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Review Article

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The Constituents and Pharmacology of *Corchorus aestuans*: A Review

Ali Esmail Al-Snafi

Department of Pharmacology, College of Medicine, Thi qar University, Nasiriyah, P O Box 42, Iraq

Abstract The preliminary phytochemical investigation of various extracts of leaves of *Corchorus aestuans* showed the presence of phenolic compounds, flavonoids, glycosides, carbohydrates, protins, amino acids, fatty acids, saponins, phytosterols, triterpenoids, cardiac glycosides and tannins. The previous pharmacological studied revealed that *Corchorus aestuans* exerted apoptotic, anticancer, antioxidant, antimicrobial, cardiovascular, anti-inflammatory and other pharmacological effects. However, despite the increasing use of herbal medicines, there is still a significant lack of research data in this field. This review will highlight the pharmacology and therapeutic benefit of *Corchorus aestuans*.

Keywords pharmacology, constituents, *Corchorus aestuans*

Introduction

Human beings have used plants for the treatment of diverse ailments for thousands of years. Plants generally produce many secondary metabolites which were constituted an important source of many pharmaceutical drugs [1-30]. The preliminary phytochemical investigation of various extracts of leaves of *Corchorus aestuans* showed the presence of phenolic compounds, flavonoids, glycosides, carbohydrates, protins, amino acids, fatty acids, saponins, phytosterols, triterpenoids, cardiac glycosides and tannins. The previous pharmacological studied revealed that *Corchorus aestuans* exerted apoptotic, anticancer, antioxidant, antimicrobial, cardiovascular, anti-inflammatory and other pharmacological effects. However, despite the increasing use of herbal medicines, there is still a significant lack of research data in this field. This review was designed to highlight the pharmacology and therapeutic benefit of *Corchorus aestuans*.

Plant profile

Synonym: *Corchorus acutangulus* Lam [31].

Taxonomic classification

Kingdom: Plantae; **Sub Kingdom**: Viridaeplantae; **Infra Kingdom**: Streptophyta; **Phylum:** Magnoliophyta; **Division**: Tracheophyta; **Subdivision**: Sparmatophytina; **Class**: Magnoliopsida; **Order**: Malvales; **Family**: Malvaceae (Tiliaceae)**; Genus**: Corchorus L.; **Species**: *Corchorus aestuans* [32-33].

Common names:

Arabic: Joot bari; **English:** Jute, mallow; West African mallow, East Indian mallow**; French**: Gombo par terre, gombo rampant, gombo sauvage; **Japanese**: togariba-tsunaso; **Zimbabwe**: Telele yabasangu [32, 34].

Distribution

Corchorus aestuans is a pantropical species, thought by some to originate from the tropics in Africa and South-East Asia [35]. It was distributed in Northern and Southern America: Mexico, Antigua and Barbuda, Bahamas, Barbados, Cayman Islands, Cuba, Dominican Republic, Grenada, Haiti, Jamaica, Montserrat, Puerto Rico, St. Kitts and Nevis; St. Lucia; St. Vincent and Grenadines; Trinidad and Tobago; Virgin Islands (British), Virgin Islands

(U.S.), Guatemala, Nicaragua, Guyana, Venezuela, Brazil, Colombia and Ecuador. It was also found South-East Asia, Mediterranean region and throughout tropical Africa from Senegal eastward to Somalia and southward to South Africa, and it is locally cultivated [33, 35].

Description

Prostrate to ascending, annual or perennial herb up to 50(–100) cm tall; stems much branched, pilose, red-brown. Leaves alternate, simple; stipules sharply pointed, up to 1 cm long, pilose; petiole 0.5–3(–5.5) cm long, hairy; blade narrowly to broadly ovate or elliptical, 1.5–9 cm × 1–4.5 cm, base rounded, usually with 2 basal bristles up to 5 mm long, apex acute to rounded, margin toothed, with scattered pubescence mainly on veins, with 4–7 basal veins. Inflorescence an axillary fascicle, 1–3-flowered; peduncle up to 2 mm long; bracts up to 3 mm long, sharply pointed. Flowers bisexual, regular, 5-merous; pedicel up to 3 mm long, sepals free, linear, 3–4 mm long, acuminate; petals free, narrowly obovate or oblanceolate, 3–4 mm long, golden yellow, with a basal claw 0.5 mm long; stamens c. 10, c. 3 mm long; ovary superior, style c. 1 mm long. Fruit a cylindrical capsule 1–4 cm × c. 0.5 cm, solitary or 2–3 together, straight or slightly curved, with wings up to 2 mm wide and 3–5 spreading beaks 1.5–3 mm long at the apex, glabrous, splitting into 3–5 valves, many-seeded. Seeds rhomboid-cylindrical, somewhat angular, 0.5–1 mm long, pitted, brown to black [35].

Traditional Uses

Corchorus aestuans was used as a cheaply available fiber plant (known as jute), but the product was coarser and less durable than that made from *Corchorus capsularis* L. (white jute). The leaves were widely eaten as a vegetable. In northern Benin, for instance, it was consumed as leafy vegetable in a mucilaginous sauce, and its cultivation in the rainy season for household consumption has been recorded in south-western Benin. In north-eastern India the root was cooked as a vegetable. The foliage was browsed by all livestock. In traditional African medicine, extracts of the roots or leaves were taken for the treatment of gonorrhoea, and an extract of the whole plant, including the roots, was used for making injections for the treatment of urethral discharges. In DR Congo the leaves were squeezed and the sap was sniffed for the treatment of headache. In the Philippines, the leaves were used for headache, and the seeds, in the form of powder or in decoction, as a tonic, carminative and febrifuge [35]. Seeds and aerial parts were used in India for stomachic, as anti-inflammatory and for the treatment of pneumonia. The leaf extracts were used as moisturizers in skin cosmetics [31].

Part used medicinally: All parts of the plant were used for medicinal purposes [31, 35].

Chemical constituents

Preliminary phytochemical investigation of various extracts of leaves of *Corchorus aestuans* showed the presence of phenolic compounds, flavonoids, glycosides, carbohydrates, protins, amino acids, fatty acids, saponins, phytosterols, triterpenoids, cardiac glycosides and tannins [36-40].

On cooking the leaves discharged a large quantity of mucilage, making them very slimy. The seeds contained 22.6% protein and 8.3–12.8% oil. Amino acids in the seed included valine, lysine, serine, aspartic acid, threonine and phenylalanine. The oil contained β-sitosterol and the fatty acids (palmitic acid, stearic acid, oleic acid and linolenic acid). The seed also contained corchorine, a glycoside of the strophanthidine group, and quercetine, a flavonoid [35]. β-sitosterol, lupeol, betulin, 2-methyl anthraquinone, scopoletin and corchoroside-A were isolated from the capsule extract of *Corchorus aestuans* [41]. The seeds also contained cardenolides, beta-sitosterol, ceryl alcohol, oligosaccharides [31].

Nutritional chemical analysis showed that leaves contained protein 3.7%, *β*-Carotene 76.33 mg/kg, iron 184.07 mg/kg and potasium 4000mg/kg [42].

The fusidic acid together with β-sitosterol, 2-methylanthraquinone and coumarin (scopoletin) were isolated from the leaf extract of *Corchorus aestuans* [43].

The bioactive constituents of ethanol extract of *Corchorus aestuans* were investigated using GC-MS technique. The analysis revealed the presence of fourteen different bioactive constituents namely 3,7,11,15-tetramethyl-2-hexadecen-1-ol (5.6%), Trans-2-undecen-1-ol (1.26%), E-7-Tetradecenol (1.97%), n-Hexadecanoic acid (25.82%), Phytol (22.34%), 9,12,15-octadecatrienoic acid, methyl ester, (Z,Z,Z)- (20.23%), Docosanoic acid, ethyl ester (1.99%), 1-Eicosanol (2.11 %), 9,9-dimethoxybicyclo[3.3.1] nona-2,4-dione (0.60%), Heptadecanoic acid, heptadecylester (0.95%), Pentadecanoicacid,2,6,10,14-tetramethyl-,methylester(0.91%), 3-Hexa decycloxycarbonyl-5-(2-hydroxyethyl)-4-methylimidazolium ion (0.90%), Squalene (8.03%) and Vitamin E (7.24%) [44].

Four triterpenoid glycosides, corchorusins A, B, C, and D, were isolated from the aerial part of *Corchorus acutangulus*. Based on their spectral properties and some chemical transformations, they were defined as

longispinogenin 3-O-β-β-D-galactopyranoside, saikogenin F 3-O-β-D-galactopyranoside, 23-hydroxyl ongispinogenin 3-O-β-D-galactopyranoside, and saikogenin E 3-O-β-D-gluco-pyranosyl(1→2)-β-D-galactopyranoside [45]. Other 4 triterpenoid glycosides, corchorusins C_1, D_1, D_2 and D_3 were also isolated from the aerial parts of *Corchorus acutangulus*, they were identified as saikogenin C, 3-*O*-β-D-galactopyranoside, saikogenin B, 3-*O*-β-D-glucopyranosyl (1→2)-β-D-galacto-pyranoside, longispinogenin, 3-*O*-β-D-glucopyranosyl (1→2)-β-D-galacto-pyranoside and saikogenin C, 3-*O*-β-D-glucopyranosyl (1→2)-β-D-galacto-pyranoside [46].
The leaf extracts which used as moisturizers in skin cosmetics consisted of uronic acid containing mucopolysaccharide, Ca, K and P, among others, which act as effective moisturizers [31].

Pharmacological effects

Apoptotic and anticancer effects

The alcoholic extract of the entire plant was found to have anticancer activity against epidermal carcinoma of nasopharynx in tissue culture [31, 35]. The effects of Saikosaponin-A on human breast cancer cell lines (MDA-MB-231 and MCF-7) were investigated. Results demonstrated that Saikosaponin-A inhibited the proliferation or viability of the MDA-MB-231 and MCF-7 cells in a dose-dependent manner. Saikosaponin-A treatment of MDA-MB-231 for 3 hours and of MCF-7 cells for 2 hours, respectively caused an obvious increase in the sub-G1 population of cell cycles. Apoptosis in MDA-MB-231 cells was independent of the P53/p21 pathway mechanism and was accompanied by an increased ratio of Bax to Bcl-2 and c-myc levels and activation of caspase-3. In contrast, apoptosis of MCF-7 cells was initiated by the Bcl-2 family of proteins and involved p53/p21 dependent pathway mechanism, and was accompanied by an increased level of c-myc protein [47].
The *in vitro* anti-cancer activity of Corchorusin-D (COR-D) was evaluated on melanoma cells (B16F10, SK-MEL-28, and A375). The results demonstrate that COR-D showed maximum inhibition of B16F10 cells *in vitro*. COR-D induced mitochondrial dysfunction and altered the Bax/Bcl-2 ratio with down regulation of pro-caspases 9 and activation of caspase 3 in B16F10 cells, triggering intrinsic pathway of apoptosis. Moreover, it inhibited the *in vivo* B16F10 tumor growth and increased the survival rate of mice. Greater number of Annexin V-FITC and propidium iodide (PI)-positive tumor cells signified that COR-D induced apoptosis *in vivo* also. The reduction in tumor growth was well correlated with decreased microvascular density of the tumor cells in treated mice. The authors concluded that COR-D-induced mitochondrial dysfunction was responsible for the induction of apoptotic cell death [48].
The anti-leukemic activity of the methanol extract of aerial parts (ME) of *C. acutangulus* has been investigated, with studying the active ingredient responsible for this activity. The anti-leukemic activity of ME, its fractions and corchorusin-D (COR-D), the active ingredient, was investigated in leukemic cell lines U937 and HL-60 using cell viability and MTT assays. The molecular pathways leading to the activity of COR-D were examined by confocal microscopy, flow-cytometry, caspase and Western blot assays. ME, its n-butanolic fraction and COR-D inhibited cell growth and produced significant cytotoxicity in leukemic cell lines U937 and HL-60. COR-D produced apoptotic cell death via mitochondrial disfunction and was found to pursue the intrinsic pathway by inciting the release of apoptosis-inducing factors (AIFs) from mitochondria. COR-D-induced translocation of Bax from cytosol to mitochondria facilitating caspase-9 activation and up regulation of downstream pathways leading to caspase-3 activation and PARP cleavage, which resulted in the subsequent accumulation of cells in the sub-G0 phase followed by DNA fragmentation [49].
The anticancer effect of corchorusin-D (COR-D), was studied in the chronic myelogenous leukemic cell line K562, using MTT assay, phase contrast and confocal microscopy, annexin V binding, cell cycle analysis and western blotting. COR-D inhibited cell growth in K562 cells and showed increasing number of Annexin V FITC binding cells. Characteristic apoptotic changes were recorded under phase contrast and confocal microscopes with accumulation of cells in the sub-G0 phase. The apoptosis involved drop in Bcl-2/Bax ratio, loss of mitochondrial membrane potential, release of cytochrome c in cytosol followed by activation of caspases 9 and 3, and cleavage of PARP. Down-regulation of pro-caspase 10 was observed along with formation of death-inducing signaling complex between TNF-R1 and TRADD. COR-D suppressed PDK1 and AKT with activation of MAP kinase family members ERK1/2, JNK1/2 and p38. Accordingly, it induced apoptosis by activating mitochondrial and death receptor pathways and suppressing AKT/PKB rather than MAP kinase pathway. Significant enhancement of apoptosis, noted using specific inhibitors of ERK1/2, p38 and JNK1/2, suggests that COR-D can enhance apoptosis in K562 cells in combination with MAP kinase inhibitors [50].

Antioxidant effect

The antioxidant potency of the *Corchorus aestuans* leaves crude methanol and its fractionated extracts (hexane, ethyl acetate and water) were investigated, employing three different established *in vitro* testing systems, scavenging activity on 1,1-diphenyl-2-picrylhydrazyl (DPPH) radicals, reducing power assay and β-carotene method. The data obtained in these testing systems clearly establish the antioxidant potency of *Corchorus aestuans* [51].

The antioxidant activity of the flavonoids (quercetin and quercetin 3-o-galactoside) isolated from the aerial parts of *Corchorus aestuans* was tested by two *in vitro* testing methods, scavenging activity on 1, 1-diphenyl-2-picrylhydrazyl (DPPH) radicals and hydroxyl radical scavenging activity by EDTA. The data obtained in these testing systems clearly established that *Corchorus aestuans* possessed antioxidant potential. The scavenging activity (% inhibition of 50 µg/ml) of isolated flavonoids quercetin 3-o-galactoside, quercetin and ascorbic acid on the DPPH radical decreased in the order: Ascorbic acid > Quercetin > Quercetin 3-o-galactoside was of 67.55±0.10, 28.19±0.22 and 24.64±0.14 ($P<0.0001$) at the concentration 50 µg/ml respectively. The concentration of quercetin 3-o-galactoside caused 50% inhibition of the free radical (EC_{50}) was 87 µg/ml and those of quercetin and ascorbic acid were 65µg/ml and 25µg/ml [38].

Antimicrobial effects

usidic acid which was obtained earlier from a fungi (*Fusidium coccineum*), then isolated from the plant *Corchorus aestuans*, has a wide range of antibacterial effects [43]. The antimicrobial activity of various solvent extracts of *Corchorus aestuans* was evaluated against the clinical isolates of Gram-positive and Gram-negative bacterial strains and fungus by the zone of inhibition. The Gram-positive bacteria used were included *Staphylococcus aureus, Bacillus cereus* and *Micrococcus luteus*, and the Gram-negative bacteria were *Escherichia coli, Pseudomonas aeruginosa* and *Klebsiella pneumoniae*, fungus like *Aspergillus niger, Candida albicans, Candida tropicalis, Candida kefyr* and *Cryptococcus neoformans*. It was appeared that ethanol, methanol, ethyl acetate, acetone, chloroform, petroleum ether, hexane and aqueous extracts showed activity against bacteria and fungus. The Ethyl acetate extract of *Corchorus aestuans* showed more activity against *Micrococcus luteus*, zone of diameter 13±0.15mm and *Escherichia coli*, zone of diameter 13.07±0.12mm. Hot water extract of *Corchorus aestuans* showed more activity against *Candida kefyr*, zone of diameter 12.20±0.20mm and *Cryptococcus neoformans*, zone of diameter 11.17±0.29mm, when compared to other solvent extracts. Ethyl acetate extract against bacteria and hot water extract against fungus showed a varying degree of inhibition to the growth of tested organism, than ethanol, methanol and acetone extracts [37].

The antibacterial potential of the methanol extracts of leaves and aerial parts of *Corchorus aestuans* was studied against four Gram positive and Gram negative bacteria [*Bacillus subtilis* MTCC (121), *Staphylococcus aureus* MTCC (96), *Pseudomonas aeuroginosa* MTCC (429) and *Escherichia coli* MTCC (443)], using cup-plate method. The methanol extracts of leaves and aerial parts of the plant significantly inhibited the growth of bacteria as compared to standard antibacterial drug (streptomycin) [52].

The leaf, capsule and root extracts of *Corchorus aestuans* were tested for antibacterial against Gram positive (*Bacillus subtilis, Bacillus pumilis, Bacillus cereus, Staphylococcus aureus*), Gram negative bacteria (*Escherichia coli, Psuedomonas aeuriginosa, Psuedomonas vulgaris, Serratia marceseans*) and antifungal activity (against *Aspergillusniger, Rhizopusstolonifer, Saccharomyces cervisiae*), they showed potent antibacterial activity. The leaf and root extracts of *Corchorus aestuans* showed more antibacterial activity compared to *Corchorus aestuans* capsule extract. In antifungal test, the methanolic extracts showed moderate activity. The chloroform and methanolic *Corchorus aestuans* leaf, capsule and root extracts showed potent antibacterial and antifungal activity [53].

Cardiovascular Effects

Alcoholic extract and glycosides of seeds exhibited cardiotonic activity. Corchorosid A, isolated from the plant, improved cardiac competence experimentally [31].

Cardiac glycoside was isolated from the plant fruits and tested for cardiotonic activity. The cardiotonic effect was studied by using isolated frog heart perfusion technique (IFHP). Ringer solution without calcium was used as a vehicle for administration of isolated cardiac glycoside as test and digoxin as standard. A significant increase in the height of force of contraction (positive inotropic effect) and decrease in heart rate (negative chronotropic effect) was observed at smaller doses (0.4 mg). The effect increased as dose was increased. The test compound had not produced cardiac arrest even at a dose of 2 mg, compared to standard, digoxin that showed cardiac arrest at dose of 0.2 mg. Hence, as compared to standard, the tested cardiac glycoside showed wide therapeutic index [36].

The anti-atherosclerotic activity of the *Corchorus aestuans* leaves was evaluated against Liver X alpha receptor by using GOLD study. 3-Dimensional structure of Liver X alpha receptor (Protein Date Bank ID - 3IPQ) was retrieved

using Protein Data Bank. Phytochemical molecules were retrieved from the pubchem database and the 2D chemical structures were generated from SMILES notation (Simplified Molecular Input Line Entry Specification) by using the Chemsketch Software. Screenings of different docked complex were performed by GOLD study. Absorption, distribution, metabolism, excretion and toxicity properties for all molecules was predicted by using ADMET structure-activity relationship database. Among the 14 phytochemicals, E-7-Tetradecenol was found to be the top compound with highest Gold score of 26.99. According to the results, the authors concluded that phytochemicals from *Corchorus aestuans* leaves prevent atherosclerosis [54].

Anti-inflammatory Effect

The anti-inflammatory effect of methanol extract of aerial parts of *Corchorus aestuans* was evaluated using carrageenan induced rat paw edema. The increase in paw thickness was measured using digital vernier caliper after 1, 2, 3 and 4h of injection. Methanol fraction of aerial parts of the plant at dose of 200 mg/kg significantly inhibited acute phase of inflammation [55].

Conclusion

The current review clarified the main active ingredients and pharmacological effects of *Corchorus aestuans* as a promising plant as a result of effectiveness and safety.

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