PHARMACOLOGICAL EFFECTS OF Sapindus mukorossi

Aparna UPADHYAY & D.K. SINGH

SUMMARY

Sapindus mukorossi is an extremely valuable medicinal plant, distributed in tropical and sub-tropical regions of Asia. The aim of present review is to form a short compilation of the phytochemical composition and pharmacological properties of this multipurpose tree. The main phytoconstituents isolated and identified from different parts of this plant are triterpenoidal saponins of oleanane, dammarane and tirucullane type. The structure and chemical names of all the types of triterpenoidal saponins reported in Sapindus mukorossi are included in this review. Many research studies have been conducted to prove the plant’s potential as being spermicidal, contraceptive, hepatoprotective, emetic, anti-inflammatory and anti-protozoal. The present review highlights some of the salient pharmacological uses of Sapindus mukorossi.

KEYWORDS: Sapindus mukorossi; Pharmacology; Saponins.

INTRODUCTION

Sapindus mukorossi Gaertn., a member of the family Sapindaceae, is commonly known by several names such as soapnut, soapberry, washnut, reetha, aritha, dodan and doadni. It is a deciduous tree widely grown in upper reaches of Indo-Gangetic plains, Shivaliks and sub Himalayan tracts at altitudes from 200 m to 1500 m. The Sapindus mukorossi is a fairly large, deciduous tree with a straight trunk up to 12 meters 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 is dark to pale yellow, fairly smooth, with many vertical lines of lenticels and fine fissures exfoliating in irregular wood scales. The blaze is 0.8-1.3 cm, hard, not fibrous, pale orange brown, brittle and granular. Leaves are 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 is a compound terminal panicle, 30 cm or more in length, with pubescent branches. Flowers are about 5 mm across, small, terminal, polygonous, greenish white, subsessile, numerous, mostly bisexual. Sepals 5, each with a woolly scale on either side above the claw. Fruits are globose, fleshy, 1-seeded drupe, sometimes two drupel together, about 1.8-2.5 cm across. Seeds are 0.8-1.3 cm in diameter, globose, smooth, black and loosely placed in dry fruit.

The fruit is valued for the saponins (10.1%) present in the pericarp and constitutes up to 56.5% of the drupe known for inhibiting tumor cell growth. In China and Japan it has been used as a remedy for centuries. In Japan its pericarp is called “enmei-hi”, which means “life prolonging pericarp” and in China “wu-huan-zi”, the “non-illness fruit”. The major compounds isolated from Sapindus mukorossi are triterpenoidal saponins of mainly three oleane, dammarane and tirucullane types. Recently many of the pharmacological actions of this plant have been explored which includes the antimicrobial, cytotoxic, molluscicidal, insecticidal, piscicidal and fungicidal activities. One of the most talked about activities of this plant is the contraceptive activity of the saponins extracted from the pericarp of the fruit.

Sapindus mukorossi is well known for its folk medicinal values. Pericarps of Sapindus mukorossi have been traditionally used as an expectorant as well as a source of natural surfactant. Due to the presence of saponins, soapnut is well known for its detergent and insecticidal properties and it is traditionally used for removing lice from the scalp. The fruits are of considerable importance for their medicinal value for treating a number of diseases like excessive salivation, pimples, epilepsy, chlorosis, migranes, eczema and psoriasis. The powdered seeds are employed in the treatment of dental caries, arthritis, common colds, constipation and nausea. The seeds of Sapindus mukorossi are used in Ayurvedic medicine to remove tan and freckles from the skin. It cleanses the skin of oily secretion and is even used as a cleanser for washing hair as it forms a rich, natural lather. The leaves are used in baths to relieve joint pain and the roots are used in the treatment of gout and rheumatism. Since ancient times Sapindus mukorossi has been used as a detergent for shawls and silks. The fruit of Sapindus mukorossi was utilized by Indian jewelers for restoring the brightness of tarnished ornaments made of gold, silver and other precious metals.
The major constituents of Sapindus mukorossi fruit are saponins (10%-11.5%), sugars (10%) and mucilage. Saponins are secondary plant metabolites with divergent biological activities. Sapindus saponins are a mixture of six sapindosides (sapindosides A, B, C, D and mukorozisaponins E and Y), with sapindoside B as one of the major constituents, isolated by n-butanol extraction of the ethanolic extract of fruit pericarp of Sapindus mukorossi and identified by liquid chromatography and mass spectrometry. Saponins are a large family of structurally-related compounds of steroid or triterpenoid aglycone (sapogenin) linked to one or more oligosaccharide moieties by glycosidic linkage. The aglycone, or sapogenin, may contain one or more unsaturated C-C bonds. The oligosaccharide chain is normally attached at the C1 position (monodesmosidic), but many saponins have an additional sugar moiety at the C1,2 or C2,3 position (bidesmosidic). The great complexity of the saponin structure arises from the variability of the aglycone structure, the nature of the side chains and the position of attachment of these moieties on the aglycone. The carbohydrate moiety consists of pentoses, hexoses or uronic acids. Due to this complexity, saponins are difficult to classify. Because it is no longer customary to classify compounds based on their physicochemical or biological properties, a state of the art classification based on the biosynthesis of the saponin carbon skeletons was proposed by VINCKEN et al.

Different types of triterpene, saponins of oleanean, dammarane and tirucullane type were isolated from the galls, fruits and roots of Sapindus mukorossi. Oleanean type triterpenoid saponins named Sapindoside A&B (Fig. 34 & 35) were reported from the fruits of Sapindus mukorossi. Sapindoside C (Fig. 36), Sapindoside D (Fig. 37), which is a hexaside of hederagenin, and Sapindoside E (Fig. 38), a nonaside of hederagenin, was isolated and identified 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. Triterpene-type saponins, sapinmusaponins F-J (Fig. 18-22), were isolated from the fruits of Sapindus mukorossi as reported by HUANG et al.

The structures of these saponins were elucidated on the basis of spectroscopic analysis including 1D and 2D NMR techniques.

Triterpene saponins of oleanean 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. In another study by NAKAYAMA et al., 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 tirucullane type triterpenoid saponins, sapinmusaponin Q and R (Fig. 23-24), along with three known oleanean 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. Further investigation of the roots of Sapindus mukorossi by NI et al. reported the presence of Sapimukosides E-J. The structures of Sapimukosides A-J are shown in Fig. 1 to Fig. 10 respectively. Table 1 shows whole view of all the saponins isolated from Sapindus mukorossi.

**Abbreviations**

Glc: β-D-Glucopyranosyl  
Rha: α-L-Rhamnopyranosyl  
Ara: α-L-Rabinopyranosyl  
Xyl: β-D-Xylopyranosyl

**BIOLOGICAL EFFECTS**

1. **Anti-bacterial activity**: IBRAHIM et al. evaluated that 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. In the *in vitro* study, the isolates show a considerable zone of inhibition at very low concentration (10 µg/mL) and in the *in vivo*
### Table 1

**List of Saponins isolated from Sapindus mukorossi**

<table>
<thead>
<tr>
<th>Saponins</th>
<th>Chemical name</th>
<th>Tirucullane/oleanane/dammarane type</th>
<th>Structure</th>
<th>Reference</th>
</tr>
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<tbody>
<tr>
<td><strong>Sapindoside</strong></td>
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<tr>
<td>A</td>
<td>3,7,20(S),22-tetrahydroxydammar-24-ene-3-O-α-L-rhamnopyranosyl(1→2)-D-glucopyranoside</td>
<td>Dammarane</td>
<td>11</td>
<td>Yao et al., 2005</td>
</tr>
<tr>
<td>B</td>
<td>Hederagenin-3-O-β-D-glucosyl(1→4)-β-D-xylonopyranosyl(1→3)-α-L-rhamnopyranosyl(1→2)-α-L-arabinoside</td>
<td>Oleanane</td>
<td>36</td>
<td>Chirva et al., 1970 b</td>
</tr>
<tr>
<td>C</td>
<td>Hederagenin-3-O-β-D-glucosyl(1→4)-β-D-xylonopyranosyl(1→3)-α-L-rhamnopyranosyl(1→2)-α-L-arabinoside</td>
<td>Oleanane</td>
<td>35</td>
<td>Chirva et al., 1970 a</td>
</tr>
<tr>
<td>D</td>
<td>21-ydroxysapogenol A</td>
<td>Dammarane</td>
<td>14</td>
<td>Yao et al., 2006</td>
</tr>
<tr>
<td>E</td>
<td>3,7,20(S),22,25-pentahydroxydammar-23-ene-3-O-α-L-rhamnopyranosyl(1→2)-D-glucopyranoside</td>
<td>Dammarane</td>
<td>15</td>
<td>Yao et al., 2005</td>
</tr>
<tr>
<td>F</td>
<td>21β-methoxy-3,7,20(S),22-trihydroxydammar-23-ene-3-O-α-L-rhamnopyranosyl(1→2)-D-glucopyranoside</td>
<td>Dammarane</td>
<td>16</td>
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</tr>
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<td>G</td>
<td>21α-methoxy-3,7,20(S),22-trihydroxydammar-23-ene-3-O-α-L-rhamnopyranosyl(1→2)-D-glucopyranoside</td>
<td>Dammarane</td>
<td>17</td>
<td>Yao et al., 2005</td>
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<td>H</td>
<td>21α-methoxy-3,7,20(S),22-trihydroxydammar-23-ene-3-O-α-L-rhamnopyranosyl(1→2)-D-glucopyranoside</td>
<td>Dammarane</td>
<td>18</td>
<td>Yao et al., 2005</td>
</tr>
<tr>
<td>I</td>
<td>21β-methoxy-3,7,20(S),22-trihydroxydammar-23-ene-3-O-α-L-rhamnopyranosyl(1→2)-D-glucopyranoside</td>
<td>Dammarane</td>
<td>19</td>
<td>Yao et al., 2005</td>
</tr>
<tr>
<td>J</td>
<td>21β-methoxy-3,7,20(S),22-trihydroxydammar-23-ene-3-O-α-L-rhamnopyranosyl(1→2)-D-glucopyranoside</td>
<td>Dammarane</td>
<td>20</td>
<td>Yao et al., 2005</td>
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<td>Dammarane</td>
<td>21</td>
<td>Yao et al., 2005</td>
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<td>22</td>
<td>Yao et al., 2005</td>
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<td>Yao et al., 2005</td>
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<td>Dammarane</td>
<td>24</td>
<td>Yao et al., 2005</td>
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<td>21β-methoxy-3,7,20(S),22-trihydroxydammar-23-ene-3-O-α-L-rhamnopyranosyl(1→2)-D-glucopyranoside</td>
<td>Dammarane</td>
<td>25</td>
<td>Yao et al., 2005</td>
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<td>Dammarane</td>
<td>26</td>
<td>Yao et al., 2005</td>
</tr>
<tr>
<td>Q</td>
<td>21β-methoxy-3,7,20(S),22-trihydroxydammar-23-ene-3-O-α-L-rhamnopyranosyl(1→2)-D-glucopyranoside</td>
<td>Dammarane</td>
<td>27</td>
<td>Yao et al., 2005</td>
</tr>
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<td>21β-methoxy-3,7,20(S),22-trihydroxydammar-23-ene-3-O-α-L-rhamnopyranosyl(1→2)-D-glucopyranoside</td>
<td>Dammarane</td>
<td>28</td>
<td>Yao et al., 2005</td>
</tr>
<tr>
<td>S</td>
<td>21β-methoxy-3,7,20(S),22-trihydroxydammar-23-ene-3-O-α-L-rhamnopyranosyl(1→2)-D-glucopyranoside</td>
<td>Dammarane</td>
<td>29</td>
<td>Yao et al., 2005</td>
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<td>T</td>
<td>21β-methoxy-3,7,20(S),22-trihydroxydammar-23-ene-3-O-α-L-rhamnopyranosyl(1→2)-D-glucopyranoside</td>
<td>Dammarane</td>
<td>30</td>
<td>Yao et al., 2005</td>
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<td>U</td>
<td>21β-methoxy-3,7,20(S),22-trihydroxydammar-23-ene-3-O-α-L-rhamnopyranosyl(1→2)-D-glucopyranoside</td>
<td>Dammarane</td>
<td>31</td>
<td>Yao et al., 2005</td>
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<td>V</td>
<td>21β-methoxy-3,7,20(S),22-trihydroxydammar-23-ene-3-O-α-L-rhamnopyranosyl(1→2)-D-glucopyranoside</td>
<td>Dammarane</td>
<td>32</td>
<td>Yao et al., 2005</td>
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<tr>
<td>W</td>
<td>21β-methoxy-3,7,20(S),22-trihydroxydammar-23-ene-3-O-α-L-rhamnopyranosyl(1→2)-D-glucopyranoside</td>
<td>Dammarane</td>
<td>33</td>
<td>Yao et al., 2005</td>
</tr>
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</table>
In the experiments with \( \alpha \)-acetyl-\( \beta \)-O-l-xylanopyranosyl-(1\( \rightarrow \)3)-\( \alpha \)-L-arabinopyranosyl-(1\( \rightarrow \)3)-\( \beta \)-D-glucopyranosyl-21,23R-epoxy tirucalla-7,24-diene-21\( \beta \)-methoxy-3\( \beta \)-ol \), average mortality percentage was proportional to the concentration of the extracts.

Higher concentrations (0.1\%, 1.25\%, 2.5\% and 5.0\%) caused more or less vesiculation and a disruption of the plasma membrane in the head region. However, incubation of spermatozoa for 10 minutes resulted in extensive erosion of membranes in the head region. These findings suggest that the morphological changes observed are due to alterations in the glycoproteins that the saponins interact with.

The minimal effective concentration (0.05\% in spot test) did not affect the surface topography after exposure for one minute. Electron microscopy showed that the spermatozoa after exposure to this saponin were evaluated under scanning electron microscopy. The morphology of spermatozoa was assessed for spermicidal activity.

3. Spermicidal activity: Saponins from Sapindus mukorossi are known to be spermicidal\(^{12,27}\). 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 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 (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 the plasma membrane of spermatozoa\(^{4}\). This spermicidal property has been used in contraceptive cream\(^{6}\).

4. Anti-Trichomonas activity: TIWARI et al.\(^{29}\) demonstrated that the Sapindus saponin mixture shows anti-Trichomonas activity at a 10-fold lower concentration (0.005\%) than its minimal effective concentration.
spermicidal concentration against human spermatozoa (0.05%)\(^1\). 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 with the decreased expression of adhesin AP65 and membrane-expressed cysteine proteinase TvCP2 genes. Saponins produced no adverse effect on host cells in the mitochondrial reduction potential measurement assay. Saponin disrupts the actin cytoskeleton network beneath the cell membrane and affects membrane-mediated adherence of *Trichomonas* to the host cells.

5. **Anti-cancer activity:** Due to the great variability in saponin structure, saponins always display anti-tumorigenic effect through varieties of anti-tumor pathways. There are more than 11 distinguished classes of saponins including dammarnanes, tirucallanes, lupanes, hopanes, oleananes, taraxasteranes, ursanes, cycloartanes, lanostanes, cucurbitanes and steroids. Ginsenosides, belonging to dammaranes, have been found beneficial in the inhibition of tumor angiogenesis by suppressing its inducer in the endothelial cells of blood vessels, and then in the prevention of adhering, invasion and metastasis of tumor cells\(^2\).

Dioscin, one of the steroidal saponins, and its aglycone diosgenin also has an extensive anti-tumor effect by cell cycle arrest and apoptosis\(^2\). The preliminary bioassay data revealed that saponins\(^3\) showed moderate cytotoxic activity (ED\(_{50}~9.18\mu g/mL) against human tumor cell lines (HepaS9T/VGH, NCL, HeLa and Med)\(^3\). Strychnepentamine was the reference compound used in the study. All saponins were reported to be at least five times less active than the reference compound\(^3\).

6. **Hepatoprotective activity:** IBRAHIM et al.\(^1\) reported 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 (CCl\(_4\)) mediated liver injury as judged from serum marker enzyme activities. These cultures were treated with CCl\(_4\) and extracts of *Sapindus mukorossi* & *Rheum 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 *Sapindus mukorossi* and the rhizomes of *Rheum emodi* was analyzed in liver injured CCl\(_4\)-treated male rats. Extracts of the fruit pericarp of *Sapindus mukorossi* (2.5 mg/mL) and rhizomes of *Rheum 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 *Sapindus mukorossi* and *Rheum emodi* do have a protective capacity both in vitro on primary hepatocytes cultures and in vivo in a rat model of CCl\(_4\) mediated liver injury.

7. **Anxiolytic activity:** Methanolic extracts of *Sapindus mukorossi* (200 and 40 mg/L) show significant anxiolytic activity as compared to standard anxiolytics Diazepam (2 mg/Kg) and Fluoxetine (10 mg/Kg).
hederagenin 3-O-(3,4-di-acetyl-β-D-xylopyranosyl)-(1→3)-α-L-rhamnopyranosyl-(1→2)-α-L-arabinopyranoside [5], hederagenin 3-O-β-D-xylopyranosyl-(1→3)-α-L-rhamnopyranosyl-(1→2)-α-L-arabinopyranoside [6], and hederagenin 3-O-α-L-arabinopyranoside [7]. The bioassay data revealed that I-7 were molluscicidal, causing 70-100% mortality at 10 ppm against the golden apple snail.\textsuperscript{16}

UPADHYAY & SINGH\textsuperscript{12} reported that Sapindus mukorossi fruit pericarp is a potential source of botanical molluscicides against Lymnaea acuminata. These snails are the intermediate host of liver fluke Fasciola gigantica, which causes 94% fascioliasis in the buffalo population of northern India\textsuperscript{13}. The active molluscicidal component of Sapindus mukorossi fruit is soluble in chloroform, ether, acetone and ethanol. The toxicity of Ethanolic extract of Sapindus mukorossi fruit powder is higher than other extracts which indicates that the molluscicidal component present is more soluble in ethanol than other organic solvents. UPADHYAY & SINGH\textsuperscript{12} characterized that saponin is the active component present in Sapindus mukorossi fruit by High Performance Liquid Chromatography. A comparison of the molluscicidal activity of the column-purified fraction of Sapindus mukorossi fruit powder with synthetic molluscicides clearly demonstrates that the purified fraction of Sapindus mukorossi is more potent. The LC\textsubscript{50} at 96 h of the column–purified fraction of Sapindus mukorossi fruit powder (5.43 mg/L) against Lymnaea acuminata is lower than those of synthetic molluscicide-carbaryl (14.40 mg/L), phorate (15.0 mg/L), formothion (8.56 mg/L) and niclosamide (11.8 mg/L)\textsuperscript{15}. LC\textsubscript{50} at 96 h of crude powder of Sapindus mukorossi (119.57 mg/L) against Lymnaea acuminata is lower than the crude powder of Canna indica root (359.02 mg/L)\textsuperscript{10}, Thuya orientalis leaf powder (250.55 mg/L), Thuya orientalis fruit powder (255.12 mg/L)\textsuperscript{11}, Zingiber officinale rhizome (273.80 mg/L), Allium cepa bulb (253.27 mg/L)\textsuperscript{14}.

9. Tyrosinase inhibition and free radical scavenging: CHEN et al.\textsuperscript{2} first evaluated 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.

10. Fungicidal activity: The crude extract of Sapindus mukorossi exhibits 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 investigated for their antifungal activity against clinical isolates of yeasts Candida albicans and Candida non-albicans from vaginal secretions of women with Vulvovaginal Candidiasis. Four clinical isolates of C. albicans, a single clinical isolate 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-ButOH extract and one fraction showed strong activity against all isolates tested\textsuperscript{41}. The saponin fraction inhibited the dermatophytic fungi Trichophyton rubrum, Trichophyton mentagrophytes, Sabouraudites canis and Epidermophyton floccosum\textsuperscript{37}.
11. Anti-inflammatory activity: TAKAGI et al.\textsuperscript{15} reported that crude saponin and hederagenin isolated from \textit{Sapindus mukorossi} inhibited the development of carrageen-induced edema in the rat hind paw as well as on granuloma and exudates formations induced by croton oil in rats. The effects of these agents on vascular permeability and acetic acid induced writhing in mice were also examined. Anti-inflammatory activity on carrageen edema was observed after intraperitoneal and oral administration of crude saponin, whilst hederagenin and the other agents showed activity only when administered.

12. Piscicidal activity: Effects of \textit{Sapindus mukorossi} have been studied on fish. Pericarp of \textit{Sapindus mukorossi} is the most toxic parts yielding 100% mortality within 12 hours and mean survival time was found to be 1.18 hours. LD\textsubscript{10}, LD\textsubscript{50}, LD\textsubscript{100} ranging between 3.5 ppm and 10 ppm at 48 hrs and possess high potential for fish eradication. \textit{Sapindus mukorossi} fruit pericarp can be used as a selective eradicant for horny fish like \textit{Heteropneustes fossilis} and \textit{channa punctata}\textsuperscript{4}.

13 Anti-platelet aggregation activity: HUANG and co workers demonstrated that five new tirucallane type saponins, sapinmusasaponins from the galls of \textit{Sapindus mukorossi}, showed moderate activity in a 12-0-tetradeacyanophorbol-13-acetate (TPA)-induced Epstein-Barr virus early antigen (EBV-EA) activation assay\textsuperscript{23}.

**DISCUSSION**

\textit{Sapindus mukorossi} is a versatile and exceptionally valuable medicinal plant. It is known by such regional names as soapnut, soapberry, washnut, reetha and dodan. The phytochemical screening of the plant extract showed the presence of saponins (10.1%) present in the pericarp of the fruit. The use of \textit{Sapindus mukorossi} in folk medicine worldwide\textsuperscript{40} is validated by scientific studies that have demonstrated the efficacy of the extracts in various experimental models. Pharmacological effects of \textit{Sapindus mukorossi} have been reported like anti-bacterial\textsuperscript{19}, insecticidal\textsuperscript{12,13,28}, sporicidal\textsuperscript{11,27}, anti-trichomonas\textsuperscript{11,39}, anti-tumor\textsuperscript{22,29,36} hepatoprotective\textsuperscript{18}, anxiolytic\textsuperscript{1}, molluscicidal\textsuperscript{16,42}, fungicidal\textsuperscript{17,41}, anti-inflammatory\textsuperscript{48} and piscicidal\textsuperscript{44} activities and are being employed for the treatment of different ailments in the indigenous system of medicine. Although a number of phytochemicals present in \textit{Sapindus mukorossi} have been isolated and identified by researchers working in different laboratories, their pharmacological/biological studies in human welfare has not been studied so far.

Most of the scientific study is confined to the elaboration of traditional practices of \textit{Sapindus mukorossi}. There is a long list of saponins present in \textit{Sapindus mukorossi}. It needs individual attention so that they can be explored in different pharmaceutical studies. The literature reviewed gives a limited picture of pharmacological effects of \textit{Sapindus mukorossi}. There is a need for much additional research regarding pharmacological effects of \textit{Sapindus mukorossi} at molecular level to explain their mode of action.

**CONCLUSION**

\textit{Sapindus mukorossi} is a tropical tree whose numerous economic applications and whose facility of propagation are arousing international interest. It needs to be widely cultivated in most of the areas where climatic conditions favor its optimum growth. In this way, a maximum yield of its different usable parts could be achieved to derive the maximal amount of commodities of a multifarious nature for the welfare of mankind. This plant has been used as traditional medicine for various ailments. The earlier reports on chemical investigation and pharmacological evaluation showed that \textit{Sapindus mukorossi} contains a number of bio-active novel compounds. As literature illustrates, many biological and pharmaceutical activities are shown by fractions of crude extracts and isolated substances. Furthermore, the detailed chemical analysis is required to isolate bio-active constituents from \textit{Sapindus mukorossi} and to trace out their biological activities. Thus, it can be concluded that \textit{Sapindus mukorossi} can play an important role in modern medical system in near future.

**RESUMO**

\textit{Sapindus mukorossi} é planta medicinal extremamente valiosa distribuída nas regiões tropical e subtropical da \textit{Ásia}. O propósito da presente revisão é uma compilação curta da composição fitoquímica e das propriedades farmacológicas desta \textit{árvore} que apresenta múltiplos propósitos. O principal fitoconstituinte isolado e identificado das diferentes partes desta planta são as saponinas triterpenoidais do tipo da oleana, damaran e tiruculana. A estrutura e o nome químico de todos os tipos de saponinas triterpenoidais encontrados no \textit{Sapindus mukorossi} estão incluídos nesta revisão. Muitas pesquisas tem sido conduzidas para provar o potencial desta planta como espermicida, contraceptivo, hépato-protetor, emético, anti-inflamatório e anti-protozoário. A presente revisão exalta alguns principais usos farmacológicos do \textit{Sapindus mukorossi}.

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