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SAPINDUS MUKOROSSI (AREETHA): AN OVERVIEW

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ABSTRACT

The objective of this review is to form a short compilation of phytochemical screening, pharmacological activity and some analytical methods available for *Sapindus mukorossi* plant. Although the plant is of importance in Ayurvedic system of medicine mainly as cleansing agent, a review article based on the phytochemical and pharmacological screening of *Sapindus mukorossi* is not so far reported. The main phytoconstituent isolated and identified from different parts of this plant are triterpenoidal saponins of oleanane, dammarane and tirucullane type. The structure and chemical name of the all the types of triterpenoidal saponins reported in *Sapindus mukorossi* is included in this review. Many research studies have been conducted to prove the plant's potential as spermicidal, hepatoprotective, anti-inflammatory, anti-protozoal etc. This review focuses on the phytochemistry and pharmacological actions of *Sapindus mukorossi*.

INTRODUCTION: *Sapindus mukorossi* (fam: Sapindaceae), well known as soapnuts, are used medicinally as an expectorant, emetic, contraceptive, and for treatment of excessive salivation, epilepsy, chlorosis, and migranes. *Sapindus mukorossi* is a popular ingredient in Ayurvedic shampoos and cleansers. They are used in Ayurvedic medicine for treatment of eczema, psoriasis, and for removing freckles. Soapnuts have gentle insecticidal properties and are traditionally used for removing lice from the scalp [1].

Most of the phytochemical constituents of this plant have been discovered by various scientists. Among them the most explored phytoconstituents are triterpenoidal saponins of mainly three types viz oleanane, dammarane and tirucullane type. Recently many of the pharmacological actions of this plant has been explored which includes the antimicrobial, hepatoprotective, insecticidal, piscidal activity. One of the most talked activities of this plant is the contraceptive activity of the saponins extracted from the pericarp of the fruits.

Botanical description: It is known as tree of North India, a deciduous tree, known to the common man as 'areetha'. It is also known as doda, dodan, and ritha in Indian dialects. It is one of the most important trees of tropical and sub-tropical region of Asia. It is common tree in Shivaliks and the outer Himalayas of Utter Pradesh, Uttranchal, Himachal Pradesh, Haryana and Jammu and Kashmir [2].

It is a fairly large, deciduous tree, usually up to 12 m in height, sometimes attaining a height of 20 m and a girth of 1.8 m, with a globose crown and rather fine leathery foliage. Bark: dark to pale yellow, fairly smooth, with many vertical lines of lenticels and fine fissures exfoliating in irregular wood scales. Blaze: 0.8-1.3 cm, hard, not fibrous, pale orange brown, brittle and granular. Leaves: 30-50 cm long, alternate, paripinnate; common petiole very narrowly bordered, glabrous; leaflets 5-10 pairs, opposite or alternate, 5-

18 by 2.5-5 cm, lanceolate, acuminate, entire, glabrous, often slightly falcate or oblique; petioles 2-5 m long. Inflorescence: a compound terminal panicle, 30 cm or more in length, with pubescent branches. Flowers: about 5 mm across, polygamous, greenish white, subsessile, numerous, mostly bisexual. Sepals 5, each with a woolly scale on either side above the claw. Fruit: a globose, fleshy, 1-seeded drupe, sometimes 2 drupels together, about 1.8-2.5 cm across. Seed: 0.8-1.3 cm in diameter, globose, smooth, black, loose in dry fruit [3].

Vernacular names [4]:

Assamese: Haithaguti, **Bengali**: Ritha, **Hindi:** Aritha, Dodan, kanmar, **Kumon**: Ritha, **Punjabi**: Aritha, Dodan, Ritha, Thali, **Sanskrit**: Aristha, Phenila, Urista, **United provinces:** Kanmar, Ritha, **Italian**: Uriya, **Telugu**: Kunkudu.

Taxonomical classification [5]**:**

Kingdom: Plantae (plants)

Subkingdom: Tracheobionta(Vascular plants)

Superdivision: Spermatophyta (seed plants)

Division: Magnoliophyta (Flowering plants)

Class: Magnoliopsida (Dicotlyedons)

Subclass: Rosidae

Order: Sapindales

Family: Sapindaceae

Genus: Sapindus L (Soapberry)

Species: Sapindus mukorossi Geartn(Chinese soapberry)

Morphological parts used: Woods, seeds, pericarp extracts, kernels etc.

Phytochemistry: 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 [6].

According to Sengupta *et al.*, two lipid fractions 'A' and 'B' were isolated from *Sapindus mukorossi* seed oil by preparative TLC(Thin Layer Chromatography). Fraction 'A' (70.4%, R_f value 0.76) is a normal triglyceride and its fatty acid compositions was determined by GLC (Gas Liquid Chromatography). Fraction 'B' (29.6%, R_f value 0.51) shows the presence of nitrogenous constituents. This non-glyceridic component of the seed oil is a cyanolipid (1-cyano-2-hydroxymethyl prop-1-ene-3-ol) [7]. Fruits of *Sapindus mukorossi* are reported to contain sesquiterpenoidal glycosides and six different fatty ester of tetracyclic triterpenoids [8]. Leaf extract of *Sapindus mukorossi* contains different type of flavanoids like quercetin, apigenin, kaempferol and rutin. All these flavanoids were isolated by column chromatography on a polyamide sorbent [9].

Various types of triterpene, saponins of oleanane, dammarane and tirucullane type were isolated from the galls, fruits and roots of *Sapindus mukorossi*. Oleanane type triterpenoid saponins named Sapindoside A&B **(Fig. 34 & 35)** were reported from the fruits of S*apindus mukorossi* [10]. Sapindoside C **(Fig. 36)** [11], Sapindoside D **(Fig. 37)** [12], which is a hexaoside of hederagenin, and Sapindoside E **(Fig. 38)** [13], 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 **(Fig. 11 & 12)**, C-E **(Fig. 15, 16, 17)**, together with three known phenylpropanoid glycosides, were isolated from the galls of *Sapindus mukorossi* [14]. Tirucallane-type saponins, sapinmusaponins F-J **(Fig. 18-22)**, were isolated from the galls of Sapindus mukorossi as reported by Huang *et al*., [15]. The structures of these saponins were elucidated on the basis of spectroscopic analysis including 1D and 2D NMR techniques.

Triterpene saponins of oleanane type like, Sapinmusaponin K-N **(Fig. 25-28)**, Mukorozisaponin G & E1 **(Fig. 29-30)**, Sapindoside A & B along with dammarane types like Sapinmusaponin O and P **(Fig. 13 & 14)** were isolated from fruits and the galls of Sapindus mukorossi as per Huang *et al.,* [16]. In another study by Nakayama *et al*., [17] Mukorozisaponin Y1 **(Fig. 31)**, Y2 **(Fig. 32)**, X **(Fig. 33)** 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 tirucallane type triterpenoid saponins, sapinmusaponin Q and R **(Fig. 23-24)**, 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 [18].

The roots of *Sapindus mukorossi* contain tirucallane-type triterpenoid saponins like Sapimukoside A & B [19], Sapimukoside C &D [20] 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 [21]. The structures of Sapimukosides A-J are shown in **Fig. 1 to Fig. 10** respectively.

Saxena *et al*., [22] 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.

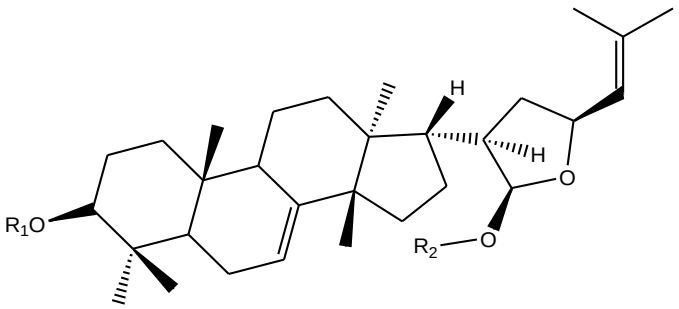

FIG.: STRUCTURE OF SAPIMUKOSIDES A-J

Glc: β-D-Glucopyranosyl
Rha:α-L-hamnopyranosyl
Ara:α-L-rabinopyranosyl
Xyl: β-D-Xylopyranosyl

Fig	R1	R2
1	$Glc^{3\text{-}Ara}_{2\text{-}Rha}$	H
2	Glc_6-Rha	H
3	$Glc^{3\text{-}Ara}_{2\text{-}Rha}$	Et
4	$Glc^{3\text{-}Ara}_{2\text{-}Rha}$	Me
5	$Glc^{3\text{-}Ara}_{2\text{-}Rha_3\text{-}Ara}$	Et
6	$Glc^{3\text{-}Ara}_{2\text{-}Rha_3\text{-}Xyl}$	Et
7	$Glc^{3\text{-}Ara}_{2\text{-}Rha_3\text{-}Xyl}$	Me
8	$Glc^{3\text{-}Rha}_{2\text{-}Rha_3\text{-}Ara}$	Et
9	$Glc^{3\text{-}Rha}_{2\text{-}Rha_3\text{-}Ara}$	Me
10	Glc_6-Rha	Et

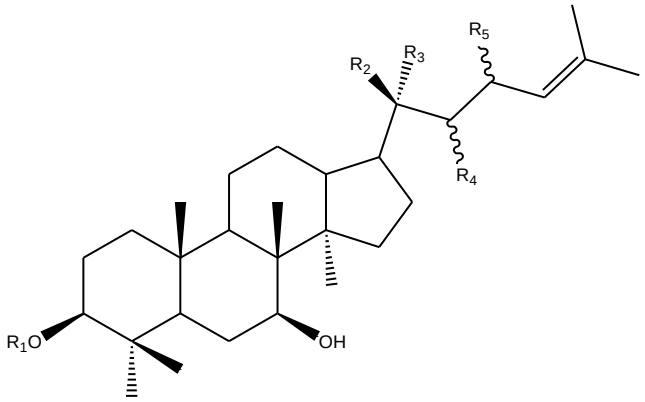

FIG.: STRUCTURE OF SAPIMUSAPONINS A-B AND O-P

Fig	R1	R2	R3	R4	R5
11	Glc_2-Rha	H	OH	OH	H
12	Glc_2-Rha	H	OH	OH	OH
13	Glc_2-Rha	OH	CH_3	H	H
14	Glc_2-Rha	CH_3	OH	H	H

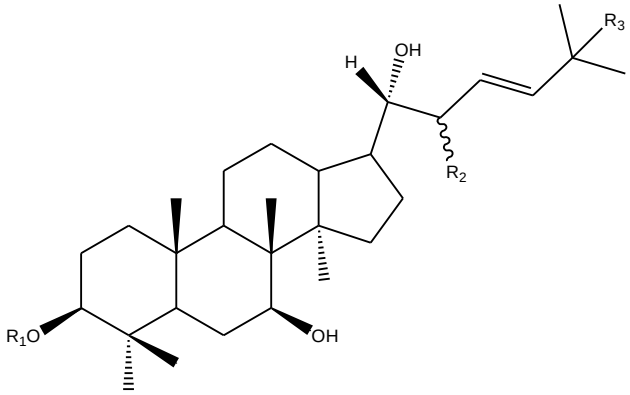

FIG.: STRUCTURE OF SAPIMUSAPONINS C-E

Fig	R1	R2	R3
15	Glc_2-Rha	OH	OH
16	Glc_2-Rha	OH	OCH_3
17	Glc_2-Rha	H	OCH_3

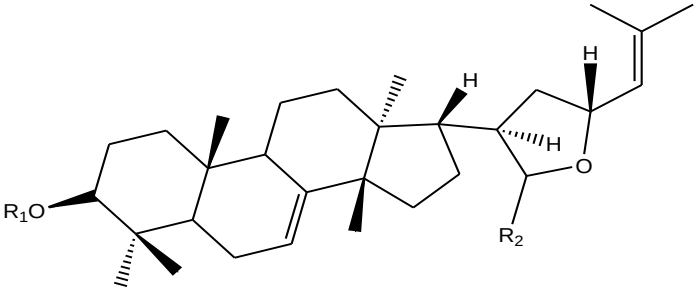

FIG.: STRUCTURE OF SAPIMUSAPONINS F-J, Q-R

Fig	R1	R2
18	Glc_6-Rha	β-OCH_3
19	Glc_6-Rha	α-OCH_3
20	Glc_2-Rha	α-OCH_3
21	$\mathbf{Glc}^{2\text{-Rha}}_{6\text{-Rha}}$	β-OCH_3
22	$\mathbf{Glc}^{2\text{-Rha}}_{6\text{-Rha}}$	α-OCH_3
23	Glc_2-Glc	α-OCH_3
24	$\mathbf{Glc}^{2\text{-Glc}}_{6\text{-Rha}}$	α-OCH_3

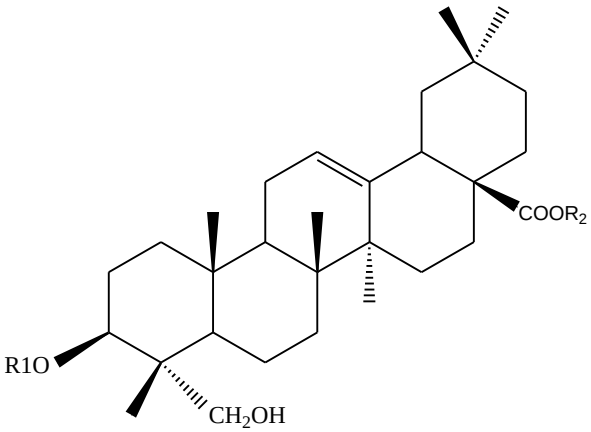

FIG.: STRUCTURE OF SAPIMUSAPONINS K-N, SAPINDOSIDES A-E, MUKOROZI SAPONIN E1, G, Y1, Y2 &X

Fig.	R1	R2
25	Ara_2-Rha_3-Ara_3-OAc	H
26	Ara_2-Rha_3-Rha_4-OAc	H
27	Ara_2-Rha_3-$Xyl^{2\text{-OAC}}_{3\text{-OAC}}$	H
28	Ara_2-Rha_3-$Xyl^{2\text{-OAC}}_{4\text{-OAC}}$	H
29	Ara_2-Rha_3-$Xyl^{3\text{-OAC}}_{4\text{-OAC}}$	H
30	Ara_2-Rha_3-Xyl_4-OAC	H
31	Ara_2-Rha_3-Xyl	Glc_2-Glc
32	Ara_2-Rha_3-Xyl	Glc_2-Glc
33	Ara_2-Rha	Glc_2-Glc
34	Ara_2-Rha	H
35	Ara_2-Rha_3-Xyl	H
36	Ara_2-Rha_3-Xyl_4-Glc	H
37	Ara_2-Rha_3-Xyl_4-$Glc^{6\text{-Rha}}_{2\text{-Glc}}$	H
38	Ara_2-Rha_3-Xyl	Ara_2-Rha_3-Xyl_4-$Glc^{6\text{-Rha}}_{2\text{-Glc}}$

The chemical names of all the types of saponins mentioned above are summarized in **Table 1**. (The chemical names are as reported by the authors in various journals).

TABLE 1: LIST OF SAPONINS ISOLATED FROM *SAPINDUS MUKOROSSI*

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*-α-L-rhamnopyranosyl-(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-L-rhamnopyranosyl-(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-L-rhamnopyranosyl-(1→6)-β-D-glucopyranosyl	Tirucullane	19	15

H	21 α-methoxy-3-β-21(S), 23I-epoxy tirucall-7,24-diene-3-O-α-L-rhamnopyranosyl-(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-L-dirhamnopyranosyl-(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-L-dirhamnopyranosyl-(1→2,6)-β-D-glucopyranosyl	Tirucullane	22	15
K	hederagenin-3-O-(3-O-acetyl-alpha-L-arabinopyranosyl)-(1→3)-alpha-L-rhamnopyranosyl-(1→2)-alpha-L-arabinopyranoside	Oleanane	25	16
L	hederagenin-3-O-(4-O-acetyl-alpha-L-arabinopyranosyl)-(1→3)-alpha-L-rhamnopyranosyl-(1→2)-alpha-L-arabino-pyranoside,	Oleanane	26	16
M	hederagenin-3-O-(2,3-O-diacetyl-beta-D-xylopyranosyl)-(1→3)-alpha-L-rhamnopyranosyl-(1→2)-alpha-L-arabinopyranoside	Oleanane	27	16
N	hederagenin-3-O-(2,4-O-diacetyl-beta-D-xylopyranosyl)-(1→3)-alpha-L-rhamnopyranosyl-(1→2)-alpha-L-arabinopyranoside	Oleanane	28	16
O	3,7,20(S)-trihydroxydammar-24-ene-3-O-alpha-L-rhamnopyranosyl-(1→2)-beta-D-glucopyranoside	Dammarane	13	16
P	3,7,20(R)-trihydroxydammar-24-ene-3-O-alpha-L-rhamnopyranosyl-(1→2)-beta-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-L-rhamnopyranosyl-(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-D-glucopyranosyl-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-D-glucopyranosyl (21,23*R*)-epoxyl tirucalla-7,24-diene-(21*S*)-ethoxyl-3β-ol	Tirucullane	3	20
D	3-*O*-α-L-rhamnopyranosyl-(1→2)-[α-L-arabinopyranosyl-(1→3)]-β-D-glucopyranosyl (21,23*R*)-epoxyl tirucall-7, 24-diene-(21*S*)-methoxyl-3β-ol .	Tirucullane	4	20
E	3-*O*-α-L-arabinopyranosyl-(1→3)-α-L-rhamnopyranosyl-(1→2)-[α-L-arabinopyranosyl-(1→3)]-β-D-glucopyranosyl (21,23*R*)-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-L-arabinopyranosyl-(1→3)]-β-D-glucopyranosyl 21,23*R*-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-L-arabinopyranosyl-(1→3)]-β-D-glucopyranosyl (21,23*R*)-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-L-rhamnopyranosyl-(1→3)]-β-D-glucopyranosyl 21,23*R*-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-L-rhamnopyranosyl-(1→3)]-β-D-glucopyranosyl 21,23*R*-epoxyl tirucalla-7,24-diene-21β-methoxy-3β-ol}	Tirucullane	9	21
J	{3-*O*-α-L-rhamnopyranosyl-(1→6)-β-D-glucopyranosyl 21,23*R*-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-L-rhamnopyranosyl-(1→2)-α-L-arabinoside.	Oleanane	29	16
E1	Hederagenin-3-O-α-L-arabinosyl-(1→3)-α-L-rhamnopyranosyl-(1→2)-α-L-arabinoside.	Oleanane	30	16

Phytoanalytical methods: A colorimetric assay method for the estimation of total saponin content of *Sapindus mukorossi* was reported by Diwedi *et al* [23]. High performance thin layer chromatography (HPTLC) as well as high performance liquid chromatography (HPLC) method combined with ES-MS are developed and validated for fingerprinting Sapindus saponin and quantitative determination of Sapindoside B, one of the oleanane type triterpene saponin, in bulk drug samples of Sapindus saponin and its formulation consap cream [22].

Pharmacology:

Insecticidal activity: Ethanolic extract of *Sapindus mukorossi* was investigated for repellency and insecticidal activity against *Sitophilus oryzae* and *Pediculus humanus*. 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 [24].

Spermicidal activity: Saponin isolated from *Sapindus mukorossi* has potent spermicidal activity. Morphological changes in human ejaculated spermatozoa after exposure to this saponin were evaluated under scanning electron microscopy. The minimum effective concentration (0.05% in spot test) did not affect the surface topography after exposure for 1 minute. However, incubation of spermatozoa for 10 minutes resulted in extensive vesiculation and disruption of plasma membrane in the head region. Higher concentrations (0.1%, 1.25%, 2.5% and 5.0%) caused more or less similar changes which included vesiculation, vacuolation, disruption or erosion of membranes in the head region. These findings suggest that the morphological changes observed are due to alterations in the glycoproteins associated with the lipid bilayer of plasma membrane of spermatozoa [25].

Another intimate use of soapnut is as a contraceptive cream. Very soon consap a contraceptive cream developed by the Lucknow CDRI is going to hit the Indian markets. It is advocated to be totally safe and easy to use. It is intended for post-coital use [26]. The cream is recommended for all women of reproductive age group who want to space their children. It is safe and free from systemic side effects on continuous prolonged use. The preparation has been developed by using saponins from the soapnut or reetha (Sapindus mukorossi). The cream went through all regulatory testing and Phase I, II and III clinical trials and proved to be an effective contraceptive product. DCG (I) cleared the cream for use. It has been licensed to the Hindustan Latex Limited who is going to market the product [27].

Spermicidal activity on human sperm of polyherbal pessary, formulated with purified ingredient from neem leaves, *S. mukorossi* (pericarp of fruit) and Mentha oil was tested by Sander-Cramer slide test in vitro and by post-coital tests in vivo. The combination of three herbal ingredients resulted in potentiation of spermicidal action by eight folds, when tested in rabbit [28].

Anti-protozoal activity: The gonotropic cycle of female Anopheles was impaired by exposure to neem, reetha (*S. mukorossi*) and garlic [29].

Anti-inflammatory activity: The anti-inflammatory activities of hederagenin and crude saponin isolated from *Sapindus mukorossi* were investigated utilizing carrageenan-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 examined. In some experiments, the results were compared with those obtained with saikogenin A, crude platycodin, platycodigenin and oleanolic acid. Anti-inflammatory activity on carrageenan edema was observed with i. p. and p. o. administered crude saponin, while hederagenin and the other agents used showed activity only when administered i. p. Hederagenin, 100 and 200 mg/kg p. o. per day for 7 days, showed no significant inhibitory effect on granuloma and exudate formations in rats, while crude saponin, 100 and 200 mg/kg p. o., showed significant effects.

Crude saponin, 200 mg/kg p. o. per day for 21 days, significantly inhibited the development of hind paw edema associated with adjuvant arthritis in rats, but hederagenin, 50-200 mg/kg p. o., did not. Crude saponin, 400 mg/kg p. o., inhibited the increase in vascular permeability and the number of writhings

induced by acetic acid in mice. The results suggest that hederagenin and crude saponin, as well as the other agents used, show some degree of anti-inflammatory activity, especially in the case of saponin [30].

Piscicidal activity: Effects of *Sapindus mukorossi* have been studied on fish. Pericarp of *Sapindus mukorossi* is the most toxic parts yielding 100% mortality rate within 12 hours and mean survival time was found to be 1.18 hours. LD_0, LD_{50}, LD_{100} ranging between 3.5ppm and 10 ppm at 48 hrs and possess high potential for fish eradication. *Sapindus mukorossi* fruit pericarp can be used as a selective eradicant for horny fish like *Heteropneustes fossils* and *channa punctuate*[31]

Cytotoxic activity: *In- vitro* cytotoxic activity of triterpenoid saponins from *Sapindus mukorossi* showed that α-hederin, β-hederin, Sapindoside A, Sapindoside B, Sapindoside C, Sapindoside D exhibited good cytotoxic activity at 10µg/ml to 100µg/ml when tested on four cell strains like Mouse B16 melanoma cells, Mouse 3T3 non-cancer fibroblasts, Flow 2002 non-cancer human cells and HeLa human tumor cells. Strychnopentamine was the reference compound used in the study. All saponins were reported to be at least 5 times less active than the reference compound [32].

Hepatoprotective activity: The dried powder of *S. mukorossi* and *R. emodi* was extracted successively with petroleum ether, benzene, chloroform, and ethanol and concentrated in vacuum. *In- vitro* and *in-vivo* studies were done to prove the hepatoprotective activity of different extracts of S*. mukorossi* and *R. emodi*. Primary rat hepatocyte monolayer cultures were used for *in vitro* studies.

These cultures were treated with CCl_4 and extracts of S*. mukorossi* & *R. emodi*. A protective activity could be demonstrated in the CCl_4 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 *R. emodi* was analyzed in liver injured CCl_4- treated male rats. Extracts of the fruit pericarp of S*. mukorossi* (2.5 mg/mL) and rhizomes of *R. emodi* (3.0 mg/mL) were found to have protective properties in rats with CCl_4 induced liver damage as judged from serum marker enzyme activities. Thus, it was concluded that the extracts of *S. mukorossi* and *R. emodi* do have a protective capacity both in vitro on primary hepatocytes cultures and in *in-vivo* in a rat model of CCl_4 mediated liver injury [33].

Anti-platelet aggregation activity: Biological evaluation of ethanolic extract of the galls of *S. mukorossi* showed that two saponins isolated, Sapinmusaponins Q and R, demonstrated more potent anti-platelet aggregation activity than aspirin [18].

Sapinmusaponins F-J isolated from the galls of S.mukorossi showed anti-platelet-aggregation effects, but no obvious cytotoxic activity for platelets as assayed by lactate dehydrogenase (LDH) leakage was reported [15].

Anti-trichomonas activity: Using *in- vitro* susceptibility assay, the MIC of *Sapindus* saponins for *T. vaginalis* (0.005%) was found to be 10-fold lower than its effective spermicidal concentration (0.05%). Saponins concentration dependently inhibited the ability of parasites to adhere to HeLa cells and decreased proteolytic activity of the parasite's cysteine proteinases. This was associated with decreased expression of adhesin AP65 and membrane-expressed cysteine proteinase TvCP2 genes. Saponins produced no adverse effect on host cells in mitochondrial reduction potential measurement assay.

Saponins also reversed the inhibitory mechanisms exerted by *Trichomonas* for evading host immunity. Early response of saponins to disrupt actin cytoskeleton in comparison with their effect on the nucleus suggests a membrane-mediated mode of action rather than via induction of apoptosis [34].

Anti-fungal activity: Extracts from the dried pericarp of *Sapindus saponaria* L. (Sapindaceae) fruits were investigated for their antifungal activity against clinical isolates of yeasts *Candida albicans* and *C. non-albicans* from vaginal secretions of women with Vulvovaginal Candidiasis. Four clinical isolates of *C. albicans*, a single clinical isolated of each of the species *C. parapsilosis, C. glabrata, C. tropicalis*, and the strain of *C. albicans* ATCC 90028 were used. The hydroalcoholic extract was bioactivity-directed against a clinical isolate of C. parapsilosis, and showed strong activity. The n-BuOH extract and one fraction showed strong activity against all isolates tested [35].

CONCLUSION: *S. mukorossi* is a common plant available at various places in India. The plant is widely used in cosmetic preparation like shampoos and cleansers. It is reported to contain mainly oleanane, dammarane and tirucullane type saponins. The structures and chemical name of various saponins isolated from *S. mukorossi* have been compiled in the present review. The pharmacological studies reported in the present review confirm the therapeutic value of this plant.

There is a lack of phytoanalytical methods available for the estimation of chemical markers from this plant. Quantitative analysis of the different constituents of *S. mukorossi* from its different parts is still not successful. Phytochemical studies on this plant except for saponins have not yet been explored. This review will provide a basic idea of most of the phytoconstituents present in *S. mukorossi* less than one heading With the availability of primary information, further studies can be carried out like phytopharmacology of different extracts, standardization of the extracts, identification and isolation of active principles, and pharmacological studies of isolated compound.

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