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Pharmacological review of *Luffa acutangula* (L) Roxb

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Abstract
Luffa acutangula (Cucurbitaceae), a perennial plant grows mainly in India, Southeast Asia, China, Japan, Egypt, and other parts of Africa, it is widely used in the traditional Indian medicinal system to treat various health ailments. It is commonly present in the waste land also. This plant fruit portion is valuable for hypoglycaemic, antiulcer, anti pyretic, and anti hypertensive effect. In this present review is focused on the pharmacognostical characters like scientific classification, vernacular name and the plant potential in biological activity is described. The plant has been used in jaundice, diabetes, hemorrhoids, dysentery, headache, ringworm infection, and leprosy. More than 50 chemical compounds have been isolated from a plant which mainly comprises flavonoids, anthraquinones, proteins, fatty acids, saponin triterpene, volatile components, and other phytoconstituents. Crude extract of plant and its isolated compounds possess broad pharmacological activities such as antidiabetic, hepatoprotective, antiulcer, anticancer, immunomodulatory, antihyperlipidemic, antioxidant, antimicrobial, CNS depressant, analgesic, and anti-inflammatory. The present review work focused on its distribution, botanical characters, ethanobotanical uses, folklore claims, nutritional value, phytochemical constituents, medicinal properties and biological properties of *L. acutangula*.

Keywords: *Luffa acutangula*, traditional medicine, anthraquinones, saponin triterpene, antidiabetic activity, antioxidant activity

Introduction
Medicinal compounds from plant sources play a key role in prevention and treatment of disease since ancient time. Some of these compounds are toxic to plant predators, but have the beneficial effects in the treatment of human diseases Luffa acutangula is a medicinal plant, usually referred as a ridge gourd. It is prevalent in subtropical region of Asia. India is considered as a primary center of origin. The plant is widely cultivated in India, Southeast Asia, China, Japan, Egypt, and other parts of Africa. Propagation of this plant is done through seeds and are sown in February–March orJune–July. The purpose of the present review is to analyze the traditional uses, phytochemistry, pharmacological activity, and toxicological studies of plant. Moreover, the knowledge eobtained from various experimental studies was critically assessed to provide justification for traditional and medicinal uses of Luffa acutangula [1].

Plant Profile
Synonyms
Cucumis acutangulus, Cucumis lineatus, Cucumis longus var. indicus, Cucumis megacarpus, Cucumis operculatus, Cucurbita acutangula, *Luffa acutangula* var. amara, *Luffa acutangula* var. forskalii, Luffa amara, Luffa drastic, Luffa fluminensis, Luffa foetida, Luffa forskalii, Luffa gosa and Momordica tubiflora [2].

Taxonomic classification
Kingdom: Plantae, Subkingdom: Viridiplantae, Infra kingdom: Streptophyta, Superdivision: Embryophyta, Division: Tracheophyta, Subdivision: Spermatophytina, Class: Magnoliopsida, Superorder: Rosanae, Order: Cucurbitales, Family: Cucurbitaceae, Genus: Luffa, Species: Luffa acutangula.

Common Names
Arabic: leef; Chinese: guang dong si gua; English: angled loofa, angled loofah, Chinese okra, Chinese squash, dishcloth gourd, ribbed loofah, ridged gourd, silk gourd, silk squash, sinkwa towelsponge, strainer vine, vegetable gourd; French: papangaye; German: gerippte Schwammgurke; India: jhinga tor, kalitori, turiya; Japanese: tokado-hechima; Malaysia: ketola, petola segi; Philippines: patola; Portugese: Bucha de purge,

Lufa riscada; Russian: ljufa; Spanish: espoja, esponja, esponja estropajo, muñeco, servilleta de pobre; Swedish: kantgurka; Vietnam: muop khia [3].

Distribution

Luffa acutangula is native to Indian subcontinent (India and Pakistan) and naturalized through out tropics and subtropics. It was found in Asia: (Bangladesh, China, Hong Kong. India, Japan, Kazakhstan, Malaysia, Myanmar, Pakistan, Philippines, Sri Lanka, Taiwan, Thailand, Vietnam, Yemen); Africa: (Benin, Chad, Ghana, Kenya, Madagascar, Mauritius, Mozambique, Nigeria, Sierra Leone, Uganda); North America: (USA, Mexico); Central America and Caribbean: (Costa Rica, Cuba, Dominican Republic, El Salvador, jamaica, Martinique, Puerto Rico, Trinidad and Tobago); South America: (Brazil, Ecuador, Peru, Venezuela)and Australia

Description

Luffa acutangula is a coarse, annual, herbaceous, Stems green, angular, scabrous; tendrils trifid. Leaves alternate; blades 15-20 cm long, 5-7-palmatilobed, chartaceous, the lobes more or less deep, the apex acute or acuminate, the base cordiform or hastate, the margins sinuate-dentate or denticulate; upper surface scabrous; lower surface pale green, scabrous; petioles 8-10 cm long. Flowers unisexual, actinomorphic. Calyx urceolate, with keeled lobes, 10-12 mm long, triangular; corolla pale yellow, the lobes deep, obtuse. Staminate flowers in racemes; stamens 3, the filaments free, 3-4 m long, villous. Pistillate flowers solitary, with a hypanthium less than 1 cm long; staminodia 3, minute, glandular; ovary inferior, tricarpellate, claviform, 10-angled, with numerous horizontal ovules, the style short, the stigmas globose. Fruit claviform, with 10 longitudinal ribs, 15-30 cm long, the pericarp crustose, dehiscent by apical pores; seeds numerous, ovate, 11-12 mm long, blackish.

Parts used medicinally

Leaves, fruits, roots, seed and seeds oil [4].

Botanical Aspect

Luffa acutangula (L.) Roxb. is classed in the Cucurbitaceae, a family of flowering of plants with 98 accepted genera and about 975 species. Many of the annual or perennial species native to temperate and tropical areas are fruit bearing or ornamental plants. The synonyms of plants are Cucumis acutangulus, Cucurbita acutangula, Luffa foetida, Luffa drastica, Cucumis operculatus Roxb., Luffagosa Ham. The plant has different names in different languages of India such as: English: Ridged gourd, angled loofah, ribbed gourd, Chinese okra, silk squash (En); Hindi: Turai, Kadaviturai; Marathi: Dodaka; Sanskrit: Dhamargava, Koshataki; Bengali: Titotorai, Titojhinga, Titodhundal, Jhinga, Ghoshalata; Kannada: Kahire, Kahi heere, Naaga daali balli; Malayalam: Athanga; Tamil: Itukari, Itukarikkoti, Kacappi, Kacappuppirkku, Kaccam, Kaippuppirkku, Karniti; Telugu: Adavibira, Chedubira, Sendubirai, Adavibeera, Chathibeera. The roots of the plant are yellowish brown in color and cylindrical in shape. Longitudinal wrinkles on root contribute to their rough texture. Five angled, glabrous stem is brownish yellow in color along with tendrils up to 6-fid. Flowers are regular, unisexual and consists of yellow petals. Female flowers are yellow colored solitary, 2–15 cm long on pedicels, with inferior, longitudinally ridged ovary and 3-lobed stigma while male flowers are light greenish in color, consist of three free stamens with yellow corolla inserted into the receptacle tube. Leaves are simple, alternate and orbicular in outline with 15–20 cm long, palmately 5–7 angled, triangular to broadly rounded lobes and pale green in color. Veins and vein islets are prominent. Fruits are cylindrical, pale yellowish-brown in color, bitter in taste, tapered toward the base and are covered with 8–10 prominent ribs. Inner part of the fruit is three chambered, fibrous and easily detachable from the outer part. Seeds are elliptical and black colored [5].

Traditional Uses and Ethnopharmacology

Different parts of Luffa acutangula have been used extensively by different ethnic groups in India for medicinal purposes. In Maharashtra and the tribal areas of Madhya Pradesh, leaves and fruit powder are used for the treatment of jaundice. A local inhabitant from reserve forest of Mahadevpur (previously in Andhra Pradesh now in Telangana) widely uses the fruit for diabetes treatment. Apart from this, the plant is also used by the tribes of western Maharashtra on insect bite. Fruit powder is applied topically to treat swollen hemorrhoids. The kernel of the seed is used as an efficient remedy for dysentery while the juice of the fruit is applied to cure a headache. Oral administration of seed powder is extensively used for the treatment of urinary bladderstone in Rajasthan. Local application of pulverized leaves is reported to be useful in splenitis, hemorrhoids, ringworm infection, and leprosy while the juice of the leaves is administered into the eye for treatment of granular conjunctivitis in children. In addition, the fruit possesses demulcent and diuretic properties while the seeds have purgative, emetic and anthelmintic properties. The dried fruit powder is useful in preventing premature graying of hair. The root of the plant is laxative and used in dropsy. Immature fruits of less-bitter cultivars of *Luffa acutangula* were used as a vegetable. They were cooked or fried and used in soups and sauces. Occasionally, the stem tops with young leaves and flower buds were used as a leafy vegetable. In South-East Asia, ridged gourd was a popular vegetable because of the mildly bitter flavour, the slightly spongy texture and sweet juiciness. Young fruits of sweet cultivars were also eaten raw and small fruits were sometimes pickled. The seeds yield an edible oil that is, however, sometimes bitter and toxic. The best sponges come from mature-green fruits, although dry fruits may be used. The fruits were soaked for several days and then peeled. Once cleaned, the sponges were bleached and then dried in the sun, and were used for cleaning, filtering, and bathing. It was used traditionally in insect bites by tribes of Western Maharashtra Decoction of leaves was used for amenorrhea. Poultice of leaves was used for hemorrhoids.

Juice of fresh leaves was used for granular conjunctivitis in children, to prevent the lids from adhering at night from excessive secretion and used externally for sores and various animal bites. Pulp of fruit was used internally, like calocynth, to cause vomiting and purging. Powdered dried fruit made into snuff for use by those afflicted with jaundice. Seed oil was used in dermatitis. In Russia, roots was used as a purge, In Iran and Iraq infused seeds was used as purgative and emetic, In India, roots was used in dropsy and as laxative and leaf and fruit juice were used in jaundice, In Bangladesh, pounded leaves was used in hemorrhoids, splenitis, leprosy, and the juice of leaves was used for conjunctivitis in children, In West Africa, leaf extract of ridged gourd was applied to sores caused by Guinea worms, leaf sap was used as eyewash in conjunctivitis and the fruits and seeds were used in herbal

preparations for treatment of venereal diseases. In Mauritius, seeds were eaten to expel intestinal worms, while leaf juice was applied externally in eczema [6].

Phytochemistry

The phytochemical studies have resulted in isolation and identification of approximately 50 compounds, such as flavonoids, anthraquinones, proteins, fatty acids, saponin triterpene, volatile components, and other phytoconstituents. Proteins Various ribosome inactivating proteins (RIPs) were isolated from different parts of Luffa acutangula. Medicinal applications of RIP have received wide attention, as they possess various pharmacological activities including abortifacient, antifungal, anti-tumor, antivirus and HIV-1 integrase inhibitory activities. Junkaietal. (2002) isolated two RIPs, luffaculin1 (1) and2 (2) from seeds by using sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE). The molecular mass of luffaculin 1 and2wasfound to beat 28kD. Significant anticancer activity was shown by both RIP in human leukemia K562 cells with an IC50 value of 1.1× 10−6 and 2.0 × 10◦7 mol/L, respectively (Junkai etal.,2002). Another RIP, luffangulin (3) was isolated from seed which inhibited cell-free translation (IC50 = 3.5 nM) but showed no activity against HIV-1reverse transcriptase. Flavonoids Schilling and Heiser (1981) isolated total 10 flavonoids from different species of Luffa. Among these, only two flavonoids, i.e., apigenin-7-glucoside(4)and luteolin-7-glucoside (5)were present in leaf and flower (SchillingandHeiser,1981). Anthraquinone Anthraquinone derivative1,8-dihydroxy-4-methylanthracene 9, 10-dione(6)was isolates using bioassay-guided approach. Only five fractions out of the fourteen were evaluated for anti-cancer activity against non-small cell lung cancer cells (NCI-H460). Fraction obtained at second position significantly decreased growth of cell with IC50 value of 10 mg/mlconcentration (Vanajothiand Srinivasan, 2015). Fatty Acids Nutritional evaluation of seed showed the presence of fats, proteins, and minerals. The protein and fat obtained from the kernel were 39% and 44% of the total weight, respectively.

Investigational analysis of seed oil showed the presence of total saturated (32.1%) and unsaturated (67.9%) fatty acids which were recognized as myristic (0.45%) (7), palmitic (20.9%) (8), stearic (10.8%) (9), oleic (24.1%) (10), and linoleic (43.7%) acid (11). Iodine value, saponification value and acid value of the seed oil were found to be 99.5, 190.8, and 10.5, respectively. The minerals like Fe, Ca, Zn, Cu, P, and Mg were also identified from the seed kernel (Kamel and Blackman, 1982). Saponin Triterpene Seven saponins belonging to the oleanane – type triterpene were isolated from the aerial parts of Luffa acutangula. Methanolic extract was repeatedly chromatographed on normal and reversed phase to obtain designated Acutosides A to G. The triterpene saponins isolated were named as: oleanolic acid 3-O-β-D-glucopyranosyl-(1→2)β-D-glucopyranoside (Acutoside-A) (12), 28-O-[O-β-Dxylopyranosyl-(1→4)-O-α-L-rhamnopyranosyl-(1→2)-α-L-arabinopyranosyl] ester (Acutoside-B) (13), 28-O-[O-β-Dxylopyranosyl-(1→3)-O-β-D-xylopyranosyl-(1→4)-O-α-L-rhaMnopyranosyl mnopyranosyl-(1→2)-α-L-arabinopyranosyl] ester (Acutoside-D) (14), 28-O-[O-α-L-arabinopyranosyl-(1→3)-O-β-Dxylopyranosyl-(1→4)-O-α-L-rhamnopyranosyl-(1→2)-α-L-arabinopyranosyl] ester (Acutoside-E) (15), 28-O-[O-β-Dxylopyranosyl-(1→3)-[O-β-D-xylopyranosyl-(1→4)-O-α-L-rhamnopyranosyl-(1→2)-α-L-arabinopyranosyl] ester (Acutoside-F) (16), 28-O-β-D-xylopyranosyl-(1→3)-[O-α-L-arabinopyranosyl-(1→3)-O-β-D-xylopyranosyl-(1→4)]-O-α-L-rhamnopyranosyl-(1→2)-α-L-arabinopyranosyl] ester (Acutoside-G) (17). Acutoside-C (machaelinic acid, = 21-β-hydroxyoleanolic acid)(18)contains the same sugar moiety as that of Acutoside-B. The study revealed that Acutosides have a common prosapogenin structure but differ in the ester-linked sugar moieties structure [7]

Volatile Components Total 25 volatile components from flower were isolated using solid-phase microextraction (SPME) coupled with capillary gas chromatography/mass spectrometry (GC–MS). Out of 25 compounds, 16 volatiles were positively identified and 9 were tentatively identified as 3-methyl-1-butanol (19); 4,5dimethyl-1-hexene(20); α-thujene(21); α-pinene(22);sabinene (23); β-pinene (24); β-myrcene (25); D,L-limonene (26); 1,8cineole (27); β-ocimene (Z) (28); β-ocimene (E) (29); βterpinene(30);γ-terpinene(31);methyl,methylethylsubstituted benzene (32); trans-linalool oxide (33); trans-dihydrocarvone (34); linalool (35); cis-sabinene hydrate (36); α-thujone (37); 2-methyl-6-methylene-1,7-octadien-3-one (38); 3,4-dimethyl2,4,6-octatriene (39); epoxylinelol (40); α-terpineol (41); 1Hindole (42); nerylacetate (43) (FernandoandGrun,2001).

Other Phytoconstituents Six compounds were isolated and analyzed from ethanolic fruit extract using GC-MS named as: 2,3-dihydro,3,5-dihydroxy6-methyl-(4H)-pyran-4-one (44); 3,7,11,15-tetramethyl-2hexadecen-1-ol (45); (3β, 20R)-cholest-5-en-3-ol (46); n-hexadecanoic acid (08); 9,12,15-octadecatrienoic acid methyl ester (47) and citronellyl tiglate (48) (Suryanti *et al*., 2017). Nagarajaiah and Prakash (2014) evaluated physical characteristics and the chemical composition of the dehydrated fruit peel. The results exhibited the presence of iron (4.74 mg), calcium (416 mg), phosphorous (233 mg), ascorbic acid (35 mg) (49), carotene (36.96 mg) (50) and tannin (778.20 mg) per 100 gm of peel (Figure 6) (Nagarajaiah and Prakash, 2014) [8].

Pharmacological Activity of Luffa acutangula

The extracts and purified compounds from Luffa acutangula have been investigated for various pharmacological activities using *in vitro* and *in vivo* models. Extracts from different parts of the plant exhibited potent hepatoprotective, antidiabetic, antihyperlipidemic, antioxidant, anticancer, antibacterial, CNS depressant, immunomodulatory, and antiulcer activity. Some of these activities are discussed below.

Hepatoprotective Activity

Various studies have reported therapeutic potential of Luffa acutangula against liver diseases. Ethanolic fruit extract showed significant hepatoprotective activity compared to pet ether extract in carbon tetrachloride-induced liver necrosis. It also significantly reduced SGPT, SGOT, serum alkaline phosphatase (ALP), serum bilirubin, serum cholesterol, triglyceride (TG), serum high density lipoproteins (SHDLs), serum total proteins and serum albumin. Histopathological studies of liver showed early necrosis in petroleum ether extract while no necrosis was observed in the ethanolic extract, indicating the hepatoprotective potential of the latter (Ibrahim *et al*., 2014).

In another study, researchers investigated hepatoprotective activity of hydro-alcoholic (70%) fruit extract against carbon tetrachloride and rifampicin-induced hepatotoxicity in Wistar rats. The doses of 100, 200, and 400 mg/kg, p.o. significantly

reduced serum marker enzyme (AST, ALP, ALT, and LDH) levels which attributed to the hepatoprotective action of the extract in the rat (Jadhav *et al*.,2010).

Hepatoprotective activity of different fractions of alcoholic fruit extract was evaluated by Mishra and Mukerjee (2017) against paracetamol induced liver toxicity. Toluene, chloroform, and ethyl acetate fractions of ethanolic extract were administered orally (100 mg/kg) and biochemical parameters were measured. Ethyl acetate fraction increased direct bilirubin level while ALT, AST, and ALP levels were restored to normal when compared with other fractions. Histopathological evaluation of live cells indicated the absence of necrosis with less vacuole formation (Mishra and Mukerjee, 2017). Furthermore, Ulaganathan *et al*. (2010) screened hepatoprotective activity of ethanolic extract of the leaves against carbon tetrachloride. Carbon tetrachloride induced elevated levels of serum markers (SGPT, SGOT, and ALP) were brought to normal by oral administration of leaf extract.

Tissue specific antioxidant activity of extract have been observed with the help of improved levels of glutathione peroxidase, glutathione-s-transferase, reduced glutathione, superoxide dismutase, catalase, and lipid peroxidation (Ulaganathan *et al*., 2010). Taken together, these results support the traditional use of Luffa acutangula as hepatoprotective agent. However, hepatoprotective effect is still unconvincing as humans studies were not performed. Hence, ridge gourd is worth considering for treatment of hepatic diseases in human and therefore, should be extensively studied. Antidiabetic Activity Ancient literature reported the use of fruit juice in an adrenal variety of diabetes (Nadkarni, 1996) [9].

Antimicrobial effects

The antibacterial effect of ethanolic extract of *Luffa acutangula* was studied against Pseudomonas aeruginosa, Escherichia coli, Staphylococcus aureus, and Candida albicans. It showed inhibitory zones of 10, 9, 8 and 8 mm against the tested bacteria and fungi respectively.

The antimicrobial activity of methanolic and aqueous extracts of different *Luffa acutangula* var. amara parts (fruits, leaves, roots and seeds) were evaluated against Escherichia coli, Staphylococcus aureus, Klebsiella pneumonia, Proteus vulgaris, Candida albicans, Aspergillus niger, and Fusarium sp, by *in vitro* well diffusion assay. Methanolic and aqueous extracts of different parts showed antimicrobial activity at significant levels. The methanolic extract of seed possessed more inhibitory action against Escherichia coli and Staphylococcus aureus. The methanolic extracts of fruit and leaves also showed antimicrobial activity against Klebsilla pneumonia. Methanolic extracts of fruit and root were effective against Fusarium sp. Both aqueous and methanolic extracts of leaf possessed inhibitory action against Aspergillus niger. Seeds showed the least antifungal activity The antimicrobial activity of the dried leaves extract was studied against Staphylococcus aureus, Staphylococcus pneumonia, Streptococcus pyrogens, Klebsciella pneumonia, Candida albicans and Candida tropicalis. The highest zone of inhibition recorded for the alcoholic extracts of *Luffa acutangula* leaves wasrecorded against Streptococcus pyrogens (20.0 ±0.35 mm), followed by (18.0 ±0.65 mm) against Candida albicans. The lowest combined MIC and MBC values was recorded against Streptococcus pneumonia and Streptococcus pyrogens. The lowest combined MIC and MFC values was recorded against Candida albicans

Antibacterial activity of *Luffa acutangula* fruit extracts was studied against Pseudomonas aeruginosa, Escherichia coli, Bacillus subtilis and Staphylococcus aureus, E. aerogenes, Shigella dysentriae and Salmonella thypi. Fruit powder was macerated with methanol, and the methanol extract extracted sequentially with hexane, chloroform, ethyl acetate and buthanol. The methanol extract inhibited the growth of the Pseudomonas aeruginosa, Escherichia coli, Bacillus subtilis and Staphylococcus aureus, but did not inhibit the growth of the E. aerogenes, Shigella dysentriae and Salmonella thypi. The ethyl acetate extract showed the highest antibacterial activity against Pseudomonas aeruginosa, Escherichia coli, Bacillus subtilis and Staphylococcus aureus, followed by chloroform, buthanol, and hexane extract, respectively

The antimicrobial effects of the extract of *Luffa acutangula* var amara fruits were studied against Staphylococcus aureus (ATCC 9144), Bacillus subtilis (ATCC 6633), Pseudomonas aeruginosa (ATCC 25668), Escherichia coli (ATCC 2091), Candida albicans (ATCC 2091), Aspergillus niger (ATCC 6275) and Aspergillus fumigatus (ATCC 13073). The chloroform extracts showed potent antimicrobial activity against Staphylococcus aureus and Bacillus subtilis at concentration of 64 µg/ml and Pseudomonas aeruginosa and Escherichia coli at concentration of 32 µg/ml, chloroform extract showed more antibacterial activity against Gram negative bacteria when compared with standard drug ceftriaxone 0.5 µg/ml. Aqueous extracts showed antibacterial effect against Pseudomonas aeruginosa and Escherichia coli at concentration of 64 µg/ml. Chloroform extract showed more antibacterial activity than aqueous extract. Both extracts showed weak antifungal activities The antibacterial (against Escherichia coli, Staphylococcus aureus and Pseudomonas aeruginosa) and antifungal (against Curvularia lunata, Drechslera hawaiiensis, Fusarium equiseti and Phoma sorghina) activities of fruits and leaves extracts of Luffa acutngula were studied *in vitro*. The fruit extract of *Luffa acutangula* possessed more antibacterial and antifungal activity than the leaf extract. Escherichia coli was more sensitive (29 and 32mm respectively) than Staphylococcus aureus (17 and 20 mm respectively) and Pseudomonas aeroginosa (12 and 18 mm respectively) to the leaf and fruit extracts of Luffa acutangula. Fungi, Curvularia lunata (22 and 31mm respectively) and Drechslera hawaiiensis (20 and 28 mm respectively) showed high sensitivity to leaf and fruit extract, while Phoma sorghina (9 and 13 mm respectively) and Fusarium equiseti (10 and 4 mm respectively) showed weak sensitivity

Antiparasitic effect

The larvicidal effect of extract of *Luffa acutangula* was studied against the late third larval age group of Culex quinquefasciatus. The larval mortality was observed after 24 h exposure. The LC50 values of the extract of *Luffa acutangula* was 839.81 ppm.

The anthelmintic activity of the of aerial parts extract of *Luffa acutangula* was studied by *in vitro* test using earth worm Pheretima posthuma test. The methanol extracts of aerial part of *Luffa acutangula* showed moderate anthelmintic activity. At 10 mg/ml concentration, it induced paralysis and death after >90 minutes.

Anticancer effect

The cytotoxic potential of the ethanolic and aqueous extracts of *Luffa acutangula* was evaluated against human neuronal glioblastoma cells (U343) and human lung cancer cells

(A549). The results showed significant decrease of the viability of the cells in a concentration-dependent manner. The ethanolic and aqueous extracts of *Luffa acutangula* showed significant cytotoxic activity in both MTT and SRB assay. In brine shrimp lethality bioassay, the aqueous extract also showed more potent cytotoxicity as compared to ethanolic extract.

The *in vitro* anticancer effect of *Luffa acutangula* leaf extracts was studied against human lung cancer cell line (NCI-H460). The leaf extracts exhibits high anti-proliferative activity against the tested cell line, as determined with MTT assay. The IC50 was 20 µg/ml. The extract treated group exhibits high DCF fluorescence (enhanced ROS levels) and significant increase in mitochondrial depolarization when compared to control groups. Nuclear morphology with induction of apoptosis in cells treated with leaf extracts were also observed by microscopic examination using dual staining method of acridine orange-ethidium bromide. The anticancer activity of the ethanolic and aqueous extracts (200 and 400 mg/kg bw orally, for 13 consecutive days) of the *Luffa acutangula* was evaluated in mice against Ehrlich ascites carcinoma (EAC) cell line. Ethanolic and aqueous extracts showed significant decrease in (p<0.0001) tumor volume, viable cell count, tumor weight and elevated the life span of EAC tumor bearing mice. Red blood cell, hemoglobin, and white blood cell count were reverted to normal level in treated mice The anti-cancer effects of a methanolic and aqueous extract (200 and 400 mg/kg, oral) of fruit of *Luffa acutangula* was studied in Dalton's lymphoma ascites (DLA) cell induced solid tumor in mice. The Development of solid tumor in mice was significantly diminished by both extracts Five major fractions were obtained from *Luffa acutangula* and evaluated for their anti-proliferative activity against non-small cell lung cancer cells (NCI-H460). Among the tested fractions, one fraction was effectively decreased the growth of cancer cells with IC50 values of 10 µg/ml concentration. Furthermore, it significantly increased intracellular reactive oxygen species and decreased the mitochondrial membrane potential. The apoptogenic activity of this fraction was confirmed by cell shrinkage, membrane blebbing and formation of apoptotic bodies. A single bioactive compound was isolated from the active faction, and identified as 1,8 dihydroxy-4-methylanthracene 9,10-dione.

Antioxidant effect

The antioxidant effect of ethyl acetate and ethanol extracts of dried leaves of *Luffa acutangula* var amara was evaluated by 1, 1-diphenyl-2-picrylhydrazyl hydrochloride (DPPH) reduction method, lipid peroxidation method, reduced glutathione and nitric oxide scavenging method. The ethanol and ethyl acetate extracts at 25 to 800 mcg/ml concentrations showed significant anti-oxidant effect in nitric oxide and DPPH models. Significant inhibitory activity on lipid peroxidation and glutathione reduced assay were also possessed by the extracts DPPH scavenging capacity of various ridge *Luffa acutangula* peel extracts was analyzed. Extracts were able to quench the DPPH radical, among five different extracts, aqueous extract showed comparatively more scavenging activity (24.71%) followed by ethanol (18.87%), acetone (13.05%), methanol (11.13%) and ethyl acetate extracts (7.14%)

The antioxidant activity of the extracts of *Luffa acutangula* var. amara were assessed using DPPH, ABTS, superoxides radical, reducing power and phosphomolybdenum assay. Among the all extracts, the ethanolic extract of fruit pericarp produced potent antioxidant activity and showed presence of gallic acid and catechin, the total phenolic and flavonoid contents showed positive correlation with antioxidant potential of the extract.

The ethanolic seed extract of *Luffa acutangula* var amara was evaluated for antioxidant activity by 1,1-Diphenyl-2-picryl hydrazyl and hydrogen peroxide method. The extract showed potent antioxidant activity (75.33±0.592 and 76.50±0.281%) at 200 µg/ ml by 1,1-Diphenyl-2-picryl hydrazyl and hydrogen peroxide method as compared to ascorbic acid

The antioxidant activity of the methanol extract of *Luffa acutangula* and its derived fractions, such as n-hexane, chloroform, ethyl acetate, n-butanol and residual aqueous fraction were studied using β-carotene bleaching method, in addition to their correlation to the total phenolics and flavonoids contents. The results showed that methanol extract of Luffa acutangula, n-hexane and chloroform extracts possessed significant antioxidant activities. The total phenolics content was ranged from 18.7±0.11 to 105.1±0.08 mg GAE/g and the total flavonoids content was ranged from 34.9±0.09 to 105.3±0.09 mg QE/g of dried weight basis. The correlation coefficients between the antioxidant activities and the phenolics/flavanoids contents were found to be very small. The highest antioxidant activity was demonstrated by n-hexane extract and the highest total phenolics/flavonoids contents were presented by ethyl acetate extract The methanolic extract of *Luffa acutangula* fruit showed higher antioxidant activity (71.4±4.46% at 1 mg/ml) compared to hexane and aqueous extracts (13.93±1.3 and 51.84±3.76%, respectively). This extract was further partially purified chromatographically and out of these fractions (F1, F2, F3, F4, F2-1, F2-2, F2 -3 and F2-4), F2-3 showed significant antioxidant activity (73.96±6.4% at 25 µg/ml). This fraction was further tested for its effect on lipid peroxidation, on superoxide dismutase, catalase and glutathione, in t-butyl hydroperoxide (t-BHP) treated-erythrocytes. Pretreatment with fraction F2-3 significantly inhibited lipid peroxidation in a dose and time dependent manner compared to control. Catalase, SOD and GSH levels were also brought up in a dose and time dependant manner compared to control.

Luffa acutangula pulp and peel powders as well as their extracts were evaluated for their antioxygenic activity using linoleic acid peroxidation, β-carotene-linoleic acid bleaching and 1,1-diphenyl-2-picryl-hydrazyl (DPPH) methods. Ethanol/water extracts from *Luffa acutangula* pulp and peel showed highest antioxygenic activity followed by water extracts, while the petroleum ether extract showed moderate antioxygenic activity. *Luffa acutangula* peel powder and its extracts showed slightly higher antioxygenic activity than *Luffa acutangula* pulp powder and its extracts. The antioxidant effect of four successive extracts of L. amara pericarp (LAP) were evaluated *in vitro*. The extracts exhibited significant antioxidant activity in the DPPH, ABTS assays. The IC50 values obtained for DPPH, ABTS scavenging of ethanol extract were 84.00 ± 0.76 and 43.76 ± 0.62 µg/ml which were found the least among all extracts and comparable to the reference standard ascorbic acid (IC50= 41.89 ± 0.36 and 12.16±0.04 µg/ml). The total antioxidant capacity of ethanol extracts found to be highest (30.72 ± 0.73 µg/ ml) (equivalent to ascorbic acid). In superoxide radical scavenging assay, the petroleum ether and aqueous extracts showed the least, while ethyl acetate and ethanol extracts showed the highest scavenging ability, similar to the results of DPPH assay. It was found that the reducing power increased with the concentration of test extracts. The extracts exhibited

a good reducing power. The ethyl acetate and ethanol extracts exhibit maximum reducing of 0.615 ± 0.058 and 0.512 ± 0.004 at 0.80 mg/ml for, respectively [10]

Hypoglycemic effect

Antihyperglycemic activity of the methanolic fruit extract of *Luffa acutangula* was evaluated through oral glucose tolerance tests in glucose-loaded mice. The methanolic extract of the fruits significantly and dose-dependently reduced blood sugar concentrations (38.5, 39.6, and 41.8% reduction at 100, 200 and 400 mg / kg bw). At a lower extract dose of 50 mg per kg bw, the extract reduced blood sugar concentrations by 13.1%, but the effect was not statistically significant.

The antidiabetic activity of fruits and seeds ethanolic extract of *Luffa acutangula* was studied in streptozotocin induced diabetic in rats. The extract (200 and 400 mg/kg) significantly (p<0.05) reduced fasting blood sugar of streptozotocin diabetic rats in a dose-related manner, with maximum hypoglycemic effect after 21 days.

The hypoglycemic activity of the methanolic leaves extract of *Luffa acutangula* was evaluated in mice. *Luffa acutangula* extract possessed significant hypoglycemic activity when administered 15 min after glucose load using a modified oral glucose tolerance test in mice. Among three plant extracts (Bixa orellana, Kyllinga monocephala and Luffa acutangula), *Luffa acutangula* showed the most potent glucose level decreasing effect (37.5%) comparable to that of possessed by glibenclamide (37.88%).

The hypoglycemic effect of petroleum ether, chloroform and ethanol extracts of fruits of *Luffa acutangula* were evaluated in alloxan induced diabetic Wister rats. Chloroform and alcoholic extracts of fruits of *Luffa acutangula* showed more significant (p< 0.01) reduction in blood glucose level in alloxan induced diabetic Wister rats compared to control and glibenclamide (10 mg/kg bw).

The antidiabetic and antihyperlipidemic potentials of methanolic and aqueous extracts (100, 200 and 400 mg/kg, po) of *Luffa acutangula* (LA) fruits were studied in Streptozotocin(65 mg/kg, ip) and nicotinamide (120 mg/kg, ip) induce non insulin dependent diabetes mellitus in rats. The methanolic extract at a dose of 100 mg/kg was found to be active (p< 0.05) but the antidiabetic activity was increased significantly (p< 0.01) at a dose of 200 and 400 mg/kg as compared to the aqueous extract, the methanolic extract also showed dose dependent pronounced (p<0.01) antihyperlipidemic activity in comparison with the aqueous extract

Hepato- cardio- and nephro-protective effects

The hepatoprotective activity of *Luffa acutangula* var amara fruits extracts was studied against carbon tetrachloride induced hepatotoxicity. Alcoholic extract (150 mg/kg, po) showed good hepatoprotective activity, while petroleum extract (150 mg/kg, po) showed moderate hepatoprotective activity as compared with standard silymarin (100 mg/kg, po). These effects were further confirmed by histological study

The hepatoprotective activity of hydroalcoholic extract of *Luffa acutangula* was also evaluated against CCl4 and rifampicin-induced hepatotoxicity in rats. The hydroalcoholic extract showed significant hepatoprotection against CCl4 and rifampicin induced hepatotoxicity in rats. Hepatoprotective activity of the hydroalcoholic extract was due to the decreased levels of serum marker enzymes (AST, ALT, ALP and LDH) and increased total protein including the improvement in histoarchitecture of liver cells of the treated groups as compared to the control group. The hydroalcoholic extract also showed significant decrease in malondialdehyde formation, increased activity of non-enzymatic intracellular antioxidant, glutathione and enzymatic antioxidants, catalase and superoxide dismutase.

The hepatoprotective and antioxidant activity of ethanol leaves extract (200, 400, 600 mg/kg, po) of *Luffa acutangula* var amara were evaluated in CCl4- induced hepatic damage in rats. The elevated serum enzymatic levels of serum glutamate oxaloacetate transaminase, serum glutamate pyruvate transaminase, serum alkaline phosphatase, total bilirubin, total cholesterol and total protein were restored towards normalization significantly by the extract. The possible mechanism of these activities could be due to free radical scavenging and antioxidant activities which attributed to the flavanoids in the extractThe protective effects of hydroalcoholic extract of *Luffa acutangula* on doxorubicin induced cardio and nephrotoxicity were investigated in mice using various parameters such as serum biomarkers, antioxidants in target organs and histoarchitecture alterations. Pretreatment with hydroalcoholic extract reversed significantly the elevated serum alanine amino transferase, lactate dehydrogenase and creatinine phosphokinase in heart and kidney in doxorubicin treated mice. Hydroalcoholic extract treatment also inhibited the elevated malondialdehyde and restored the depleted glutathione, catalase, superoxide dismutase in heart and kidney tissue. The altered histoarchitecture of heart and kidney tissue due to doxorubicin treatment were also improved with hydroalcoholic extract. The protective activity observed with hydroalcoholic extract on doxorubicin induced cardio and nephrotoxicity in mice was related to antioxidant property of the plant extract.

Gastroprotective effect

The gastroprotective effect of *Luffa acutangula* methanolic and aqueous extracts (100, 200 and 400 mg/kg once daily for 21 days) on aspirin induce gastric ulcerations was studied in streptozotocin induced diabetic rats. Methanolic extract significantly (p< 0.01) increased mucosal glycoprotein and antioxidant enzyme level in gastric mucosa of diabetic rats than aqueous extract (p< 0.05). Methanolic extract was efficient in reversing the delayed healing of gastric ulcer in diabetic rats close to the normal level. It exhibited better ulcer healing effect than glibenclamide and aqueous extract, because of its antihyperglycemic and mucosal protective actions.

CNS effects

The ethanolic extracts of defatted fruits of *Luffa acutangula* var amara were studied for its effect on behavioral changes, exploratory activity and barbiturate sleeping time in mice. The extract exhibited dose-dependent CNS depressant activity. The ethanolic extract showed significant reduction in exploratory activity in a dose dependent manner. Furthermore, it enhanced pentobarbitone sodium induced hypnosis in single dose treated as well as in chronically treated groups of mice.

The anticataleptic efficacy of ethanol extract of *Luffa acutangula* in haloperidol induced catalepsy was studied in rats using block method, locomotor activity in actophotometer and exploratory behavior in hole board apparatus. Ethanol extract treated rats showed significant (p< 0.01 and p< 0.05) increase in head dippings and line crossings when compared with negative control group at 90, 120, 150, 180 min after haloperidol challenge. The author postulated that the

protective effect of ethanol extract of *Luffa acutangula* against symptoms of Parkinson's disease could be due to regulation of neurotransmitters such as dopamine, serotonin, glutamate which were playing an important role in protection of catalepsy, in addition to antioxidant properties of the extract.

Anti-inflammatory and analgesic effects

The anti-inflammatory effect of ethyl acetate and ethanol extracts (250 and 500 mg/kg, po) of dried leaves of *Luffa acutangula* var amara was evaluated by carrageenan induced hind paw edema and cotton pellet granuloma models in rats. Both extracts at both dose levels possessed significant anti-inflammatory effect in acute and chronic models.

The anti-inflammatory activity of ethanolic extract (500mg/kg) of the fruit of *Luffa acutangula* was studied using carrageenan induced paw edema in rats. The ethanolic extract of *Luffa acutangula* fruit exhibited statistically significant ($p< 0.05$) inhibition of paw volume 72.73%

The ethanolic seed extract of *Luffa acutangula* var amara was evaluated for anti-inflammatory by carrageenan induced rat paw edema method and analgesic activity by tail flick and tail immersion methods. The extract showed significant anti-inflammatory effect (60.8% at 300 mg/ ml as compared with diclofenac sodium) and significant analgesic activity, the reaction time noted was 6.25±0.52 and 5.80±0.52 seconds, by tail flick and tail immersion methods, at a dose of 400 mg

The antinociceptive potential of the methanolic fruit extract of *Luffa acutangula* was evaluated in gastric pain model mice, where pain was induced through intraperitoneal administration of acetic acid, resulting in pain and concomitant abdominal constrictions. The extract, dose-dependently reduced the number of abdominal constrictions caused by the gastric pain in mice, by 46.7, 50.0, 53.3, and 63.3% at100, 200 and 400 mg / kg bw respectively. The results were statistically significant at all doses of the extract.

Immunomodulatory effect

The ethanol extract of *Luffa acutangula* var amara was evaluated for immunomodulatory activity by *in vivo* phagocytosis using carbon clearance and neutrophil adhesion test. The ethanolic extracts showed potent *in vitro* antioxidant ability, increased phagocytic index (0.028 ± 0.002), and increased the % neutrophil adhesion (24.63 ± 0.87%).

Abortifacient effect

Several farmers from the northeastern region of Brazil have reported abortions in ruminants that had ingested fruits of Luffa acutangula. Tea made from this plant was used by women for induction of abortion. The ingestion of *Luffa acutangula* during pregnancy inhibited normal development of rat pups as shown by reduced fetal weight and the occurrence of a single cleft palate

Toxicity

The ethanolic extract of the leaves did not show any toxic symptoms or mortality up to dose of 2g/kg orally in ratsAcute toxicity and lethality test of the ethanolic extract of fruits and seeds of *Luffa acutangula* in rats gave an oral LD50 greater than 5 g/kgHydro-alcoholic (70%) extract of fruit of *Luffa acutangula* caused no mortality in mice up to 10 g/kg dose, even after 72 h [11].

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