponins are glycosides and have predominantly been studied for different properties. Surfactant properties of plant makes it interesting in various applications where they can potentially replace synthetic surfactants. It's find applications in pharmaceutical, food and cosmetic industries for their emulsifying properties and due to increased awareness of environmental safety, there has been rapid progress in such natural surfactants from microbial and plant sources. Saponins have been traditionally used from *Sapindus mukorossi*, Quillaja bark, *Balanites aegyptica* and *Fagonia indica* [1]. Most of these reports are mainly on the properties of pure saponin chemically extracted from either ritha or other sources. It is well known that ritha in the form of powder or organic extracts are being used as one of the major ingredients in the herbal products like bath soaps, fabric washing, hair dyes, shampoo, body-care lotions etc. In a recent report, they have studied anti-microbial activity against H. pylori using extracts from ritha. In view of these applications, it is interesting to study the functional properties of crude ritha as an economically viable biosurfactant. We considered

basic aqueous solution of 'ritha', as crude bio-surfactant for analysing the various functional properties viz. surface tension, CMC, emulsification and haemolytic activity. The present study showed that crude bio-surfactant from ritha maintains similar functional properties as a chemically extracted and purified saponin [4].

The biosurfactant extracts from *Sapindus* can be used in place of synthetic surfactants in products such as shampoos, soaps and other cosmetics. Being natural, apart from eco-friendly aspects, it is important to also understand their antimicrobial activities. Such characteristics would enhance their utility. Hence, the main objective of the present study was to evaluate the antimicrobial properties of plant biosurfactant extracts prepared from fruits of *S. mukorossi.* To our knowledge, comprehensive studies on the effect of biosurfactant from *S. mukorossi* for activity against common skin microorganisms have not been carried out. Our report presents the results of a study on its antibacterial activity against such skin-inhabiting and other bacteria. Further, *in silico* studies were performed on saponins from this plant to evaluate their antibacterial and other bioactivity potential. [1]

II. SCIENTIFIC DESCRIPTION OF SAPINDUS MUKOROSSI

A. Classification:

Botanical Name(s): Sapindus Mukorossi

Family Name: Sapindaceae

Sub family: sapindoideae

Kingdom: Plantae

Subkingdom: Tracheobionta

Phylum: Spermatophyta

Sub phylum: Angiospermae

Division: Magnoliophyta (Flowering plants)

Class: Magnoliopsida (Dicotyledons)

Subclass: Rosidae

Order: Sapindales

Family: Sapindaceae (Soapberry family)

Tribe: Andropogoneae

Genus: Sapindus (Soapberry)

Species: Sapindus Mukorossi.

Popular Name(s): Soapnut, Soapberry, Washnut, Ritha, Aritha, Dodan, Doadni,

Doda, Kanma and Thali

Morphological parts used: Woods, seeds, pericarp extracts, kernels etc.
Parts Used: Soapnuts, Fruits, Leaves, Flowers, Soapnut Shells, Soapnut Shells Powder.

Biophysical Limits: Altitude: 0-1500 m, mean annual rainfall: 150 to 200 cm

Soil type: The tree requires deep, well drained soils. It also grows on sandy loams.

B. Structure and Chemical Constituents:

Seeds of Sapindus mukorossi contain 23 % oil of which 92 % is triglycerides; the triglyceride fraction contained 30 % oleo-palmito-arachidin glyceride, 13.3 % oleo-diarachidin glyceride and 56.7 % di-olein type glycerides such as dioleo-palmitin, dioleo- stearin and dioleo-arachidin. Fruits of Sapindus mukorossi are reported to contain sesquiterpenoidal glycosides and six different fatty ester of tetracyclic triterpenoids. Leaf extract of Sapindus mukorossi contains different type of flavonoids like quercetin, apigenin, kaempferol and rutin. Various types of triterpene, saponins of Oleanane,

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dammarane and tirucullane type were isolated from the galls, fruits and roots of Sapindus mukorossi. Sapindoside C, Sapindoside D, which is a hexaoside of hederagenin, and Sapindoside E, a nonaoside of hederagenin, was isolated and identified by Chirva et al from the methanolic extract of the fruits of Sapindus mukorossi.

Dammarane-type saponins, named Sapinmusaponins A & B, C-E (Fig. 2 & 3), together with three known phenyl-propanoid glycosides, were isolated from the galls of Sapindus mukorossi. Tirucullane-type saponins, sapinmusaponins F-J (Fig. 4), were isolated from the galls of Sapindus mukorossi as reported by Huang et al., Triterpene saponins of Oleanane type like, Sapinmusaponin K-N(Fig. 5), Mukorozisaponin G & E1(Fig. 5), Sapindoside A & B along with dammarane types like Sapinmusaponin O and P were isolated from fruits and the galls of Sapindus mukorossi as per Huang et al.,In another study by Nakayama et al.,Mukorozisaponin Y1, Y2, X were isolated from the pericarp of Sapindus mukorossi. Fractionation of an ethanolic extract of the galls of Sapindus mukorossi has resulted in the isolation of two tirucullane type triterpenoid saponins, sapinmusaponin Q and R, along with three known Oleanane type triterpenoid saponins: sapindoside A, sapindoside B, and hederagenin-3-O-[β-D-xylopyranosyl-(1→3)]-[α-L-rhamnopyranosyl- (1→2)]-α-L-arabinopyranoside.

The roots of Sapindus mukorossi contain tirucullane- type triterpenoid saponins like Sapimukoside A & B, Sapimukoside C &D as reported by Teng et al. Further investigation of the roots of Sapindus mukorossi by the Ni et al reported the presence of, Sapimukosides E-J Fig. 1). The structures of Sapimukosides A-J are shown in Fig. 1 respectively. Saxena et al., recognized six different saponins from the fruits of Sapindus mukorossi by LC-MS. They were found to be Sapindoside A, Sapindoside B, Sapindoside C, Sapindoside D, Mukorozisaponin E1 and Mukorozisaponin Y1[7]

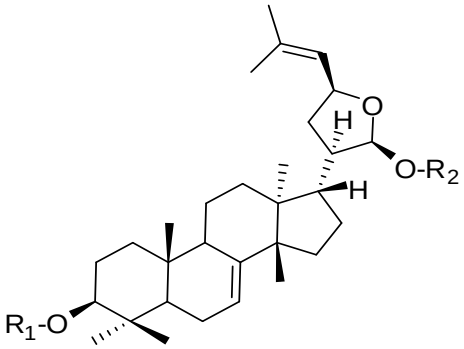

FIG.1: STRUCTURE OF SAPIMUKOSIDES A-J

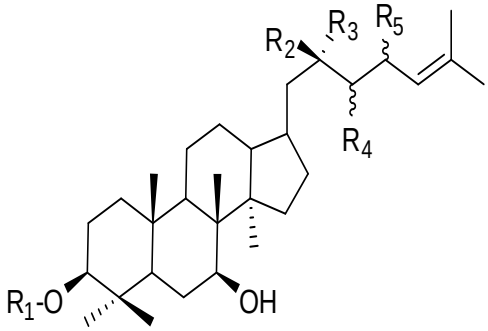

FIG.2: STRUCTURE OF SAPIMUSAPONINS A-B AND O-P

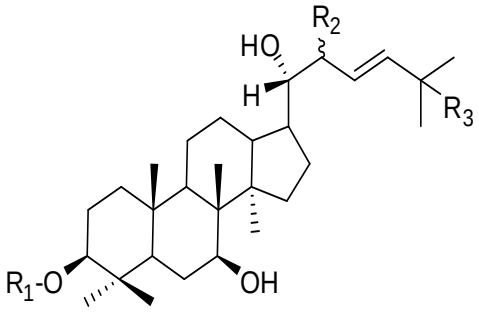

FIG.3: STRUCTURE OF SAPIMUSAPONINS C-E

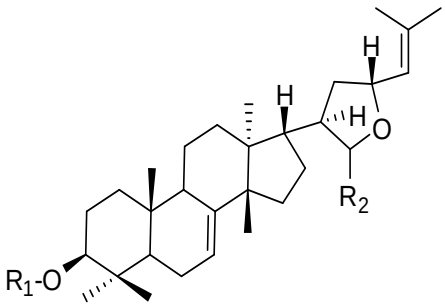

FIG.4: STRUCTURE OF SAPIMUSAPONINS F-J, Q-R

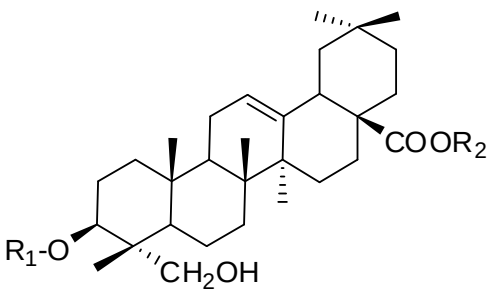

FIG.5: STRUCTURE OF SAPIMUSAPONINS K-N, SAPINDOSIDES A-E, MUKOROZI SAPONIN E1, G, Y1, Y2 &X

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TABLE 1: LIST OF SAPONINS ISOLATED FROM SAPINDUS MUKOROSSI [7]

Saponins	Chemical Name	Tirucullane/ dammarane type	Structure	Reference
Sapindoside				
A	Hederagenin-3-O-α-L-arabinosyl-(2→1)-α-L-rhamnopyranoside	Oleanane	34	10
B	Hederagenin-3-O-α-L-arabinosyl-(2→1)-O-α-L-rhamnopyranosyl-(3→1)-β-D-xylanopyranoside	Oleanane	35	10
C	Hederagenin-3-O-β-D-glucosyl(1→4)-β-D-xylosyl (1→3)-α-L-rhamnosyl(1→2)- α-L-arabinoside	Oleanane	36	11
Sapinmusaponin				
A	3,7,20(S),22-tetrahydroxydammar-24-ene-3-O-α-L rhamnopyranosyl-(1→ 2) –D-glucopyranoside.	Dammarane	11	14
B	3,7,20(S),22,23-pentahydroxydammar-24-ene-3-O-α-L-rhamnopyranosyl- (1→ 2)-D-glucopyranoside	Dammarane	12	14
C	3,7,20(S),22,25-pentahydroxydammar-23-ene-3-O-α-L-rhamnopyranosyl- (1→ 2)-D-glucopyranoside	Dammarane	15	14
D	25-methoxy-3,7,20(S),22-tetrahydroxydammar-23-ene-3-O- -Lrhamnopyranosyl-(1 2)-D-glucopyranoside,	Dammarane	16	14
E	25-methoxy-3,7,20(R)-trihydroxydammar-23-ene-3-O-α-L-rhamnopyranosyl- (1→ 2)-D-glucopyranoside	Dammarane	17	14
F	21 β-methoxy-3-β-21(S), 23I-epoxy tirucall-7,24-diene-3-O-α-Lrhamnopyranosyl-(1→6)-β-D-glucopyranosyl	Tirucullane	18	15
G	21 α-methoxy-3-β-21(S), 23I-epoxy tirucall-7,24-diene-3-O-α-Lrhamnopyranosyl-(1→6)-β-D-glucopyranosy	Tirucullane	19	15
H	21 α-methoxy-3-β-21(S), 23I-epoxy tirucall-7,24-diene-3-O-α-Lrhamnopyranosyl-(1→2)-β-D-glucopyranosyl	Tirucullane	20	15
I	21 β-methoxy-3-β-21(S), 23I-epoxy tirucall-7,24-diene-3-O-α-Ldirhamnopyranosyl-(1→2,6)-β-D-glucopyranosyl	Tirucullane	21	15
J	21 α-methoxy-3-β-21(S), 23I-epoxy tirucall-7,24-diene-3-O-α-Ldirhamnopyranosyl-(1→2,6)-β-D-glucopyranosy	Tirucullane	22	15
K	hederagenin-3-O-(3-O-acetyl-α-L-arabinopyranosyl)-(1→3)-α-Lrhamnopyranosyl-(1→2)-α-L-arabinopyranoside	Oleanane	25	16
L	hederagenin-3-O-(4-O-acetyl-α-L-arabinopyranosyl)-(1→3)-α-Lrhamnopyranosyl-(1→2)-α-L-arabino-pyranoside,	Oleanane	26	16
M	hederagenin-3-O-(2,3-O-diacetyl-β-D-xylopyranosyl)-(1→3)-alpha-Lrhamnopyranosyl-(1→2)-α-L-arabinopyranoside	Oleanane	27	16
N	hederagenin-3-O-(2,4-O-diacetyl-β-D-xylopyranosyl)-(1→3)-α-Lrhamnopyranosyl-(1→2)-α-L-arabinopyranoside	Oleanane	28	16
O	3,7,20(S)-trihydroxydammar-24-ene-3-O-α-L-rhamnopyranosyl-(1→2)- β-D-glucopyranoside	Dammarane	13	16
P	3,7,20(R)-trihydroxydammar-24-ene-3-O-α-L-rhamnopyranosyl-(1→2)- β-d-glucopyranoside	Dammarane	14	16

Q	21α-methoxy-3β, 21I, 23(S)-epoxytirucall-7,24-diene-3-O-β-D-glucopyranosyl- (1→2)-β-D-glucopyranoside	Tirucullane	23	18
R	21α-methoxy-3β, 21I, 23(S)-epoxytirucall-7,24-diene-3-O-α-Lrhamnopyranosyl-(1→6)-β-D-glucopyranosyl-(1→2)-β-D-glucopyranoside	Tirucullane	24	18
Sapinmukoside				
A	3-O-α-L-rhamnopyranosyl-(1→ 2) – [α-L-arabinopyranosyl-(1 → 3)]–β-Dglucopyranosyl-21, 23R-epoxyl tirucall-7, 24R-diene-3 β, 21 – diol	Tirucullane	1	19
B	3-O-α-L-rhamnopyranosyl-(1→ 6) – β-D-glucopyranosyl-21, 23R-epoxyl tirucall-7, 24R-diene-3 β, 21-diol	Tirucullane	2	19
C	3-O-α-L-rhamnopyranosyl-(1→2)-[α-L-arabinopyranosyl-(1→3)]-β-Dglucopyranosyl (21,23R)-epoxyl tirucalla-7,24-diene-(21S)-ethoxyl-3β-o	Tirucullane	3	20
D	3-O-α-L-rhamnopyranosyl-(1→2)-[α-L-arabinopyranosyl-(1→3)]-β-Dglucopyranosyl (21,23R)-epoxyl tirucall-7, 24-diene-(21S)-methoxyl-3β-ol .	Tirucullane	4	20
E	3-O-α-L-arabinopyranosyl-(1→3)-α-L-rhamnopyranosyl-(1→2)-[α-Larabinopyranosyl-(1→3)]-β-D-glucopyranosyl (21,23R)-epoxyl tirucalla-7,24- diene-21β-ethoxyl-3β-ol}	Tirucullane	5	21
F	{3-O-β-D-xylanopyranosyl-(1→3)-α-L-rhamnopyranosyl-(1→2)-[β-Larabinopyranosyl-(1→3)]-β-D-glucopyranosyl 21,23R-epoxyl tirucalla-7,24- diene-21β-ethoxyl-3β-ol}	Tirucullane	6	21
G	{3-O-β-D-xylanopyranosyl-(1→3)-α-L-rhamnopyranosyl-(1→2)-[α-Larabinopyranosyl-(1→3)]-β-D-glucopyranosyl (21,23R)-epoxyl tirucalla-7,24-diene-21β-methoxy-3β-ol}	Tirucullane	7	21
H	{3-O-α-L-arabinopyranosyl-(1→3)-α-L-rhamnopyranosyl-(1→2)-[α-Lrhamnopyranosyl-(1→3)]-β-D-glucopyranosyl 21,23R-epoxyl tirucalla-7,24- diene-21β-ethoxy-3β-ol}	Tirucullane	8	21
I	{3-O-α-L-arabinopyranosyl-(1→3)-α-L-rhamnopyranosyl-(1→2)-[α-Lrhamnopyranosyl-(1→3)]-β-D-glucopyranosyl 21,23R-epoxyl tirucalla-7,24- diene-21β-methoxy-3β-ol}	Tirucullane	9	21
J	{3-O-α-L-rhamnopyranosyl-(1→6)-β-D-glucopyranosyl 21,23R-epoxyl tirucalla-7,24-diene-21β-ethoxyl-3β-ol}	Tirucullane	10	21
Mukorozi-saponin				
G	Hederagenin-3-O-(2-O-acetyl-β-D-xylanopyranosyl)-(1→3)-α-Lrhamnopyranosyl-(1→2)-α-L-arabinoside.	Oleanane	29	16
E1	Hederagenin-3-O-α-L-arabinosyl-(1→3)-α-L-rhamnopyranosyl-(1→2)-α-Larabinoside.	Oleanane	30	16

C. Methods of Extraction

The various extraction techniques employed in saponin extraction like conventional and the green technologies. The conventional extraction techniques having maceration, Soxhlet, and reflux extraction, where the green technologies having Microwave-assisted [4], ultrasound-assisted and accelerated solvent extraction. The conventional extraction is

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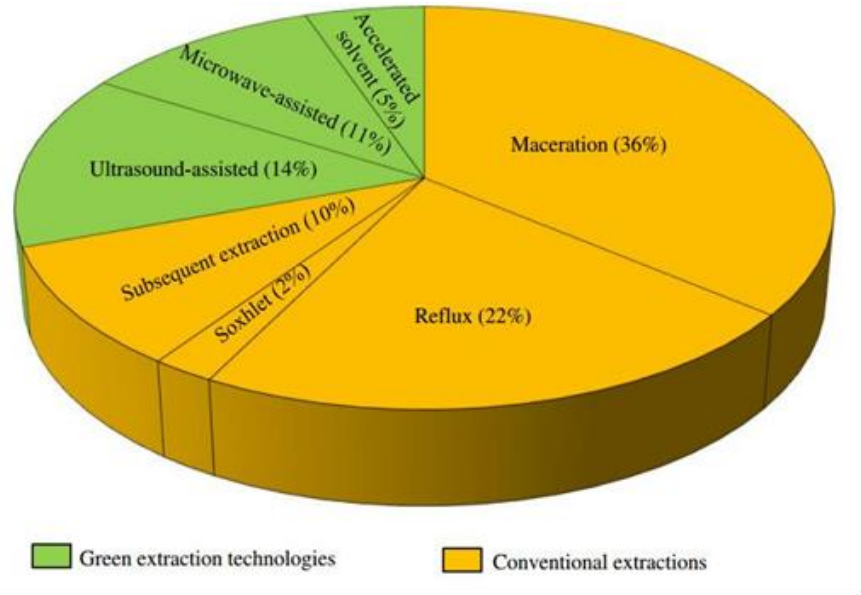
depends on the solubility of solute from plant materials into solvent. So, it's considerably utilizes a large quantity of solvent to extract. The green extraction method is less hazardous, chemical synthesis, safer chemicals, and energy efficiency and pollution prevention [3]



III. RECENT STUDIES ON THE BIOLOGICAL AND PHARMALOGICAL ACTIVITIES OF SAPINDUS MUKOROSSI.

A. Biological Activities:

Antifertility and antiandrogenic activity:

Fruit extract of Sapindus Mukorossi was found to have potent antifertility and antiandrogenic activity. Saponin which is isolated from reetha, it derivatives of hederagenin. At higher concentration of saponin means 1-50 mg/ml spermatozoa showed marked effect like disruption, vacuolation, vesiculation, erosion of the membrane covering the head region and coiling of the tail[2]. The extract shows the frequent activity by selective androgen deprivation to epididymis, therefore affecting sperm motility and metabolism. The androgen deprived effect of the extracts is evident by the significant increase in the testicular cholesterol content by this treatment. It is further substantiated by significant fall in levels of seminal vesicle fructose in these animals [5].

Antihyperlipidemic activity:

Hyperlipidemia is a condition where plasma cholesterol and triglycerides increased mostly from the increase secretion of VLDL secretion by the liver accompanied by strong decrease of VLDL and LDL breakdown. Sapindus Mukorossi fruit extract used for Antihyperlipidemic activity because it's have significant Antihyperlipidemic activity. Methanolic extract have a dose of 100 and 200 mg/kg significantly lowered both plasma glycerides and cholesterol levels. The cholesterol lowering activity of the fruit extract result from the breakdown of LDL cholesterol by enhancing enzymatic action. The active ingredients which are present in the extract recover the disorders in lipid metabolism occurring in hyperlipidemic state. The Antihyperlipidemic activity of plant Sapindus Mukorossi could be attributed to the presence of valuable saponins and flavonoids [5].

Antimicrobial activity:

Methanolic extract of leaves also showed the antifungal activity against the tested fungus Aspergillus niger. S. emarginatus showed strong antibacterial activity against M. flavus, S.epidermidis and P. morganii25. Another investigation was also reported on the leaf extract of Sapindus emarginatus against six bacterial strains, Pseudomonas testosteroni, Staphylococcus epidermis, Klebsiella pneumonia, Bacillus subtilis and Proteus morganii and showed most potent antibacterial activity [5].

CNS activity:

Methanolic extract of fruit of reetha observe to produce CNS depressant activity. The methanolic extract of Pericarps of Sapindus Mukorossi at 100 and 200 mg/kg caused a significant reduction in the spontaneous activity, significant decrease in exploratory behavioural pattern, reduction in muscle relaxant activity, inhibition of cocaine induced hyperactivity and also extensively potentiated phenobarbitone sodium–induced sleeping time. A different dose of methanol extract produced a considerable increase in the hypnotic effect induced by the phenobarbitone, in a dose dependent manner, suggesting a profile sedative activity. Various scientific research reports showed that Triterpenoids produced CNS depressant activity. The presence of these active constituents in the methanol extract of S. Mukorossi may be responsible for the CNS depressant activity [5].

Anti-mosquito activity or Larvicidal activity:

Sapindus emarginatus fruit extract shows that the presence of saponins which having Larvicidal activity against the larvae of mosquito Aedes aegypti, which is a vector for dengue and chikungunya. Investigations with kernels from the soapnut Sapindus emarginatus explained it as a new source of botanical biocide with potent antimosquito activity, which is proved from the ability of the aqueous extract of kernel to kill all the developmental stages of three important vector mosquito species, Aedes aegypti, Anopheles stephensi and Culex quinquefasciatus. Later studies revealed that exposure of the kernel extract produces changes in total proteins, and esterase's, phosphatases resulting in metabolic disturbances. The extract shows its anti-mosquito activity by multiple modes of action as clear from several adverse changes noticed in three main enzymes, namely, Acetylcholinestrase, β- carboxyl esterase and acid phosphatases of larvae of A. aegypti [5].

Antioxidant activity:

The antioxidants play important role in protecting human beings from the dangerous effects of pollutants which enhance production of reactive oxygen species thereby increasing oxidative stress in the body. Phytochemicals mainly reetha plant phenolic constitute a major group of compounds that act as primary antioxidants and its investigation revealed that the presence of phenols and flavones in the leaves which contributed the antioxidant activity of the plant. The antioxidant activity may be due to proton donating capability of the leaf extract. Due to this, the plant Sapindus mukorossi used for manufacturing of cosmetics, herbal products for skin as antiaging agents, anticancer agents [5]

Antihyperglycemic and antidiabetic activity:

Diabetes mellitus is a one type of chronic disorder, with a worldwide incidence of 5% in local population. Type I diabetes is treated with exogenous insulin and type II is with oral hypoglycemic agents. Since time immemorial, patients with non-insulin dependent Diabetes have been treated orally in folk medicines. A number of medicinal plants are reported in literature and Sapindus mukorossi is one of them. In 2009 S. Jeyabalan et al studied the Antihyperglycemic effect of leaves extract of Sapindus emarginatus in the glucose overloaded hyperglycemic rats. Various extract of leaves of plant Sapindus Mukorossi different doses exhibited a significant hypoglycemic activity and the activity shown was dose dependent. The study also revealed that total haemoglobin level, Glycosylated haemoglobin level, serum creatinine, serum urea and lipid profiles measured showed the antidiabetic activity [5].

B. Pharmalogical Activities:

Antibacterial activity:

Antibacterial activity of plant extracts used against the bacterial pathogens, such as E.coli and staphylococcus aureus using agar well diffusion method. Initially, the stock cultures of bacteria were revived by inoculating in broth media and growth at 37ºCfor 18hrs [19]. IBRAHIM et al.examined that the ethanolic and chloroform extracts of Sapindus mukorossi inhibited the growth of Helicobacter pylori (both sensitive and resistant), at very low concentrations, when given orally for seven days to male wister rats [6].

Anti-Inflammatory Activity:

Takagi and coworkers observed that the anti-inflammatory activity of hederagenin and crude saponin isolated from S. mukorossi, utilising carrageenin-induced edema, granuloma pouch and adjuvant arthritis in rats. The effects of these agents on vascular permeability and acetic-acid-induced writhing in mice were also resulted. The aqueous extract of leaves for four different solvents such as Aqueous, 1,4-dioxan, methanol and acetone showed antibacterial activity

against Pseudomonas testosteroni NCIM5098 and Proteus morganii NCIM2040. The maximum inhibitory activity was shown by TDi (1,4-dioxan extract) whereas minimum activity was shown by TMe (methanol extract) and TAc (acetone extract) and TAq (water extract) [8]

Cytotoxic Activity:

Kuo and coworkers examined the cytotoxic effect of saponins which is isolated from the galls of Mukorossi. The preliminary bioassay data revealed that saponins showed moderate cytotoxic activity (ED50~9-18μg/ml) against human tumor cell lines (Hepa59T/VGH, NCl, HeLa and Med) [8]

Molluscicidal Activity:

Huang and coworkers examined that the Extracts of Sapindus mukorossi showed molluscicidal activity against the golden apple snail, Pomacea canaliculata Lamarck. (Ampullariidae) with LC50 values of 85, 22 and 17 ppm at 24, 48 and 72h exposure period, respectively. Upadhay and singh, reported that Sapindus mukorossi fruit pericarp is a potential source of botanical molluscicides against Lymnaea acuminata. [6, 8]

Anti-Platelet-Aggregation Activity:

Huang and corworkers revealed that five new tirucallane type saponins, sapinmusaponins from the galls of S. mukorossi showed moderate activity in a 12-O-tetradecanoylphorbol- 13-acetate (TPA)-induced Epstein- Barr virus early antigen (EBV-EA) activation assay [8]

Anti-diabetic Activity:

In 2009 S. Jeyabalan and coworkers demonstrated that the antihyperglycemic effects of alchoholic extract of S.emarginatus at different doses in glucose-loaded hyperglycemic and normal fasted rats. The study also showed that the level of total hemoglobin, glycosylated- hemoglobin, serum urea, serum creatinine, and lipid profiles measured in alloxan induced diabetic rats which show Antidiabetic activity [8]

Anti-hyperalgesic activity:

S.trifoliatus had examined that the effect of aqueous pericarps extract of fruits in an in vivo migraine hyperalgesic model. They suggested that antagonism to dopamine D2 might underlie the mechanism involved in the anti- hyperalgesic activity of the plant extract [8]

Tyrosinase inhibition and free radical scavenging:

CHEN et al.2 first examined that the extracts of Sapindus mukorossi seeds using methanol (MeOH), ethyl acetate (EA) or hexane as solvents show tyrosinase inhibition, free radical scavenging, antimicrobial and anticancer properties. Sapindus mukorossi extracts showed strong specific inhibition activities on the proliferation of human melanoma and lung cell lines. The data exhibited the high potential of applying Sapindus mukorossi extracts in medical cosmetology, food supplementation, antibiotics and chemotherapy [6]

Fungicidal activity:

The crude extract of Sapindus mukorossi observed a strong growth inhibition against the pathogenic yeast Candida albicans, which causes cutaneous candidiasis. Extracts from the dried pericarp of Sapindus L. (Sapindaceae) fruits were examined for their antifungal activity against clinical isolates of yeasts Candida albicans and Candida non-albicans from vaginal secretions of women with Vulvovaginal Candidiasis. The hydro alcoholic extract was bioactivity-directed against a clinical isolate of C. parapsilosis, and showed strong activity. The n-butanol extract and one fraction showed strong activity against all isolates tested41. The saponin fraction inhibited the dermatophytic fungi Trichophyton rubrum,

Trichophyton mentagrophytes, Sabouraudites canis and Epidermophyton floccosum [6]

Piscicidal activity:

Sapindus mukorossi effects have been studied on fish. Pericarp of Sapindus mukorossi is the most toxic parts yielding 100% mortality within 12 hours and mean survival time was found to be 1.18 hours. LD10, LD50, LD100 ranging between 3.5 ppm and 10 ppm at 48 hrs and possess high potential for fish eradication. Sapindus mukorossi fruit pericarp used as a selective eradicant for horny fish like Heteropneustes fossils and channa punctuate [6].

Antigonorrhoeal activity:

Antigonorrhoeal activity of S. mukorossi extracts Muller Hinton chocolate agar plates with 5% sheep red blood cells were swabbed all over the surface with freshly prepared inoculum, using sterile cotton swab. Three wells (6 mm diameter) were bored in the medium with the help of sterile cork-borer and were labeled properly. 50 µl of each solvent extracts of a plant was added in each sample well. Plates were left for 5 minutes till the extract diffuse in the medium and then incubated at 37^0C in a moist atmosphere containing 5- 10% CO2 for 48 hours. The antigonorrhoeal activity of the plant extracts were recorded by measuring the inhibition zones in millimeters with a Measuring scale. The whole process was repeated in triplicate [10].

Antifungal activity:

Antifungal activity of extract was carried out against fungal pathogens such as Aspergillus niger and Aspergillus fumigate

Using agar well diffusion method. The stock cultures of fungal pathogens were revived by inoculating in broth media and growth 27ºC for 48 hrs. The potato Dextrose agar plates of the above media were prepared and wells are made in the plate. Each plate was inoculated with 18 h old cultures (100µl 10^{-4} FCU and spread evenly on the plate. After 20 min, the wells were filled with ethanol plant extracts (25%,50%,75%,100%) and Aqueous plant extract (25%,50%,75%,100%). The control plates with water and was also prepared. All the plates were incubated at 27ºC for 48 hours and the diameter of inhibition zone in mm were noted [9].

Insecticidal activity:

Saponins possess insecticidal activity, causing mortality and/or growth inhibition in the insects examined, the cotton leafworm Spodoptera littoralis caterpillars and the pea aphid Acyrthosiphon pisum. The test with Acyrthosiphon pisum, 0.1% saponin killed all aphids, whereas with Spodoptera some caterpillars were still able to develop into apparently normal adults on food containing 7% saponin. Saponins is employed as novel natural tactics in integrated pest management (IPM) to control pest insects, which suitable for modern agriculture and horticulture. Average mortality percentage indicated that the extracts caused significant mortality and repellency on the target insects and bioassays indicated that toxic and repellent effect was proportional to the concentration [6]

Spermicidal activity:

Saponins from Sapindus mukorossi are well known to be spermicidal. The minimum effective concentration (0.05% in spot test) did not affect the surface topography after exposure for one minute. However, incubation of spermatozoa for 10 minutes resulted in extensive vesiculation and a disruption of the plasma membrane in the head region. Higher concentrations caused more or less similar changes which involved vesiculation, vacuolation, disruption or erosion of membranes in the head region [6]

Anti-cancer activity:

Due to the great variability in saponin structure, saponins always shows anti-tumorigenic effect through varieties of anti-tumor pathways. There are more than 11 distinguished classes of saponins including dammaranes, tirucallanes, lupanes, hopanes, oleananes, taraxasteranes, ursanes, cycloartanes, lanostanes, cucurbitanes and steroids. Ginsenosides, belonging to dammaranes, found beneficial in the inhibition of tumor angiogenesis by suppressing its inducer in the endothelial cells of blood vessels and then prevented adhering, invasion and metastasis of tumor cells22 Dioscin, one of the steroidal saponins, and its aglycone diosgenin also having extensive anti-tumor effect by cell cycle arrest and apoptosis [6]

Hepatoprotective activity:

Ibrahim et al.18 showed that the extracts of Sapindus mukorossi (2.5 mg/L) and Rheum emodi (3.0 mg/L) have a protective capacity both in vitro on primary hepatocytes cultures and in vivo in a rat model of tetrachloride carbon (CCl4) mediated liver injury as judged from serum marker enzyme activities. These cultures were tested with CCl4 and extracts of Sapindus mukorossi & Rheum emodi. A protective activity could be demonstrated in the CCl4 damaged primary monolayer culture. For the in vivo study, the hepatoprotective capacity of the extract of the fruit pericarp of S. mukorossi and the rhizomes of Rheum emodi was analyzed in liver injured CCl4- treated male rats. Thus, it was mentioned that the extracts of Sapindus mukorossi and Rheum emodi do have a protective capacity both in vitro on primary hepatocytes cultures and in in vivo in a rat model of CCl4 mediated liver injury [6]

Anxiolytic activity:

Methanolic extracts of Sapindus mukorossi (200 and 40 mg/L) show meaningful anxiolytic activity as compared to standard anxiolytics Diazepam (2 mg/Kg) and Fluoxetine (10 mg/Kg) [6]

Anti-Trichomonas activity:

Tiwari et al.studied that the saponin mixture showed anti-Trichomonas activity at a 10-fold lower concentration (0.005%) than its minimal effective spermicidal concentration against human spermatozoa (0.05%). Saponin concentration dependently inhibited the ability of parasites to adhere to HeLa cells and decreased the proteolytic activity of the parasite's cysteine proteinases. This was associated to the decreased, expression of adhesin AP65 and membrane-expressed cysteine proteinase TvCP2 genes. Saponins introduced no adverse effect on host cells in the mitochondrial reduction potential measurement assay [6]

Anticardiovascular activity:

It has been studied that ingestion of saponin containing food decrease cholesterol levels in the bloodstream and as a consequence decrease the risk of cardiovascular diseases. It was reported that ginseng saponins decrease blood cholesterol levels in rabbits by increasing cholesterol excretion through bile acid formation. And consumption of saponin from Solanum anguivifruit lead to reduction in the risk of hyperlipidemic symptoms and heart diseases. It was significantly revealed that the total saponins extracted from G. glabra and Q. saponaria were capable of forming complex with cholesterol. It was proved that oral administration of total saponins of G. glabra and Q. saponaria may cause a reduction in cholesterol absorption through gastrointestinal system and as a result lowering the blood cholesterol [3].

Adjuvant activity:

The saponins were used as adjuvants in vaccines. Q. saponaria saponins can stimulate both the humoral and the cellular immune responses against the pathogens. So, due to this, it can be used as adjuvants in vaccine formulations. The mechanism of immune stimulatory action of saponins have not been clear, but it is assume that these compounds may induce production of cytokines such as interleukins and interferons in animal systems, that may be lead to stimulation of immune responses [3]

IV. CONCLUSION

Sapindus mukorossi is a very valuable medicinal plant whose numerous economic applications and whose facility of exploring international research interest. It needs to be widely cultivated in different parts of India. As a literature introduced, various biological and pharmacological activities by fractions of crude extracts and isolated substances. Thus, it can be concluded that Sapindus mukorossi can play a very important role in modern medical system in the future. The main objective of this review is to present the whole research which is carried out with species Sapindus mukorossi, in order to organize the data produced. Furthermore, the chemically unknown species of plant become a source of novel activity of different compounds.

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