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A review on *Luffa acutangula*: A potential medicinal plant

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Abstract: The phytochemical analysis of *Luffa acutangula* extracts showed that the fruits contained tannin, saponin, anthroquinone, sterols, glycosides, carbohydrates, reducing sugar, flavinoids, phenolic compounds, quinines, lignins, cucurbitacins, oil and triterpenes**.** Pharmacological studied showed that Luffa acutangula possessed antimicrobial, antiparasitic, anticancer, antioxidant, hypoglycemic, hepato-, cardio-, nephro- and gastroprotective, anti-inflammatory and analgesic, immunomodulatory, abortifacient, anticataleptic and behavioral changing effects. The current review discussed the chemical constituents and pharmacological effects of *Luffa acutangula*.

Keywords: constituents, pharmacology, therapeutics, *Luffa acutangula*

I. INTRODUCTION

Recent reviews revealed that the medicinal plants possessed central nervous[1-2], cardiovascular[3-4], antioxidant[5-6], reproductive[7-10], gastro-intestinal[11-14], respiratory[15-16], antidiabetic[17-19], antimicrobial[20-25], antiparasitic[26-27], dermatological[28], anticancer[29-30], anti-inflammatory, antipyretic and analgesic[31-33], immunological[34-35], hepato and reno-protective[36-38] and many other pharmacological effects. The phytochemical analysis of *Luffa acutangula* extracts showed that the fruits contained tannin, saponin, anthroquinone, sterols, glycosides, carbohydrates, reducing sugar, flavinoids, phenolic compounds, quinines, lignins, cucurbitacins, oil and triterpenes**.** Pharmacological studied showed that *Luffa acutangula* possessed antimicrobial, antiparasitic, anticancer, antioxidant, hypoglycemic, hepato-, cardio-, nephro- and gastroprotective, anti-inflammatory and analgesic, immunomodulatory, abortifacient, anticataleptic and behavioral changing effects. This review was designed to highlight the chemical constituents and pharmacological effects of *Luffa acutangula*.

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*[39].

Taxonomic classification:
Kingdom: Plantae, **Subkingdom**: Viridiplantae, **Infrakingdom**: Streptophyta, **Superdivision**: Embryophyta, **Division**: Tracheophyta, **Subdivision**: Spermatophytina, **Class**: Magnoliopsida, **Superorder**: Rosanae, **Order**: Cucurbitales, **Family**: Cucurbitaceae, **Genus**: *Luffa*, **Species**: *Luffa acutangula*[40].
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[40-41].

Distribution:

Luffa acutangula is native to Indian subcontinent (India and Pakistan) and naturalized throughout 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**[40-41].

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[40, 42].

Traditional uses:

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[43-45]. 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[46].

Parts used medicinally:

Leaves, fruits, roots, seed and seeds oil[8].

Physico-chemical characteristics and chemical constituents:

Physicochemical characteristics of *Luffa acutangula* fruit were: loss in dryness 2.56%, total ash 6.36, acid insoluble ash 0.68, water soluble ash 3.77%, sulphated ash 8.05%, solubility (alcohol 17.2%, water 30.2%) and extractive values (hexane 4.38%, chloroform 1.23%, ethyl acetate 1.02%, ethanol 5.43% and water 17%)[47].

Ash values of *Luffa acutangula* var. *amara* fruit (% w/w) were: total ash 9.0, acid insoluble ash 1.0, water soluble ash 7.6 and sulphated ash 6.4, while, the extractive values of *Luffa acutangula* var. *amara* fruit (%w/w) were: petroleum ether 60-80^0 1.03, ethyl acetate 0.97, alcohol 1.56 and water 9.3[48].

The preliminary phytochemical analysis of *Luffa acutangula* extracts showed that the fruits contained tannin, saponin, anthroquinone, sterols, glycosides, carbohydrates, reducing sugar, flavinoids, phenolic compounds, quinines, lignins, cucurbitacins, oil and triterpenes[48-51].

The seeds of *Luffa acutangula* var. amara contained fixed oil consisted of glycerides of palmitic, stearic and myristic acids. The protein and fat contents of the kernel were 39% and 44%, respectively, and on a moisture and fat-free basis the kernel's protein content was 74.6%. The fatty acid profile indicated that the glycerides of oleic and linoleic acid constitute 68% of the total kernel oil. Iodine value, saponification value and acid value were 99·5, 190·8 and 10·5, respectively. The maximum melting and freezing points were −3 and −10°C, respectively. The seeds were also found to be a good source of certain amino acids, phosphorus, iron and magnesium[52-53].

The oil characteristics and nutritional composition of seeds of two local varieties [Prince ridge gourd (PRG) and Hercules ridge gourd (HRG)] seeds grown in Bangladesh were studied. Both varieties contained considerable amounts of lipid (26.8-28.2% in PRG and 23.2-25.4% in HRG) and protein (20.8-23.1% in PRG

and 25.9-26.8% in HRG). Acylglycerol contents were: monoacylglycerols (1.6-1.9% in PRG and 1.4-1.6% in HRG), diacylglycerols (4.0-4.6% in PRG and 2.6-3.0% in HRG) and triacylglycerols (84.6-86.7% in PRG and 86.7-88.3% in HRG), whereas lipid classes were: neutral lipids (92.5-94.2% in PRG and 91.7-94.9% in HRG), glycolipids (2.8-3.2% in PRG and 2.5-3.9% in HRG) and phospholipids (1.9-2.4% in PRG and 1.2-2.6% in HRG). GLC analysis showed that linoleic acid was the major (49.5% - 51.0%) in PRG and (48.6% - 49.2%) in HRG[54].

A novel ribosome inactivating peptide, luffangulin, has been identified in the seeds[55]. The composition of *Luffa acutangula* dried leaves were: ash 6.3%, fat 5.1%, fibre 4.0%, protein 2.6%, moisture 10.6%, carbohydrate 71.4%, calcium (58.6 mg/g), copper (0.6 mg/g), magnesium (12.4 mg/g), manganese (0.9 mg/g), zinc (0.6 mg/g), sodium (14.4 mg/g) and potassium (143.6 mg/g)[56].

Chemical compounds identified in the headspace of *Luffa acutangula* flower were: 3-methyl-1-butanol, 4,5-dimethyl-1-hexene; α-thujene, α-pinene, sabinene, β-pinene β-myrcene, L-limonene, 1,8-cineole, β-ocimene(Z), β-ocimene(E), β-terpinene ϒ-terpinene, methyl, methyl ethyl substituted benzene, trans-linalool oxide, trans-dihydrocarvone, linalool, cis-sabinene hydrate, α-thujone, 1,7-octadien-3-one, 2-methyl-6-methylene, 2,4,6-octatriene 3,4-dimethyl, epoxylinelol, α-terpineol, indole and neryl acetate[57]. While, the composition of *Luffa acutangula* fruit were: moisture 94.6%, ash content 0.26%, carbohydrates 3.86, crude protein 0.46, crude fiber content 42.94%, fat 0.1% and energy 18.18 Kcal/100gm[58].

The amount of lignin in the fruit was (58.7 mg/kg), tannin (1.84 mg /kg), phenol (0.62 mg/kg), flavonoid (0.45 mg/kg) and alkaloid (0.19 mg/kg)[59-60].

The fruits contained vitamin A 0.0001 µg/100gm, thiamine 0.7692mg/100gm, riboflavin 0.2061 mg/100gm, niacine 3.1282 mg/100gm, vitamin C 0.083 mg/100 gm, Cu 0.9 mg/100gm, Fe 34.1 mg/100gm, Mg 27.38 mg/100gm, Mn 2.34 mg/ 100gm, Ca 99.78 mg/100gm and Zn 9.52mg/100gm[58].

Ten compounds were isolated from ethanolic extract of *Luffa acutangula* fruits [4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl; n-hexadecanoic acid; 9-octadecynoic acid; 9,12,15-octadecatrienoic acid, (Z,Z,Z); 9,12,15-octadecatrienoic acid, (Z,Z,Z); 1,2-benzenedicarboxylic acid, diisooctyl ester; bicyclo[4.4.0]dec-2-ene-4-ol, 2-methyl-9-(prop-1-en-3-ol-2-yl); spiro[androst-5-ene-17,1'-cyclobutan]-2'-one, 3-hydroxy-, (3á,17á); diazoprogesterone and 1,6,10,14-Hexadecatetraen-3-ol, 3,7,11,15-tetramethyl-, (E,E)[60].

2,3-dihydro,3,5-dihydroxy-6-methyl-(4H)-pyran-4-one; 3,7,11,15-tetramethyl-2-hexadecen-1-ol; (3β, 20R)-cholest-5-en-3-ol; *n*-hexadecanoic acid, 9, 12, 15-octadecatrienoic acid methyl ester, citronellyl tiglate and 1,8 dihydroxy-4-methylanthracene 9,10-dionewere also isolated from the fruits of *Luffa acutangula* [61-62].

However, GC-MS analysis of hexane extract of *Luffa acutangula* fruits revealed the presence of forty five different class of compounds: undecane, 2,2-dimethyl-, octane, 2,4,6-trimethyl-, octane, 2,4,6-trimethyl-, octane, 2,4,6-trimethyl-, undecane, 4-methyl-, heptane, 5-ethyl-2,2,3-trimethyl-, decane, 3,7-dimethyl-, 1-pentanol, 4-methyl-2-propyl-, decane, 2,4-dimethyl-, dodecane, 2,6,10-trimethyl-, decane, octane, oxalic acid, allyl octyl ester, heptadecane, 2,6-dimethyl-, tridecane, oxalic acid, allyl pentadecyl ester, decane, 2,3,5,8-tetramethyl-, n-decanoic acid, 6,10-dimethyl-4-undecanol, heptadecane, 2,6,10,14-tetramethyl-, benzene, (1-butylhexyl)-, benzene, (1-propylheptyl)- , benzene, (1-ethyloctyl)-, dodecanoic acid, undecanoic acid, ethyl ester, benzene, (1-methylnonyl)-, benzene, (1-butylheptyl)-, benzene, (1-propyloctyl)-, benzene, (1-ethylnonyl)-, benzene, (1-methyldecyl)-, benzene, (1-butyloctyl)-, benzene, (1-ethyldecyl)-, ethyl tridecanoate, 3,7,11,15-tetramethyl-2-hexadecen-1-ol, pentadecanoic acid, ethyl ester, hexadecanoic acid, methyl ester, E-11-hexadecenoic acid, ethyl ester, hexadecanoic acid, ethyl ester, 7,10,13-hexadecatrienoic acid, methyl ester, 7,10,13-hexadecatrienoic aci, methyl ester, 9,12-octadecadienoic acid, ethyl ester, 9,12,15-octadecatrienoic acid, ethyl ester, (Z,Z,Z)- , octadecanoic acid ethyl ester and eicosanoic acid ethyl ester. GC-MS of chloroform extract of *Luffa acutangula* fruits revealed the presence of 35 compounds included: 2,4-heptadienal, (E,E)-, 2-Octenal, (E)-, octanoic Acid, octanoic acid, benzoic acid, 4-methyl-, 2-oxo-2-phenylethyl ester, 2-butanoyl-5-methylfuran, 2-cyclohexyl-3-isopropyl-pent-4-en-2-ol , dodecanoic acid, D-allose , 9-oxononanoic acid, vanillin, n-decanoic acid , 2-methoxy-4-vinylphenol, 2,4-nonadienal, (E,E)-, E-11,13-tetradecadien-1-ol, Z,Z-7,11-hexadecadien-1-ol, 2-butanone, 4-butoxy-3-methyl-, octadecanoic acid, 9,12,15-octadecatrienoic acid, methyl ester, (Z,Z,Z)-, octadecanoic acid, methyl ester, phytol, n-hexadecanoic acid, hexadecanoic acid, methyl ester, heptadecane , 2-cyclohexen-1-one, 4-hydroxy-3,5,6-trimethyl-4-(3-oxo-1-butenyl)-, 3,7,11,15-tetramethyl-2-hexadecen-1-ol, 11,14,17-eicosatrienoic acid, methyl ester, citronellyl tiglate, 6-hepten-2-one, 7-phenyl-, hexatriacontane and triacontane[44].

Minerals identified in the fruits of *Luffa acutangula* were: sodium 282.9 ppm, potassium 702 ppm, calcium 312 ppm, P 4.86%, S 2.22%, Mo 0.07%, Mg 2.62%, Si 2.19%, Fe 0.85%, Al 0.17%, Zn 0.06% and Cu 0.10%[47].

Seven oleanane-type triterpene saponins, acutosides A-G, were isolated from *Luffa acutangula* (Acutoside A was oleanolic acid 3-O-beta-D-glucopyranosyl-(1-2)-beta-D-glucopyranoside. Acutosides B, D, E, F and G have a common prosapogenin structure, acutoside A, and only differ in the structures of the ester-linked sugar moieties). Acutosides H and I, were also isolated from the seeds of *Luffa acutangula*, they have the same

prosapogenin structure, oleanolic acid 3-O-[O-α-L-arabinopyranosyl-(1→3)-β-D-glucopyranosyluronic acid] and differ in the structures of the ester-linked sugar moieties[63-64].

The composition of *Luffa acutangula* peel (%) were: moisture content 12.40 ± 0.23, carbohydrate content 38.94 ± 0.49, protein content 14.26 ± 0.17, fat content 6.10 ± 1.41, fiber content 20.60 ± 0.16 and ash content 7.70 ± 0.45. The total phenolic content of methanol, aqueous, acetone, ethanol and ethyl acetate extracts was 00.43 ± 00.1, 00.26 ± 00.1, 0.063 ± 0.01, 0.043 ± 0.03, 0.041 ± 0.01 mg/100 g of *Luffa acutangula* peel, respectively. It also contained significant amount of phenolic acids like p-coumaric acid (68.64 mg/100 g of dry weight) followed by gallic acid (34.98 mg/100 g of dry weight), protocatechuic acid (30.52 mg/100 g of dry weight) in free form and ferulic acid (13.04 mg/100 g of dry weight) in bound form. The amino acid composition of *Luffa acutangula* peel were: alanine 12.12 ± 0.41, amino adipic acid 21.20 ± 0.73, anserine 3.93 ± 0.74, arginine 1.68 ± 0.19, aspartic acid 21.77 ± 0.78, carnosine 23.20 ± 0.12, cysteine 10.00 ± 0.08, glutamic acid 5.14 ± 0.45, histidine 2.34 ± 0.43, hydroxyl lysine 8.00 ± 0.11, isoleucine 15.61 ± 0.19, leucine 5.40 ± 0.81, lysine 6.95 ± 0.51, methionine 2.51 ± 0.19, 1-methyl histidine 0.73 ± 0.13, phosphoethanolamine 5.61 ± 0.56, proline 15.42 ± 0.48, taurine 0.49 ± 0.28, tryptophan 3.23 ± 0.71and tyrosine 14.01 ± 0.13 µg/mg of protein[65].

The total phenolic and the total flavonoid contents were studied in aqueous petroleum ether, ethanol, ethyl acetate extract of the fruits of *Luffa acutangula* var. *amara*. Total phenolic content of extract varied between 3.85 ± 0.003 to 30.11 ± 0.005 mg/g GAE. The highest total phenolic content was recorded in ethanol extract 30.11 ± 0.005 mg GAE, while the least in petroleum ether extract 3.85 ± 0.003 mg GAE. The total flavonoid content varied between 5.07 ± 0.001 to 86.50 ± 0.074 mg /g QE of dry extract. The highest flavonoid content was observed in ethyl acetate extract 86.50 ± 0.074, while the least was observed in petroleum ether extract 5.07 ± 0.001 mg /g QE[66].

Many phenolics included gallic acid, catechin and *p*-hydroxybenzoic acid were isolated from *Luffa acutangula* var. amara[66-67].

Pharmacological effects:

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[68].

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[69].

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 was recorded 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*[56].

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[70].

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[71].

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[72].

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 LC_{50} values of the extract of *Luffa acutangula* was 839.81 ppm[73].

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[74].

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[75].

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 IC_{50} 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[76].

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[77].

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[78].

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 IC_{50} 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[62].

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[79].

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%)[65].

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[66].

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[80].

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[81].

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[82].

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[83].

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 IC_{50} 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 (IC_{50}= 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[67].

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[84].

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[85].

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%)[86].

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)[87].

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[88].

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[49].

The hepatoprotective activity of hydroalcoholic extract of *Luffa acutangula* was also evaluated against CCl_4 and rifampicin-induced hepatotoxicity in rats. The hydroalcoholic extract showed significant hepatoprotection against CCl_4 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[89].

The hepatoprotective and antioxidant activity of ethanol leaves extract (200, 400, 600 mg/kg, po) of *Luffa acutangula* var *amara* were evaluated in CCl_4- 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 extract[90]

The 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[91].

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[92].

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[43].

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[93].

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[79].

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%[94].

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/[80].

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[84].

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%)[66].

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[95].

Toxicity:

The ethanolic extract of the leaves did not show any toxic symptoms or mortality up to dose of 2g/kg orally in rats[90]. Acute toxicity and lethality test of the ethanolic extract of fruits and seeds of *Luffa acutangula* in rats gave an oral LD_{50} greater than 5 g/kg[47]. Hydro-alcoholic (70%) extract of fruit of *Luffa acutangula* caused no mortality in mice up to 10 g/kg dose, even after 72 h[89].

II. CONCLUSION

The current review discussed the pharmacological effects of *Luffa acutangula* which included antimicrobial, antiparasitic, anticancer, antioxidant, hypoglycemic, hepato-, cardio-, nephro- and gastroprotective, anti-inflammatory and analgesic, immunomodulatory, abortifacient, anticataleptic and behavioral changing effects. The review also highlighted the chemical constituents and safety of *Luffa acutangula* as a promising medicinal plant for therapeutic purposes as a result of effectiveness and safety.

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