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Review Article

Bombax ceiba Linn. : A review of its phytochemistry and pharmacology

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ABSTRACT

Background: Since ancient time plants are main sources of human need in terms of food, shelter or medicine. *Bombax ceiba* L. (Fam: Bombacaceae) is an important plant in South East Asian countries not only for medicinal values but also for its economical importance. It a large, perennial tree available in Asia, Africa, Australia and India ascending the hills up to 1,500 m.

Aim of the review: The purpose of this review is to exhibit up-to-date and comprehensive information about phytochemistry, pharmacological activities of the plant and has an insight into the opportunities for the future research and development of plant.

Materials and methods: A bibliographic investigation was performed on all the available information regarding B. ceiba via electronic search (using Pubmed, SciFinder, Scopus, Scirus, Google Scholar, JCCC@INSTIRC, Web of Science and a library search for articles published in peer-reviewed journals).

Conclusion: Various phytoconstituents from the plant has been reported, which includes mangiferin, quercetin, shamimin, shamimoside, β–sitosterol, taraxeryl acetate, lupeol, simalin a, simalin b, shamimicin, bombamalones a–d, bombaxquinone b, bombamaloside and bombasin. The plant was evaluated for a number of activities such as analgesic, anthelmintic, anti cancer, antibacterial, antidiabetic, anti-inflammatory, hepatoprotective, immunomodulatory, cardioprotective, antiulcer, anti-diarrhoeal, antiviral, hypotensive activity. Present review demonstrates that the B. ceiba may serve as a good source of medicines in future. Majority of therapeutic claims for the plants in the various traditional medicines have been confirmed through experimental pharmacology.

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1. Introduction

Since ancient time, traditional medicine based on plant products are used by tribes, health care practioners and ethnic communities for the treatment of diseases all over the world. Some of established themselves and gloom worldwide (Patwardhan et al., 2005). When World Health Organization has started promotion of Primary Health Care (PHC) system development in developing countries, traditional health care systems and medicinal plants have been incorporated in the programme and given equal importance (Sofowora et al., 2013; Anonymous, 2013). The plants possess certain phytochemicals which act as healing agents. In traditional system of medidicne like Ayurveda and Chinese medicine etc., the plant used as whole in crude form (Verma et al., 2017; Sharma et al., 2017). With development of scientific communities theses phytoconstituents were not only identified but also used in therapies (Mahomoodally, 2013; Maurya et al., 2015a).

Due to adverse effect exerted by the synthetic drugs researchers work on isolation and identification of phytochemicals with modern scientific techniques. Many of them served as chemical leads for the development of therapeutic drugs against several diseases (Saklani and Kutty, 2008; Butler, 2004).

India has a rich and diverse medicinal flora and the root of healing system is so strong that a number of treatment methodology based on plants have been established such as Ayurveda, unani etc. (Maurya et al., 2015b). A number of plants are used in Ayurvedic medicine (Maurya et al., 2015b; Maurya and Seth 2014; Kushwaha and Maurya 2014; Maurya et al., 2015c; Mishra et al., 2015). *B. ceiba*, one of them, belongs to family Bombacaceae which contains about 30 tropical genera and 250 species (Anonymous, 2010). The plant species is used in different systems of medicine in India, China and Southeast Asian countries too. Every part of the

plant served not only as medicine but also used for various commercial purposes (cotton, fodder, fuel fiber and ship/ boat/catamaran building). The present review is based on the phytochemical and pharmacological studies of *B. ceiba*. This review is an effort to incorporate the available information concluding the valuable utility of *B. ceiba* and the gaps that need research intervention.

2. Plant description

2.1. Taxonomical classification

***Kingdom**: Plantae*
***Division**: Magnioliophyta*
***Class**: Magniolipsid*
***Order**: Malvales*
***Family**: Bombacaceae*
***Genus**: Bombax*
***Species**: ceiba*
***Binomial name**: Bombax ceiba L.; Bombax malabarica D.C. Salmalia malabarica (D.C.) Schott & Endl.*

2.2. Vernacular Names

- **Hindi**: Semal, Semar, Shimal, Nurma, Deokapas, Huttain
- **Sanskrit**: Shalmali, Chirajivika, Picchila, Kukkuti, Raktapushpaka, Kantakadruma, Bahuvirya, Tulavriksha
- **English**: Kapok tree, Silk cotton tree
- **Marathi**: Shembalsavari
- **Telugu**: Mandlaboorugachettu, Kondaburaga
- **Malayalam**: Mullulavamarum, Samparuthi

2.3. Distribution

B. ceiba, the large, beautiful and deciduous tree has its origin from Northern Australia. It is widely distributed in temperate Asia, tropical Asia, Africa and Australia. Plant grows throughout hotter parts of India, ascending the hills up to 1,500 m.

2.4. Morphology

The plant grows upto 25-30m height having large spreading branches with young stems covered with stout and hard prickles. The bark is pale ash to silver grey in color 1.8-2.5cm thick. Leaves are large, palmate, glabrous, 13-15cm long, 7- 10cm wide and leaflets 3-7, entire and lanceolate. In winter session the leaves usually drops and at the time of flowering again appear. Flowers are large in diameter, red in color and numerous with copious nectar. The fruits are brown in colour, capsule-like, upto 15 mm long, filled with numerous

Figure 1. *Bombax ceiba* Linn. (a): Leaves; (b): Flowers; (c): Semul Gum; (d): Young Root (e): Bark

-black, irregular obovoid shaped seeds. Seeds are smooth, embedded in white wool. Gummy exudate is obtained from the bark is sold in the market as "Semul gum", "Mocharasa" or "Suparika phula"(**Figure 1**).

3. Phytochemistry

Mangiferin [2–β–D–glucosyl–1,3,6,7–tetrahydroxyxanthone] **(1)**(Dar et al., 2005; Faizi et al., 2006; Faizi et al., 2012; Wang et al., 2012; Shahat et al., 2003), acyl and methyl derivatives of mangiferin **(15)** (Faizi et al., 2006), polysaccharide (Du et al., 2011), shamimoside [4–C–β–D–glucopyranosyl–1,3,6,8–tetrahydroxy–7–O– (p–hydroxybenzoyl)–9H–xanthen–9–one] **(2)**, stigma–5–en–3–O–β–glucoside, β–amyrin **(3)** (Faizi et al., 2012), shamimin [2– (2,4,5–trihydroxyphenyl)–3,5,7–trihydroxy–6–C-glucopyranosyloxy–4H–1–benzopyran–4–One] **(4)** [20-22](Saleem et al., 1999; Faizi and Ali, 1999; Yadav et al., 2014), quercetin **(5)**(Wang et al., 2012; Verma et al., 2015), aesculetin **(6)**, aesculin **(7)**, gentisic acid **(8)**, protocatechuic acid (9), glucosyringic acid (10), luteolin–4'–glucoside **(11)**, scoparone **(12)**, limettin **(13)**, scopoletin **(14)**, scopolin **(15)**(Wang et al., 2012), β–hydroxyl–pregnane–4,16–diene–3,20–bione, 1H–Indole–3–carboxylic acid **(16)**, 4–methylstigmast–7–En–3–Ol,5– (hydroxymethyl) furfural, 6–O–palmitoylsitosteryl–D–glucoside, loliolide **(17)**, squalene **(18)**, taraxerol **(19)**, taraxerone **(20)**, taraxeryl acetate **(21)** (Wang et al., 2014), β–sitosterol **(22)** (Yadav et al., 2014; Wang et al., 2014), lupeol **(23)**, α–amyrin **(24)** (Yadav et al., 2014) were reported from leaves of *B. ceiba*.

Phytoconstituents (+/–)–lyoniresinol 2a–O–β–D–glucopyranoside, lupenone **(25)**, opuntiol, stigmasta–3,5–diene **(26)** (Faizi et al., 2011), shamiminol (3,4,5–trimethoxyphenol 1–O–β–D–xylopyranosyl– (1–––> 2)–β–D–glucopyranoside) **(27)** (Faizi et al., 2011; Joshi et al., 2014), β–sitosterol, (2S,3R,4E,8Z)–3–hydroxy–2– [(2R)–2–hydroxyoctadecanoylamino]–1–β–D–glucopyranosyloxy–4,8–octadiene; 2,6–dimethoxy–benzoquinone, eriodictyol, laminaribioside, p–hydroxybenzoic acid **(28)** (Feng, et al., 2014), BME3, epicatechin **(29)** (Ho et al., 2011) (–)–catechin–7–O–β–xylopyranoside, (–)–epicatechin–7–O–β–xylopyranoside (+)–isolarisiresinol–9′–O–B–glucopyranoside (+)–lyoniresinol–9′–O–β–glucopyranoside, simalin A **(30)**, simalin B (31) (Joshi et al., 2014), shamimicin **(32)**, 1"',1""""'–bis–2– (3,4–dihydroxyphenyl)–3,4–dihydro–3,7–dihydroxy–5–O–xylopyranosyloxy–2H–1–benzopyran, upeol (Saleem et al., 2003), lupeol (You et al., 2003) from stem bark, trans–triacontyl–4–acetoxy–3–methoxycinnamate (Singh et al., 2008) from spines, lupeol, β–sitosterol, friedel–1–en–3–one, friedelin (Krishna et al., 2002), 7–hydroxy–5–isopropyl–2–methoxy–3–methyl–1,4–naphthoquinone **(34)**, 7–hydroxycadalene, 8–formyl–7–hydroxy–5–isopropyl–2–methoxy–3–methyl–1, 4–naphthoquinone (Sreeramulu et al., 2001) were isolated from heartwood.

Isohemigossylic acid lactone–2–methyl ether **(35)**, hemigossylic acid lactone–7–methyl ether **(36)** (Puckhaber and Stipanovic 2001) (+)–pinoresinol **(37)**, bombasinol A [4–(4– (3, 5–dimethoxyphenyl) hexahydrofuro [3,4–c]furan–1–yl)–2–methoxy–phenol], **(38)** matairesinol **(39)**, 5,6–dihydroxymatairesinol **(40)**, (Wang et al., 2013), isohemigossypol–1–methyl ester **(41)**, 2–o–methyl-isohemigossylic acid lactone, bombamalones A–D **(42-45)**

bombaxquinone B **(46)**, bombamaloside **(47)**, lacinilene C **(48)** (Zhang et al., 2007) were reported from root. Moreover certain compound like 5–isopropyl–3–methyl–2,4,7–trimethoxy–8, 1–naphthalene carbolactone, naphthoquinone, 8–formyl–7–hydroxy–5–isopropyl–2–methoxy–3–methyl–1, 4–naphthoquinone (Reddy et al., 2003), 7–hydroxycadalene, hemigossypol–6–methyl ether, 8–formyl–7–hydroxy–5–isopropyl–2–methoxy–3–methyl–1, 4–naphthaquinone, 7–hydroxycadalene, hemigossypol–6–methyl ether, isohemigossypol–1–methyl ether **(49)** isohemigossypol–1,2–dimethyl ether **(50)** (Sankaram et al., 1981) were isolated from Root Bark.

Flower contains α–amyrin, campesterol, cholesterol, stigmasterol, linarin **(51)**, vicenin 2 **(52)**, saponarin **(53)**, cosmetin **(54)**, isovitexin **(55)**, xanthomicrol **(56)**, apigenin **(57)** (El–Hagrassi et al., 2011), 2R, 3R, 4R, 5S)–5– (6– (2,3–dimethylbutyl)–7–hydroxy–2– (4–hydroxyphenyl)–2h–chromen–5–yloxy)–6–methyl–tetrahydro–2h–pyran–2, 3, 4–triol (Pathan et al., 2012), quercetagetin **(58)**, quercetagetin–3–O–d–glucofuranoside **(59)** (Kumar et al., 2010), mangiferin, protocatechuic acid (3, 4–dihydroxy–benzoic acid), anthocyanins, apigenin 7–O–β–D–glucopyranoside, isovanillic acid (4–methoxy–3–hydroxy–benzoic acid), quercetin 3–O–β–D–galactouronopyranoside quercetin 3–O–β–D–glucopyranoside **(60)**, rutin (61) (Said et al., 2011), 5,4' dimethoxy 8 me 7–O–β–D glucopyranoside–5'–β–D–glucopyranoside, 3–acetoxy–1–hydroxy–6–methoxy8–O–β–D–glucopyranosyl– (1→3)–α–l–rhamnopyranoside (Sati et al., 2011), β–sitosterol, some fatty acids **(44)** (Tundis et al., 2014), polysaccharides (Wang et al., 2000), 3–methyl–2 (3h)–benzofuranone, hexadecanoic acid, tetradecanoic acid, α–cedrol, β–cedrol (Wang et al., 2003), bombasin, bombasin 4–O–β–glucoside, D–gulono–Γ–lactone derivatice, bombalin, dihydrodehydrodiconiferyl alc. 4–O–β–D–glucopyranoside, neochlorogenic acid, trans–3– (p–coumaroyl) quinic acid (Wu et al., 2008). While O–α–l–arabinosyl (1 ← 2 or 4)–O–α–l–rhamnosyl (1 (6)–d–galactose (va or vb), 3–β–galactosyl–l–arabinose, 3–β–l–arabinosyl–l–arabinose, 43–β–galactosylgalactotriose 4–β–galactosylgalactose, 62–β–galactosylgalatobiose, 6–α–l–rhmanosylgalactose, 6–β–galactosylgalactose, polysaccharide (Agarwal et al., 1972) were reported from stamens. The seed contains 5 To 23% fatty oil (Kotoky et al., 2001). The structures of these phytoconstituents were shown in **Figure 2**.

4. Bio-prospection undertaken for *Bombax ceiba*

4.1. Analgesic Activity

Methnolic crude extract of leaves (BCL, 10, 50, 100 mg/kg), isolated mangiferin (42.2 mg/kg, s.c.) and mangiferin devoid fraction (BCM, 10, 50, 100 mg/kg) demonstrates significant analgesic activity in acetic acid-induced writhing and hot plate tests in mice. The responses in the acetic acid induced pain were reported to be dose dependent. Morphine (0.25 mg/kg s.c.) and mangiferin shows 65% and 70% inhibition in acetic acid induced pain respectively. However, in the presence of non-selective opioid antagonist, naloxone (5 mg/kg), the corresponding effects were reduced to 19% and 28%. Therefore, it represents that mangiferin abolish pain through opioid pathway like morphine. In hot plate model BCL, BCM or mangiferin shows central analgesic effect in 90 min. The effect of BCL extents upto 120 min. Using naloxone, the effect of extract was reported to be independent of opioid receptor, while, mangiferin exhibit significant interaction with these receptors at periphery with a minor contribution at the central level (Dar et al., 2005). The methanolic extract of flowers (250 and 500 mg/kg) also exhibited central (in hot plate model) and peripheral (in acetic acid-induced writhing test) analgesic activity (Said et al., 2011).

4.2. Angiogenesis Activity

An active component, lupeol was isolated from methanolic extract of the stem bark demonstrates significant in vitro antiangiogenic activity and significantly inhibited the tube like formation of human umbilical venous endothelial cells at 50 and 30 µg/mL. However the lupeol did not showed any effect on the growth of tumor cell in certain cell-lines study such as SK-MEL-2, A549 and B16-F10 melanoma (You et al., 2003; Nam et al., 2003).

4.3. Anthelmintic Activity

Traditionally *B. malabarica* is used as anthelmintic by people of Southern Punjab of Pakistan. The anthelmintic activity of methanolic extract of *B. malabarica* leaves (10, 25, 50, and 100 mg/mL) was investigated using live trematode: Paramphistomum explanatum) collected from buffalo in 0.9% phosphate-buffered saline. The effect of extract has been illustred by the loss of spontaneous movement and/or death of the *P. explanatum*. All trematodes died with extract within a short period of time (less than 45 min) which was statistically highly significant. Extract at 100 mg/mL showed maximum efficacy. It paralyzed and killed trematodes in 18.50 ± 0.62 and 22.17 ± 0.48 min, respectively (Hossain et al., 2012).

4.4. Anti Cancer Activity

Diethyl ether (DE) and light petroleum (PE) extract of the flowers of B. ceiba were investigated for antiproliferative activity by protein-staining sulforhodamine B (SRB) assay against seven human cancer cell lines viz. a panel of human cancer cell lines: human renal cell adenocarcinoma (ACHN), human Caucasian lung large cell carcinoma (COR-L23), human Caucasian lung carcinoma (A549), human Caucasian colon adenocarcinoma (Caco-2), human hepatocellular carcinoma (Huh-7D12), and amelanotic melanoma (C32). Both DE and PE extracts strongly inhibit the viability of tumor cell lines against ACHN in a dose dependent manner with IC50 values of 45.5 and 53.2 µg/mL for PE and DE, respectively. PE extract shows 1.1-times more potent effect than the established drug, vinblastine with an IC50 of 52.7 µg/mL against the COR-L23 cell line (Tundis et al., 2014). Flavonoid rich B. ceiba extracts from flower was screened for its effect on fatty acid synthase (FAS) in a number of cancer cells viz. hepatoma (HepG2), esophageal carcinoma (EC109, EC8712, H5E973), uterine cervix cancer (HeLa) lung carcinoma (A549, 95-D), gastric carcinoma (N87, BGC823), and leukaemia (K562, U937). The enzyme has been reported for its overexpression and hyperactivity in certain cancers. The extract significantly inhibits the enzyme among different cancer cells. The FAS activity is the lowest in gastric cancer cell N87 and the highest in lung cancer cell A549. The cancer cell A549 was further used to demonstrate inhibitory effect of flavonoid rich extract on FAS. The minimum inhibitory concentration of *B. ceiba* was

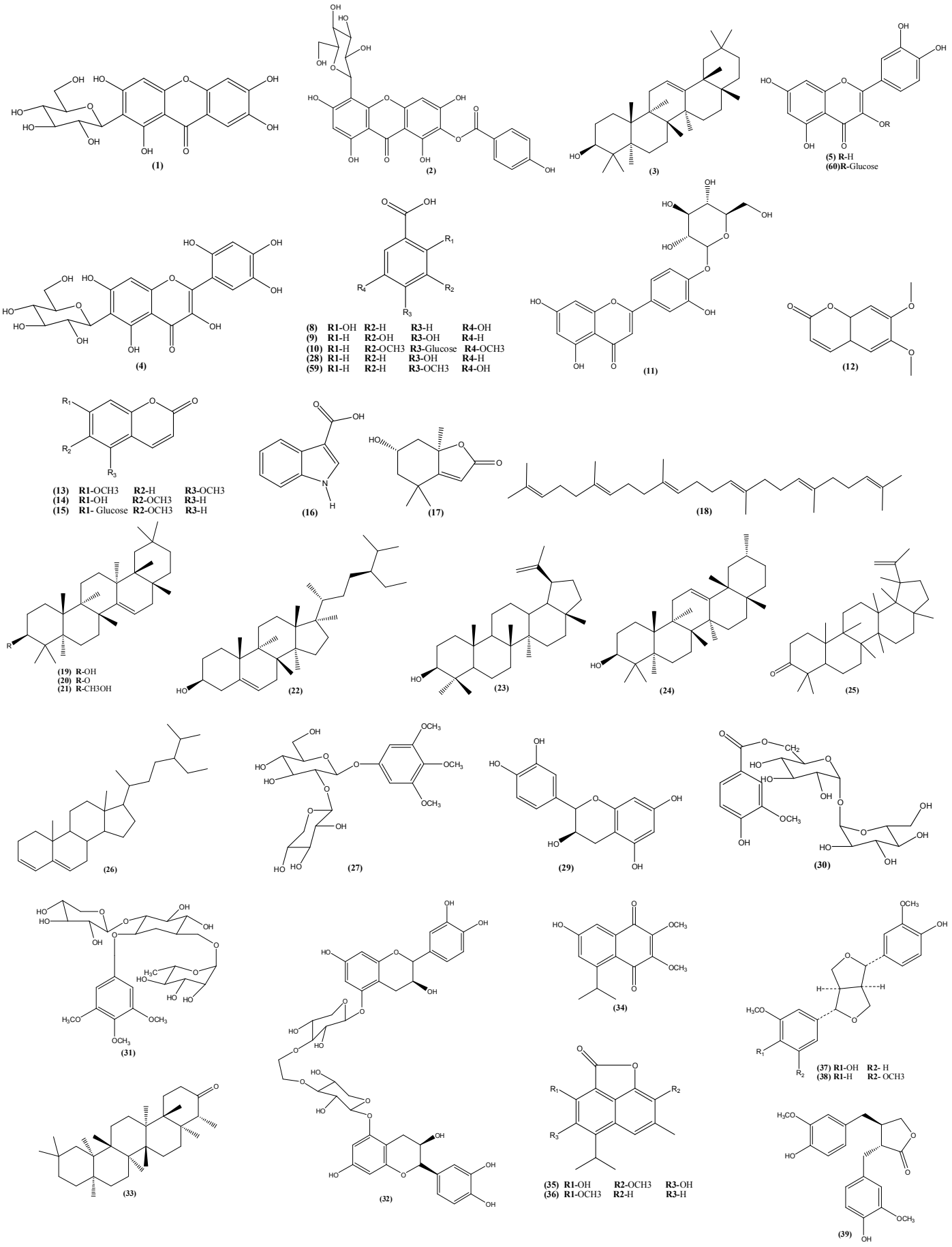

Figure 2. Isolated phytochemicals from *Bombax ceiba*

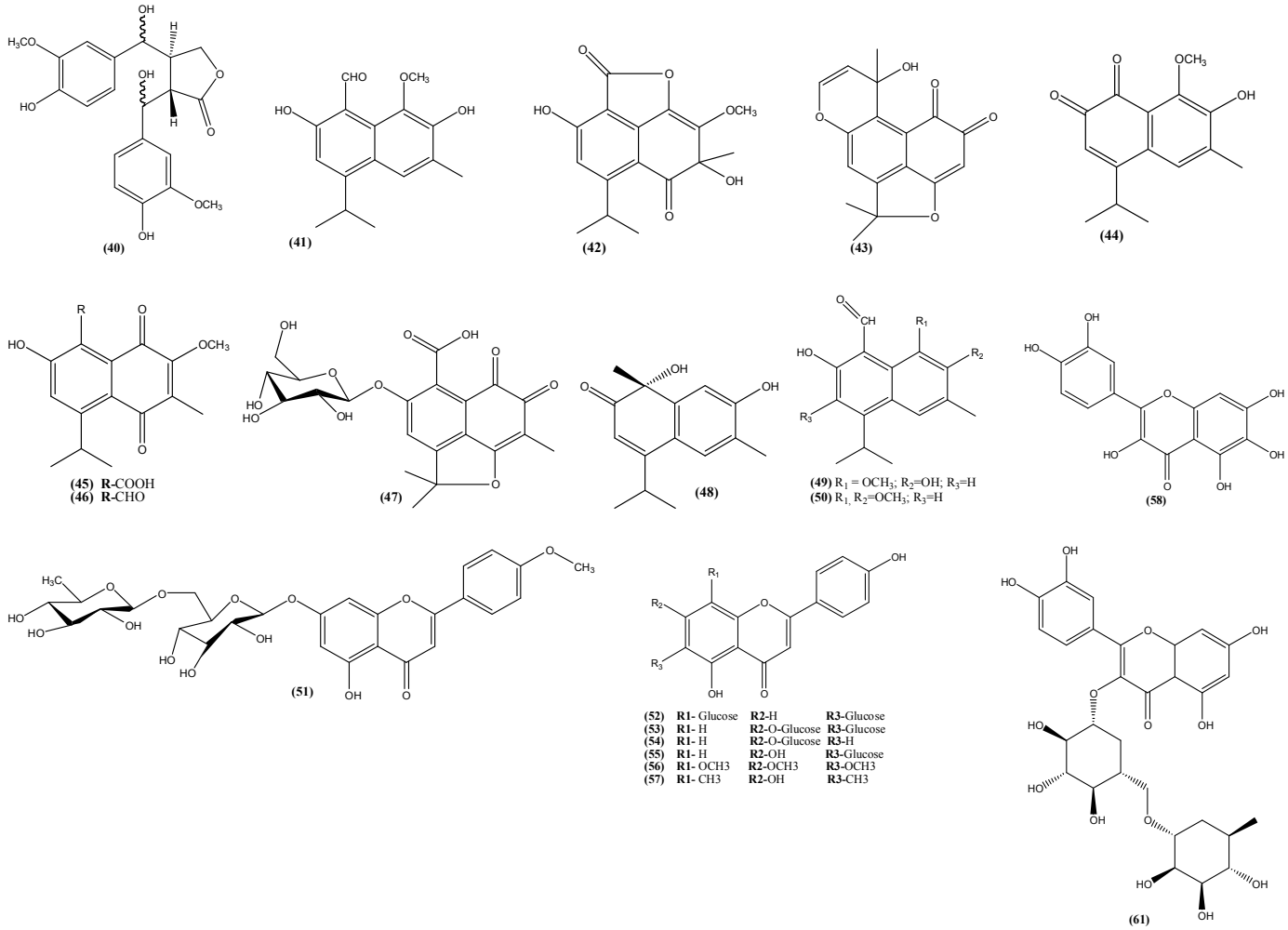

Figure 2. Isolated phytochemicals from *Bombax ceiba (Cont.)*

247.98 µg/mL (Chen et al., 2009). Nine cadinane sesquiterpenoids, bombamalones A-D; bombamaloside, isohemigossypol-1-methyl ester; 2-O-methylisohemigossylic acid lactone; β-quinone B; and lacinilene C from roots of B malabarica were evaluated against the HGC-27 human gastrointestinal cancer cell line using a MTT assay, but all were inactive (IC50 >10 microM). Bombamalone B was also inactive against the A549 lung carcinoma, MCF-7 breast carcinoma, and HeLa cervical human cancer cell lines (Zhang et al., 2007). Methanolic extract of *B. ceiba* showed very low cytotoxic activity in the Vero cell line when investigated through mitochondrial activity (Vieira et al., 2009). Methanol extract of *B. ceiba* root was investigated for anticancer activity using brine shrimp lethality bioassay and a standard cytotoxic agent, vincristine sulfate. LC50 (50% mortality) and LC90 value for the crude extract was reported to be 3.90µg/mL and 150.0µg/mL respectively (Islam et al., 2011).

4.5. Gastrointestinal effects

Indomethacin and iodoacetamide induced colitis model was used to investigate role of *B.malabarica* as a monotherapy for inflammatory bowel disease IBD. Aqueous extract of dried latex (commonly known as mocha-rasa) protects the intestine from damaging effect of indomethacin and iodoacetamide in rats at a dose level of 270 mg/kg in term of ulcer score and myeloperoxidase (MPO) activity (index of neutrophil recruit-ment). Moreover the drug (500 mg/kg) also prevents acetic acid induced colitis in mice. The extract reduces intestinal tissues edema, transmural necrosis and inflammatory masses in small and large bowel respectively in a dose dependent manner. Acetic acid induce rise in TNF-α expression was considerably reduced by mocha-rasa (500 mg/kg) (Jagtap et al., 2011).

4.6. Antibacterial Activity

Strong antibacterial activity was shown by the methanol extracts of *Salmalia malabarica* against multi-drug resistant *Salmonella typhi* (Rani et al., 2004), *Staphylococcus aureus, Micrococcus luteus* (Gram positive), *Escherichia coli* and *Pseudomonas aureginosa* (Gram negative) bacterial strains (Zulqarnain et al., 2015). Shamimin (100µg/disc) isolated from leaves also showed antimicrobial activity against bacteria like *Streptococcus pyogen*, *P. aeruginosa*, *Shigela flexneri* and fungi like *Trichophyton rubrum*, *Microsporum gypsem* etc. (Faizi et al., 1999). N-hexane and methanol extracts (100 mg/disc) of the flowers display significant antimicrobial activity. The methanol extract gives better antimicrobial result against S. aureus, *Bacillus subtilis*, *Streptococcus faecalis* and *Neisseria gonorrhea*, *P. aeruginosa* and *Candida albicans* then *n*-hexane extract. The methnolic extract was also found to be effective against certain fungus like *Aspergillus niger* and *Aspergillus flavus* but n-hexane extract fails to do so (El-Hagrassi et al., 2011). Gram positive

bacteria (*S. aureus, Bacillus cereus, E. coli* and *Vibrio cholerae*) demonstrates high susceptibility to methanol extract of flowers of *B. malabarica*. The extract also exhibits antifungal activity against *Cryptococcus neoformans* but not effective against *C. albicans* (Pavithra et al., 2013). Methanolic extract of oleo-gum resin from *B. ceiba* was also found to be most effective on *B. cereus* (10-12 mm), *E. coli* (10-12 mm), *A. niger, Cercospora pongamiae* than other extracts (acetone and aqueous) (Sravani et al., 2014). Certain pathogenic bacteria *B. subtilis, S. aureus E. coli,* and *P. aeruginosa* and fungi *A. niger* and *C. albicans* were also found to be susceptible to bark extract in different solvent. Alcoholic extract demonstrate highest activity while acetone and aqoueous extract were also found to be effective. However, petroleum ether and chloroform extract exhibits no activity. Among all tested microoraganism *E. coli* (19.50 ± 0.5000 mm) has been found to be most susceptible to the alcoholic extract (Girija et al., 2010). Moreover, the carbon tetrachloride fraction (200 µg/disc) of methanol crude extract of *B. ceiba* roots also illustrate prominent zone of inhibition against a number of bacterial (*B. subtilis, S. aureus, Shigella boydii, Shigella dysenteriae*) and fungal (*Saccharromyces cevevaceae, A. niger* and *C. albicans*) strains then other n-hexane and chloroform fraction (Islam et al., 2011). The seed extract of *B. ceiba* was also effective against *E. coli, P. aeruginosa* and *S. aureus* (Tirupathi et al., 2011). Different extract of seeds such as hexane, chloroform, diethyl ether, acetone, methanol and aqueous were investigated against *E. coli, B. subtilis, S. aureus, Enterococcus faecalis and Alcaligenes faecalis, C. albicans, A. niger, A. flaves and Aspergillus fumigatus*. Acetone and methanol extracts (200µg/mL) revealed significant antimicrobial activity especially against *E. coli, B. subtilis, E. faecalis and A. faecalis, C. albicans* (Nagamani et al., 2014).

4.7. Antidiabetic Activity

Shamimin (500 mg/kg) from *B. ceiba* leaves was reported as hypoglycaemic agent in rats (Saleem et al., 1999). Hydro-methanolic (2: 3) extract of the sepals of *S. malabarica* exhibit significant diminution effect on the Fasting Blood Sugar and Glycated Hb (HbA_{1C}) level in STZ-induced diabetic rats. The extract also shows recovery from STZ-induced decline in activity of certain carbohydrade metabolic enzyme (hexokinase, glucose-6-phosphate dehydrogenase) and hyperactivity of glucose-6-phosphatase in the liver and skeletal muscle. The elevated oxidative stress, SGOT and SGPT levels were restored by the extract (De et al., 2010). The n-hexane fraction of this hydro-methanolic extract (0.1 gm/kg) also possesses significant hypoglycemic and hypolipidemic effects. Furthermore, n-hexane fraction increases the serum insulin level, hemoglobin concentration and decreases glycated hemoglobin. Moreover, the fraction was reported helpful in preventing the cells islet's of Langerhans in diabetic rats (De et al., 2012). Certain compound from *B. ceiba* like quercetin 7-O-β-D-glucopyranoside and Epicatechin-3-O-B-Xylopyranoside significantly inhibits the α-glucosidase enzyme (50.5% and 48.3% respectively) at 100µM concentration (Khan et al., 2010). A glucosylxanthone from the plant was examined for a new anti-diabetic drug target, Dipeptidyl peptidase IV receptor (DPPIV), by using Mars Observer Laser Altimeter (MOLA). Glucosylxanthone and its analogues have shown good comparable *in silico* binding activity with FDA approved drugs and other molecules currently under development for DPPIV inhibitory activity as anti-diabetic therapy. Inhibition of DPPIV would presumably increases serum Glucagon like Peptide-1 (GLP-1) that results in net anti hyperglycaemic effect (Kumar, 2012). Aqueous and ethanolic extract of *B. malabarica* bark (100 and 200 mg/kg) (Harikiran et al., 2011) and methanol extract (200 mg/kg) (Zahan et al., 2013) were also effective in alloxan induced diabetic rats. Moreover, the bark extract (600 mg/kg/day) also have significant hypoglycemic and hypolipidemic effect in STZ-induced diabetic rats (Bhavsar and Talele, 2013).

4.8. Anti-inflammatory Activity

Bark, xylem of stem and root of *B. malabarica* exhibited significant anti-inflammatory activity against carrageenan-induced edema even better than indomethacin (Lin et al., 1992). Methanol extract of *B. malabarica* leaves possess significant positive activity in a carrageenan-induced inflammation (100, 200, and 400 mg/kg) in rats and it inhibits lipopolysaccharide-induced nitric oxide (NO) production in mice peritoneal macrophages dose dependently. In cytotoxicity assay using peritoneal macrophages, the IC_{50} for extract was reported to be 258.33 ± 6.96 µg/mL and it was non-toxic up to 125 µg/mL (Hossain et al., 2013). In an *in-vitro* study ethanol and aqueous extracts extracts of bark of *B. ceiba* (1000 mcg/mL) demonstrats enough potential to stabilize Human Red Blood Corpuscles (HRBC) membrane and put forward its anti-inflammatory activity (Anandarajagopal et al., 2013). Furthermore, the methanolic extract of flower shows anti-inflammatory activity against the acute paw edema induced by carrageenan (Said et al., 2011).

4.9. Hepatoprotective Activity

Aqueous extract of *B. malabarica* shows its hepatoprotective effect in Carbon tertrachloride (CCL_4) induced hepatotoxicity (Chiu et al., 1992). Bark, xylem of stem and root also possess propective role in CCL_4-induced hepatotoxicity (Lin et al., 1992). The aqueous bark extract (1g/kg, *i.p.*) protect liver from CCl_4 induced histopathological changes of the liver tissue such as fatty degeneration, cell necrosis (Chiu et al., 1992), ballooning degeneration, lymphocytes and Kupffer cells aggregation (Lin et al., 1992). Moreover, isolated mangiferin also heals liver from damage induced by CCL_4 (Dar *et al.,* 2005). Methanolic extract of flowers (150, 300 and 450 mg/kg *i.p.*) reverse the changes in liver biochemical markers resulted from antitubercular drugs (Isoniazid and Rifampicin) (Ravi et al., 2010) and paracetamol (Said et al., 2011) but the effect was not prominent in histology of liver (Ravi et al., 2010).

4.10. Anti-Obesity Activity

Methanolic extract of *B. ceiba* stem bark (200 and 400 mg/kg) ameliorate 10 weeks high fat diet (HFD) induced obesity in rats. *B. ceiba* extract significantly attenuated HFD induced increase in % body wt, BMI, LEE indices; serum glucose, lipid profile markers, ALT, AST; tissue TBARS, nitrate/nitrite levels; different fat pads, relative liver weight; significant decrease in food intake (in term of g and kcal), serum HDL and tissue glutathione levels, possibly due to modulation of FAS and PTP-1B signalling in rat caused by phytoconstituent Lupeol (Goyal, 2012; Gupta et al., 2013).

-pyretic effect on Baker's yeast induced pyrexia in Wister rat. The extract at a dose level of 200 and 400 mg/kg significantly reduces body temperature of the rats over a period of 8 h. Maximum antipyretic activity was observed at 6 h and remained steady upto 8h (Hossain et al., 2011).

4.17. Antiulcer Activity

A market formulation Mebarid (250, 500 mg/kg and 1 g/kg) has been reported to decrease in ulcer index in antiulcer evaluation through pylorus ligation method (Bafna et al., 2003). Ethanolic extract of root demonstrates strong inhibition against different strains of *Helicobacter pylori*. The minimum inhibitory concentration values ranged from 1.28 to 5.12 mg/mL (Wang and Huang, 2005).

4.18. Anti-Urolithiasis Activity

B. ceiba fruit extract was reported to be effective against ethylene glycol induced calculi in rats. Pretreatment with aqueous and ethanolic extract (400 mg/kg) significantly reduces renal excretion of calcium and phosphate in ethylene glycol challenged rats. The extract also significantly reduces the oxalate, calcium and phosphate excretion in urine. Crystal formation promotive constituents were also significantly lowered by both the extract. Moreover the drug prevents deposition of certain stone forming substance like oxalate, calcium, and phosphate in the kidney (Gadge et al., 2012).

4.19. Anti-Diarrhoeal Activity

An ayurvedic formulation Mebarid (containing extracts of *Salmalia malabarica* gum exudates and other) was investigated for its anti-diarrhoeal activity. Mebarid (125–500 mg/kg) was reported to have significant anti-diarrhoeal activity and showed a dose-dependent increase in the first defecation time, cumulative faecal weight in castor oil-induced diarrhoea. It also decreses intestinal motility as demonstrated in charcoal meal test. The action was probably due to absorbent and swelling properties of gum (Bafna et al. 2003).

4.20. Anti-Hepatitis B Virus Activity

Four compounds namely Bombasinol A, 5, 6-dihydroxymatairesinol, (+)-pinoresinol and matairesinol were isolated from the ethanolic extract of *B. ceiba* roots were evaluated for the anti-Hepatitis B Virus (HBV) activity. All the compounds potentially inhibit HBsAg secretion in HepG2 2.2.15 cell lines with IC_{50} values of 118.3, 123.7, 118.9 and 218.2 mM, respectively (Wang et al., 2013).

4.21. Antiviral activity

B. ceiba flowers also exhibits potent antiviral action against Epstein-Barr virus (early antigen) (EBV-EA). Methnolic extract and its fraction (ethyl acetate and butenol) of flower were evaluated *in vitro* for inhibitory effect on 12-O-tetradecanoylphorobol-13-acetate (TPA) induced EBV-EA activation in Raji cells. All extracts inhibited the activation of the early antigen (% EBV-EA pos. cells). Out of this ethyl acetate extract was reported to be most active in inhibition of activation of the early antigen at different concentratins (1, 10 and 100 µg/mL) (Said et al., 2011).

4.22. Anti-Hyperlipidemic Activity

Antihyperlipidemic effects of sepal from *S. malabarica* (n-hexane fraction from hydro-methanolic extract) were investigated in streptozotocin (STZ) induced diabetic rats. The fraction at the dose of 0.1 gm/kg twice a day was investigated in normal and streptozotocin (STZ) induced diabetic rats. Pretreatment with fraction prevents derangement in lipid profile of diabetic rats including triglyceride (TG), total cholesterol (TC), density lipoprotein cholesterol (LDLc), high density lipoprotein cholesterol (HDLc), low very low density lipoprotein cholesterol (VLDLc), phospholipids, free fatty acids as compare with control (De et al., 2012).

4.23. Hypotensive Activity

Bio-efficacy of aqueous and methnolic extract as well as an isolated C-flavonol glucoside "Shamimin" from leaves of *B. ceiba* were evaluated for the management of hypertention. The compound at the doses of 1, 3, 15 mg/kg *i.v.* exhibits significant effect as a hypotensive agent in rats (Saleem et al., 1999). Further another hypotensive agent "shamimicin" was isolated from the stem bark of the *B. ceiba* along with lupeol. Petroleum ether extract (BCBP; 10 mg/kg *i.v.*) reduces mean arterial blood pressure (MABP) of rats by 58% while lupeol demonstrate 44% and 52% fall in MABP at the dose of 5 and 15 mg/kg respectively. Moreover only 30% hypotensive response was observed with methanolic extract of defatted stem bark (BCBM; 10 mg/kg *i.v.*) but its fraction BCBMI (Residue from BCBM; 30 mg/kg *i.v.*) shows approximately 57% hypotensive effect. At a doses of 10 mg/kg and 30 mg/kg of 50% methanolic extract (BCBM-50) exhibits only 17—20% fall in MABP while BCBMM (filtrate from BCBM), illustrate 31% and 65% hypotensive action at the dose of 3 mg/kg and 15 mg/kg *i.v.* respectively. However the isolated glycoside Shamimicin has been found to be ineffective in hypertention at the dose of 15 mg/kg. In the presence of atropine sulfate (69.5 mg/kg), BCBM and BCBM-50 did not produced any hypotensive effect, which explain that BCBM and BCBM-50 produces cholinergic hypotensive action via muscarinic receptors (M_2 type) present on cardiac muscles as well as vascular dilation by endothelium derived relaxing factor. Flowers of *B. ceiba* were also evaluated for its hypotensive activity and methanolic extract of flowers (30 mg/kg *i.v.*) and pulp (30 mg/kg *i.v.*) were reported more active than methanolic extracts of bark. When the BCBMM was given per oral it demonstrates significant reduction (13.2%) of MABP (Saleem et al., 2003).

4.24. Larvicidal Activity

In 2011 it was reported that *B. malabarica* leaves powder and its methnolic extract has potent larvicidal activity after 24 h of exposure against different larval stage of *Culex quinquefasciatus* with LC_{50} and LC_{90} values of 48.85 ppm and 264.22 ppm respectively. It was also observed that LC_{50} and LC_{90} values have been declined steadily with time and it was lowest at 72 h of exposure to third instar larvae ($P<0.05$) (Hossain et al., 2011).

4.25. Effect on Sexual Behaviour

Its lyophilised aqueous extract (100mg/kg orally) stimulants

sexual activities of male albino rats in the presence of a female as well as it was reported to increase sperm count. The extract demonstrates significant improvement in mount, intromission and ejaculation frequencies. Significant rise in serum testosterone, seminal fructose content and epididymal sperm count were also recorded. Hesitation time was significantly reduces while penile erection index and copulatory rate rises as compared to control (Bhargava et al., 2012).

4.26. Diuretic Activity

Aqueous and ethanol extract of *B. ceiba* fruit at a dose level of 200 and 400 mg/kg, p.o. possess slow onset (within 5 h) diuretic action but extended upto 24 h. Both the extracts show significant improvement in urine output in dehydrated rats. The action of aqueous extract (400 mg/kg) was comparable with reference drug frusemide in 5 h. The aqueous extract also causes increase in excretion of electrolytes (Na^+, K^+ and Cl^-) in urine but no potent effect on urinary pH and specific gravity (Jalalpure and Gadge, 2011).

Conclusion

In the present review we have tried to collect knowledge on phytochemistry and pharmacological properties of *B. ceiba* which is extencively used in Indian system of medicine i.e. Ayurveda. All part of *B. ceiba* like leaves, bark, root, flower and gum etc are used in treatment of different diseases. Analysis of the active ingredients responcible for different pharmacological principles is need of today. Various phytoconstituents from the *B. ceiba* has been reported, which includes mangiferin, quercetin, shamimin, shamimoside, *β*–sitosterol, taraxeryl acetate, lupeol, simalin a, simalin b, shamimicin, bombamalones a–d, bombaxquinone b, bombamaloside and bombasin. The plant *B. ceiba* was evaluated for a number of activities such as analgesic, anthelmintic, anti cancer, antibacterial, antidiabetic, anti-inflammatory, hepatoprotective, immunomodulatory, cardioprotective, antiulcer, anti-diarrhoeal, antiviral, hypotensive activity. Majority of therapeutic claims for the plants in the various traditional medicines have been confirmed through experimental pharmacology.

Conflict of Interest

No such conflict of interest is reported.

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