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Constituents and pharmacology of *Luffa cylindrica*- A review

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Abstract: *Luffa cylindrica* was used traditionally for the treatment of asthma, intestinal worms, sinusitis, chronic bronchitis pain, carbuncles, abscesses, inflammation, heat rashes of children in summer, bowels or bladder hemorrhage, hemorrhoids, jaundice, menorrhagia, haematuria, leprosy, spleenopathy, as anthelmintic, carminative, emmenagogue, galactagogue and as antiseptic. The phytochemical screening of *Luffa cylindrica* revealed that the plant contained anthocyanins, glycosides, flavonoids, triterpenoid, cardiac glycosides, saponins, carbohydrates, proteins, alkaloids, and tannins. The pharmacological investigation showed that *Luffa cylindrica* possessed antiinflammatory, analgesic, antipyretic, hypoglycemic, antibacterial, antifungal, antiviral, anthelmintic, antioxidant, anticancer, hepatoprotective, antiemetic, wound healing, immunological, bronchodilating, reproductive effect and in treatment of cataract. The current review discussed the contents and biological effects of *Luffa cylindrica*.

Keywords: *Luffa cylindrica*, pharmacology, constituents, medicinal plants

I. INTRODUCTION

Plants generally produce many secondary metabolites which are bio-synthetically derived from primary metabolites and constitute an important source of chemicals which are used as pharmaceuticals, agrochemicals, flavours, fragrances, colours, biopesticides and food additives. Recent reviews showed that the medicinal plants possessed wide range of biological effects included central nervous, cardiovascular, antioxidant, endocrine and reproductive, gastro-intestinal, respiratory, antidiabetic, antimicrobial, antiparasitic, dermatological, anticancer, anti-inflammatory, antipyretic, analgesic, immunological[1-31] and many other pharmacological effects. *Luffa cylindrica* was used traditionally for the treatment of asthma, intestinal worms, sinusitis, chronic bronchitis pain, carbuncles, abscesses, inflammation, heat rashes of children in summer, bowels or bladder hemorrhage, hemorrhoids, jaundice, menorrhagia, haematuria, leprosy, spleenopathy, as anthelmintic, carminative, emmenagogue, galactagogue and as antiseptic**.** The phytochemical screening of *Luffa cylindrica* revealed that the plant contained anthocyanins, glycosides, flavonoids, triterpenoid, cardiac glycosides, saponins, carbohydrates, proteins, alkaloids, and tannins. The pharmacological investigation showed that *Luffa cylindrica* possessed antiinflammatory, analgesic, antipyretic, hypoglycemic, antibacterial, antifungal, antiviral, anthelmintic, antioxidant, anticancer, hepatoprotective, antiemetic, wound healing, immunological, bronchodilating, reproductive effect and in treatment of cataract. The current review discussed the contents and biological effects of *Luffa cylindrica*.

Plant profile:
Synonyms:

Luffa aegyptiaca, Luffa acutangula var. subangulata, Luffa aegyptiaca var. peramara, Luffa cylindrica var. insularum, Luffa cylindrica var. leiocarpa, Luffa cylindrica var. minima, Luffa fricatoria, Luffa insularum, Luffa leucosperma, Luffa pentandra, Luffa petola, Luffa subangulata, Luffa sylvestris, Melothria touchanensis, Momordica cylindrica, Momordica luffa and *Momordica luffa*[32].

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 cylindrica*[33]

Common names:

Arabic: Bamya seeny; **English**: dishrag gourd, loofah, rag gourd, smooth loofah, sponge gourd, vegetable-sponge, courge torchon; **Chinese**: si gua; **French**: pétole; **German**: Schwammgurke; **Hindi**: Peerkankai, Jhinga torooee, Jhingli torai, Kali, Torai, Turai, Hireballi; **Japanese**: hechima;**Korean**: susemioi; **Portuguese**: Lufa riscada; **Spanish**: Estropajo, paste[34-35].

Distribution:
It is hard to determine whether the native origin is Africa or Asia. *Luffa cylindrica* is widely distributed in the tropics and subtropics, as a cultivated and naturalized plant[36-37].

Description:
Annual, climber or trailer. Tendrils slightly pubescent, 3-6-fid. Stem 5-angled, finely hairy to glabrous. Leaves palmately 5-lobed, dark green, orbicular-cordate, 8-25 cm across, lobes triangular, lanceolate, acute-apiculate, entire or sinuate, scabrous. Petiole 5-15 cm long. Flowers bright yellow, pedicellate, 5-6 cm across; male racemose, racemes axillary, 12-25 cm long, 15-20-flowered, female flowers in the same axil as males. Probrract fleshy, ovate, with 3-7 glistening glands on the upper surface. Calyx tube short, broadly campanulate, slightly pubescent; lobes triangular-lanceolate, longer than tube. Petals obovate-cuneiform, 2.5-3.5 cm long, 1-2.5 cm broad, obtuse. Stamens 3-5, filaments 6-8 mm long. Ovary cylindrical, finely appressed hairy. Fruit cylindrical and fusiform, 20-50 cm long, 6-10 cm across, smooth. Seeds dull black, elliptic-ovoid, c. 10-12 mm long, 6-8 mm broad, with c. 1 mm wide margin[38].

Traditional uses:
Luffa cylindrica was used in wide application in packing medium, shoes mats, sound proof linings, bath sponges, utensil cleaning sponges, adsorbent for removal of heavy metal (such as nickel, lead, chromium, copper, etc) in waste water, and immobilization matrix for plant, algae, bacteria and yeast[39].

It was used traditionally for the treatment of asthma, intestinal worms, sinusitis, chronic bronchitis pain, carbuncles, abscesses, inflammation, heat rashes of children in summer, bowels or bladder hemorrhage, hemorrhoids, jaundice, menorrhagia, haematuria, leprosy, spleenopathy, as anthelmintic, carminative, emmenagogue, galactagogue and as antiseptic[40-43]. The fruit pulp of *Luffa cylindrica* was used to induce hemostasis, resolve phlegm and clear fever in traditional Korean medicine[13].

Parts used medicinally:
Leaves, fruits and flowers[40-41,43].

Physicochemical properties:
The physicochemical properties of the seed oils were: oil yield (%): 19-25, density (g/cm^3): 0.91, specific gravity: 0.92, iodine value (%): 102.67-130, saponification value (mgKOH): 108.23-168, free fatty acid (%): 10.36, acid value (%): 20.62-68.71, unsaponifiable matter (%): 3.98, peroxide value (meq/kg): 280, moisture content (%): 4.62, colour of oil: yellowish green, texture of oil: very viscous, fragrance: sweet fruity [35-36].

Chemical constituents:
The preliminary phytochemical screening of *Luffa cylindrica* revealed that the plant contained anthocyanins, glycosides, flavonoids, triterpenoid, cardiac glycosides, saponins, carbohydrates, proteins, alkaloids, and tannins[37-55].

The seeds of the plant contained crude protein 33.55±1.01 %, fiber 6.47±0 %, fat 22.17±0.28 %, carbohydrate 29.51±1.83 %. The mineral contents were: calcium 14.29, zinc 2.34, magnesium 21.40 and phosphorus 0.42 g/100 g [46].

However, Osuagwu and Edeoga found that the percentage of carbohydrate was 70.54%, crude protein 0.36%, crude fiber 29%, ash 0.15%, moisture content 0.73% and fat content 0.006% of the seeds of *Luffa cylindrica.* While, the percentage of carbohydrate was 87.49% , crude protein 0.3%, crude fiber 12%, ash 0.23%, moisture content 0.19% and fat content 0.006% of the leaves of *Luffa cylindric*, and the percentage of carbohydrate was 71.84%, crude protein 25 %, crude fiber 27%, ash 0.9%, moisture content 0.34% and fat content 0.006% of the fruit pericarp of *Luffa cylindrica* [56].

Three protein-synthesis inhibitory proteins (PSIs) were isolated from the seeds of *Luffa cylindrica*, they have molecular masses of 19 kDa, 15 kDa, and 9 kDa, and were designated 19K-PSI, 15K-PSI, and 9K-PSI, respectively. The amino acid composition of 19K-PSI was: Ser27Glx3Gly164Tyr7Lys9His6, and that of 9K-PSI was: Asx3Glx25Pro2Gly5Lys2His2Arg25Trp3[57].

The proteins luffin-a, luffin–b, luffin P1 and luffacyclin, were isolated from the seeds of *Luffa cylindrica* [58-61].

The total amino acid contents of *Luffa cylindrica* seed flour were 72.71 g/100g. Amino acid consisted of essential amino acid: lysine 5.08, histidine 2.21, arginine 9.75, threonine 2.26, valine 4.19, methionine 2.14, isoleucine 3.58, leucine 5.35 and phenylalanine 4.20 g/100g; while the non-essential amino acids were consisted of aspartic acid 10.02, serine 3.20, glutamic acid 12.27, proline 2.85, glycine 0.98, alanine 3.34, cystine 0.66 and tyrosine 0.63 g/100g. The total saturated fatty acids concentration in the seed flour was

33.07%, total monounsaturated fatty acids 14.90%, and total polyunsaturated fatty acids 52.02%. Linoleic acid (31.47%) was the most predominant in the *Luffa cylindrica* seed flour oil[54].

The total cucurbitacins in the fruit of *Luffa cylindrica* was 3.91±0.2% (w/v)[62]. Phenolics and flavonoids were predominant in the aqueous extract of peel, while oleanolic acid, carotenoids and chlorophylls were dominated in ethyl acetate extracts of peel. Total phenolic contents of different *Luffa* extracts [water extract of peel (PW), ethyl acetate extract of peel (PA), water extract of pulp (WP), ethanol extract of pulp (EP), ethyl acetate extract of pulp (AP)] were 14.02±0.80, 11.24±0.31, 1.11±0.01, 0.94±0.09 and 4.18±0.19 mg/g extract respectively. The total flavonoids contents were 16.74±0.50, 7.21±0.00, 0.22±0.00 and 0.33±0.00 mg/g extract in the PW, PA, WP and EP respectively. The total carotenoids contents were 14.87±1.42, 0.01±0.00 and 0.65±0.02 mg/g extract in PA, EP and AP respectively, while, the total chlorophylls contents were 37.29±0.16, 0.04±0.00 and 1.60±0.01 mg/g extract in PA, EP and AP respectively[51].

However, Azeez *et al*., found that the total phenol content in various extracts of pulp and peel of the plant was in the range of 0.94-14 mg GAE/g. The plant contained 20.74 mg/g as a total phenolics, 17.94 mg/g as a total flavonoids, 0.5 mg/g as a total anthocyanins, and 1.2 mg/g as an ascorbic acid[63].

Many polyphenolic compounds included: p-coumaric acid; 1-O-feruloyl-β-d-glucose; 1-O-p-coumaroyl-β-d-glucose; 1-O-caffeoyl-β-d-glucose; 1-O-(4-hydroxybenzoyl) glucose; diosmetin-7-O-β-d-glucuronide methyl ester; apigenin-7-O-β-d-glucuronide methyl ester; and luteolin-7-O-β-d-glucuronide methyl ester were isolated as hydrophilic antioxidant constituents from the fruits of *Luffa cylindrica*. The total amount of the eight compounds in the dried gourds without skin was about 1%[64].

A flavone glycoside, the methyl ester of diosmetin 7-O-beta-D-glucuronide was isolated from the fruits of *Luffa cylindrica* [65].

Saponins: saponins of oleanolic acid, gypsogenin, gypsogenin lactone, aegyptinin A, aegyptinin B, ginsenosides-Re, ginsenosides-Rg1, lucyoside 1**,** 3-0-B-D-glucopyranosyl hederagenin, *3-0-B-D*-glucopyranosyl oleanolic acid and lucyosides A to P were extracted from different parts of *Luffa cylindrica* [66-68]. Two Triterpenoids (sapogenins 1 and 2) isolated from *Luffa cylindrica* showed immunomodulatory effects[69]. Echinocystic acid, a triterpenoid sapogenin was also isolated from *Luffa cylindrica*[70].

3-hydroxy-1-methylene-2,3,4,4-tetrahydroxynapthalene-2-carbaldehyde and 22,23-dihydroxy spinasterol were isolated from petroleum ether extract of the fruits of *Luffa cylindrica* [71].

Pharmacological effects:

Antiinflammatory, analgesic and antipyretic effects:

A 70% ethanol extract of *Luffa cylindrica* was evaluated to its anti-inflammation and anti- atopic dermatitis effects *in vitro* and *in vivo*. *Luffa cylindrica* extract (10 mg/mouse/d) was topically applied to the dorsal skin and ears of *Dermatophagoides farina* (Pyroglyphidae)-sensitized Nc/Nga mice for 4 weeks. The IC_{50} values of *Luffa cylindrica* extract on PGE2 and histamine production were 16.89 and 139.9 mg/ml. The production of anti- atopic dermatitis -related chemokines (TARC and RANTES) were inhibited 20% and 12% by *Luffa cylindrica* extract (50 mg/ml) in HaCaT cells, respectively ($p< 0.05$). In sensitized-NC/Nga mice, the plasma levels of IgE and histamine were suppressed 36% and 41% by *Luffa cylindrica* extract, respectively ($p< 0.05$). *Luffa cylindrica* extract also reduced hemorrhage, hypertrophy, and hyperkeratosis of the epidermis and infiltration of mast cells in the dorsal skin and ear[44].

The ethanol extract of *Luffa cylindrica* fruit peel was evaluated for anti-inflammatory effect using carrageenan induced rat paw edema. The degree of paw edema was measured using a plethysmometer at 5th hour of carrageenan (1% w/v) administration. The anti-inflammatory effect was observed at doses of 500, 750 and 1000 mg /kg bw orally($p< 0.05$)[72].

The anti-inflammatory effect of petroleum ether and alcohol extracts of *Luffa cylindrica* fruit was studied using carrageenan induced edema in rats. The carrageenan induced edema in rats was significantly reduced by pre-treatment with petroleum ether extract of *Luffa cylindrica* fruits after 2h[62].

The anti-inflammatory activities of functional components in peel and pulp of *Luffa cylindrica* were studied on RAW 264.7 murine macrophage cells. Both ethanol and ethyl acetate extracts in peel and pulp decreased production of nitric oxide in LPS-induced RAW 264.7 cells, whereas the ethanol extract mitigated secretion of prostaglandin E2. All the extracts significantly inhibited IL-6 production, but remained ineffective in retarding generation of IL-1β and TNF-α. Ethyl acetate extract of peel reduced expression of inducible nitric oxide synthase, but enhanced expression of cyclooxygenase 2. Both ethyl acetate extracts of peel and pulp mitigated expression of p-IκBα, while the ethyl acetate extracts of pulp attenuated expression of p-ERK, and all the extracts failed to inhibit JNK phosphorylation[51].

The anti-inflammatory effect of petroleum ether, benzene, chloroform and alcohol of the seeds of *Luffa cylindrica* was determined by carragenan induced paw-odema in rats with the using of standards, external diclofenoc sodium and oral brufen. The petroleum ether extract and benzene extract were mixed and chromatographed, by using solvents n-hexane, petroleum ether, benzene, ethyl acetate and methanol. Four

compounds were isolated (Cu-1, Cu-2, Cu-3 and Cu-4). Cu-1 possessed moderate and Cu-3 possessed significant anti-inflammatory activity[73].

The anti-inflammatory of chloroform extract (25 and 50 mg/kg, po) of whole plant of *Luffa cylindrica* was investigated using carrageenan-induced rat paw edema method in rats. The chloroform extract at the dose of 50 mg/kg showed significant ($p< 0.01$) inhibition of carrageenan induced rat paw edema than that of rats received 25mg/kg[52].

The peripheral analgesic activity of the aqueous and ethanol extracts of *Luffa cylindrica* was evaluated by acetic acid induced writhing method and the antipyretic activity was evaluated by Brewer's yeast induced pyrexia in rats. The aqueous and ethanol extracts showed significant analgesic activity and ethanolic extract 200 mg/kg showed higher percentage of inhibition of wriths (72.56%) than the other doses. The aqueous and ethanol extracts also showed significant ($p< 0.05$) antipyretic activity, compared to control group[47].

The analgesic activity of alcoholic and ethanolic extracts (100mg/kg) of *Luffa cylindrica* fruits was determined by acetic acid induced writhing and tail immersion methods in mice. Ethanolic extract showed significant analgesic activity by tail immersion method after 60 ($p< 0.01$) and 90 minutes ($p< 0.001$)[53]

Ethanol extracts (500 mg/kg, po) of leaves, male flowers and fruit peel of *Luffa cylindrica* were evaluated for analgesic effect using analgesymeter test. The tested extracts produced significant analgesic effect comparable to diclofenac sodium. Analgesic response was continuously increasing till 3 hrs[43].

Hypoglycemic effect:

The antihyperglycemic effect of the methanolic extract of *Luffa cylindrica* fruits was evaluated in mice using oral glucose tolerance test in glucose-loaded mice. The methanolic extract of fruits was significantly and dose-dependently reduced blood glucose concentrations. At a dose of 50 mg/ kg bw, the extract, lowered blood glucose level by 4.9% (not significant). However, at doses of 100, 200 and 400 mg/ kg bw, the lowering percent of blood sugar was, 11.8, 23.8, and 32.7 respectively[74].

The anti-diabetic activities of aqueous and ethanol extracts of *Luffa cylindrica* fruit were investigated in rats. The aqueous and ethanolic extracts (100 and 200 mg/kg) caused time dependent and significant ($p< 0.01$) reduction of the blood glucose levels in alloxan induced diabetic rats, compared to the control group. The decreased fasting blood glucose levels was occurred at 5^{th}, 10^{th} and 15^{th} days, compared to the control group. The aqueous and ethanol extracts (100 & 200 mg/kg) also deceased the levels of LDL, VLDL, triglycerides and cholesterol, compared to the control group[47]

The hypoglycemic effects of the ethanolic extracts of *Luffa aegyptiaca* seeds were studied in both normal and streptozotocin induced diabetic rats. The extract significantly reduced the blood glucose level in streptozotocin diabetic rats during the first three hours of treatment. The total glycaemic areas were 589.61 ± 45.62 mg/dl/ 3 h and 660.38 ± 64.44 mg/dl/ 3 h for *L. aegyptiaca* and metformin, respectively, vs. 816.73 ± 43.21 mg/dl/3 h for the control ($p< 0.05$). Furthermore, in normal rats, the extract also produced insignificant decline in blood glucose levels compared to glibenclamide treatment[75].

Antibacterial and antifungal effects:

The extracts showed antimicrobial activity against *Staphylococcus aureus* and *Candida albicans*. The zones of inhibition ranged between 18.00 and 27.00 mm, the greater zone of inhibition was recorded against *Candida albicans* ranging from 20 to 27 mm. The fresh plant extract was shown to be more active than the dried plant extract[48, 73].

The antimicrobial activity of the ethanol, choloroform and methanol seeds extracts of *Luffa cylindria* was studied against *Escherichia. coli, Staphylococcus aureus, Salmonella typhi* and *Bacillus subtilis*. The extracts possessed antibacterial activity with zones of inhibition ranged between 6 to 10 mm[76].

The antimicrobial activity of petroleum ether and chloroform extract of whole plant of *Luffa cylindrica* was studied against *Staphylococcus aureus,* coagulse negative *Staphylococcus aureus, Escherichia coli, Pseusomonas aeruginosa, Salmonella typhi, Salmonella para typhi A, Enterococci, Serratia, Citrobactor, Klebsiella pneumonia, Aspergillus flavus, Aspergillus niger, Aspergillus fumigates* and *Aspergillus rhyzobus*. The extracts possessed antimicrobial activity at concentration dependent manner. The minimum inhibitory concentration of the various extract range from 266.66 µg/ml to 66.66 µg/ml against the tested bacteria and fungi. The maximum antibacterial activity was possessed by chloroform extract at 200µg/ml and the significant antifungal activity was possessed by chloroform extract at 266.66 µg/ml[77].

The antimicrobial activity of the leaves extracts of *Luffa aegyptiaca* was investigated against *Staphylococcus species, Corynbacterium ulcerans, Bacillus subtilis, Salmonella typhi, E coli, Pseudomonas aeruginosa, Klebsiella pneumoniae, Neisseria gonorrhaeae,* and *Candida albicans.* Methanolic, ethanolic and chloroform extracts showed antimicrobial activity against all the tested pathogens except *Corynbacterium ulcerans*. The zones of growth inhibition ranged from 16-27 mm for methanolic extracts, 17-29 mm for ethanolic extract and 14-30 mm for chloroform extract against the tested pathogens[78].

The antibacterial and antifungal activities of ethanolic extract of *Luffa cylindrica* fruit (50-150 mg/ml) were studied against *Staphylococcus aureus, Staphylococcus epidedermis, Micrococcus luteus, Bacilllus subtilis, Bacillus cereus, Pseusomonas aeruginosa, Escherichia coli, Klebsiella pneumonia, Aspergillus fumigates, Aspergillus niger* and *Candida albicans*. The ethanolic extract showed antibacterial and antifungal activity against the entire organism tested. The zone of inhibition of the ethanolic extract of *Luffa cylindrica* was 40-80 mm against bacteria and 45-92.5 against fungi[79].

Luffa cylindrica were screened for antibacterial and antifungal activities. The *n*- hexane fraction of *Luffa cylindrica* exhibited good (64%) and crude methanolic extract, moderate (58%) antibacterial activity against *Bacillus subtilis*. Butanol fraction presented moderate activity (58%) against *S. flexenari*. The butanol fraction of *Luffa cylindrica* showed significant antifungal activity against *Fusarium solani* (85%) and *Trichophyton longifusus* (80%). The crude methanolic extract and ethyl acetate fraction presented good linear growth inhibition against *Microsporum canis* (70%). The ethanolic fraction of *Luffa cylindrica* displayed moderate growth inhibition of 41.66% against *Lemna minor* at 1000 µg/ml[80].

The antimicrobial activity of the aqueous and alcoholic extracts of *Luffa cylindrica* fruit was studied using disc diffusion method. The zone of inhibition was maximum against *Salmonella typhi* and *Staphylococcus aureus*, moderate against *Bacillus subtilis* and *Vibreo cholera and* the least activity was recorded against *Fusarium moniliformae*[53].

The disinfectant effect of *Luffa cylindrica* was studied against total and faecal coliform bacteria in surface water using various extract doses and contact times. It appeared that the inactivation of both faecal coliforms and total coliforms was highly variable and dose-dependent. The maximum coliform inactivation achieved was 86%. Fruit extracts were more successful at inactivating total coliforms than faecal coliforms. Seed extracts achieved higher coliform inactivation levels than fruit extracts[81].

The petroleum ether extract of the fruits of *Luffa cylindrica* was tested for antimicrobial activity against *Bacillus cereus* (BTCC-19), *Bacillus megaterium* (BTCC-18), *Bacillus subtilis, Staphylococcus aureus* (BTCC-43), *Sarcina lutea* (ATCC-9341), *Escherichia coli* (BTCC-172), *Salmonella typhi, Pseudomonas aeruginosa, Salmonella paratyphi, Shigella dysenteriae, Vibrio mimicus, Vibrio parahemolyticus, Candida albicans, Aspergillus niger* and *Aspergillus niger*. It showed moderate activity against all the tested bacteria and fungi. The zone of inhibition produced by crude petroleum extract was 7 – 10 mm at a concentration of 500 µg/disc. The fungi *Sacharomyces cerevisiae* was found to be resistant[71].

The antibacterial effect of the n-hexane, chloroform and ethyl acetate extracts of leaves of *Luffa cylindrica* was carried out by disc diffusion method against Gram positive bacteria (*Staphylococus aereus, Bacillus megaterium* , *Bacillus subtilis, Sarcina lutea*) and Gram negative bacteria (*Salmonella typhi, Escherichia coli, Shigella dysenteriae, Pseudomonas aeruginosa, Salmonella paratyphi, Shigella boydii, Vibrio mimicus, Vibrio parahemolyticus*). Chloroform and n-hexane extract of *Luffa cylindrica* possessed antibacterial activity against all the tested bacteria with zone of inhibition of 6-12mm[82].

A triterpenoid sapogenin, echinocystic acid extracted from *Luffa cylindrica* was tested for antibacterial effects against *Bacillus subtilis* MTCC 121, *Listeria monocytogenes* MTCC 657, *Staphylococcus aureus* MTCC 96, *Escherichia coli* MTCC 1667, *Salmonella typhimurium* MTCC 98, *Pseudomonas aeruginosa* MTCC 741 and *Candida albicans* MTCC3018. It showed antimicrobial activity against *Bacillus subtilis, Listeria monocytogenes, Staphylococcus aureus, Salmonella typhimurium* and *Candida albicans* with MIC of 62.2 µg/ml[83].

Antiviral effect:

The antiviral effects of extract of *Luffa cylindrica* vine were reported against Japanese B encephalitis virus. A significant prophylactic effect of the extract was proved when the extract was given to mice prior to sc infection with Japanese B encephalitis virus and a partial protection was observed when administered 3.5 h post infection. The results showed that the extract didn't possess direct inactivating activity and, it showed no toxic effect both on tissue culture cells and in animals when given in considerably large doses[84-85].

Luffin P1, the smallest ribosome-inactivating peptide from the seeds of *Luffa cylindrica* was found to have anti-HIV-1 activity in HIV-1 infected C8166 T-cell lines and be able to bind with HIV reverse response element. It showed a novel inactivation mechanism probably through the charge complementation with viral or cellular proteins[58].

Anthelmintic effect:

The ethanol, methanol, and chloroform extracts of *Luffa cylindrica* leaf were investigated for anthelmintic activity against the Indian earthworm (*Pheretima posthuma*). *Luffa cylindrica* showed anthelmintic activity, the anthelmintic activities of the ethanolic extract was comparable with the standard drug, mebendazole[86].

Various extracts (50 and 100 mg/ml) of *Luffa cylindrica* were tested for anthelmintic activity against Indian earthworm *Pheretima posthuma*, in terms of time for paralysis and time for death of worms. The results revealed that the methanol and aqueous extracts possessed anthelmintic activity at a concentration of 100 mg/ml. The anthelmintic effect of extracts was comparable with that produced by the standard drug, albendazole[87].

Antioxidant effect:

The antioxidant effect of the n-hexane, chloroform and ethyl acetate extracts of leaves of *Luffa cylindrica* was studied using (DPPH) assay. Antioxidant activity of the extracts were found to be increase in a concentration dependent manner. IC_{50} of the n-hexane, chloroform and ethyl acetate extracts was 56.27, 61.24 and 50.32 µg/ml respectively[82].

Antioxidant activity of the leaves extracts of *Luffa aegyptiaca* was assayed using the (DPPH) radical method. The plant extracts showed a concentration dependent scavenging activity by quenching DPPH radicals. IC_{50} of cold water extract was 1.19 ± 0.04, hot water extract: 1.15 ± 0.04, ethanol extract: 0.75 ± 0.02 and methylene chloride/ ethanol extract: 0.45 ± 0.01[88].

The ethanol, methanol, and chloroform extracts of *Luffa cylindrica* leaf were investigated for antioxidant activity by (DPPH) and superoxide scavenging assay. The methanolic and chloroform leaf extracts showed *in vitro* antioxidant activity comparable to the standard antioxidant (ascorbic acid)[86].

The effect of different extracting solvents and cooking treatments on phenolic profile and antioxidant activity of *Luffa cylindrica* was investigated using ferric thiocyanate test, thiobarbituric acid test, ferric reducing antioxidant power and DPPH free radicals scavenging test. Cooking methods, as well as extraction solvents, had significant effects on the recovery of polyphenolic compounds available in *Luffa cylindrica*, frying emerged as a most effective cooking treatment in retention of phenolics as well as antioxidant activity. However, correlation studies indicated that the phenolic compounds including flavonoids were mainly responsible for ferric reducing power, free radical scavenging activity and percent inhibition activity[89].

Hepatoprotective effect:

The hepatoprotective activity of the ethanol and aqueous extracts (100 and 200 mg/kg) of fruit of *Luffa cylindrica* were tested against paracetamol induced hepatotoxicity in rats. Treatment with ethanol and aqueous extracts of fruit of *Luffa cylindrica* showed significant hepatoprotective effect as determined by biochemical parameters and also supported by histopathological study[90].

Methanolic extract of *Luffa cylindrica* leaves was evaluated for its hepatoprotective potential against paracetamol intoxicated rats. The methanolic extract showed significant ($p< 0.05$) hepatoprotective protection in rats based on biochemical parameters (serum glutamate oxaloacatate transaminase, serum glutamate pyruvate transaminase, alkaline phosphatase, bilirubin and some serum antioxidant enzymes). Lipid peroxidation level was decreased significantly and SOD, GSH and catalase levels were increased significantly ($p< 0.001$) after treatment with the methanolic extracts 250 mg/kg and 500 mg/kg[91].

The hepatoprotection of *Luffa cylindrica* was investigated against erythromycin toxicity in male rats. Oral daily administration of toxic dose of erythromycin estolate (100 mg/kg) was given to rats for fourteen days to induce hepatotoxicity. The hepatotoxicities were monitored by increased level of serum glutamate pyruvate transaminase, serum glutamic oxaloacetic transaminase, alkaline phosphatase and total bilirubin. The administration of hydroalcoholic extract of leaves of *Luffa cylindrica* (250, 500 and 1000 mg/kg bw) was significantly prevented the occurrence of liver damage. Furthermore, the administration of hydroalcoholic extract of leaves of *Luffa cylindrica* restored the hepatic antioxidant status. The biochemical results were further confirmed by histopathological examination of the liver [92].

Anticancer effect:

The cytotoxic effect of the n-hexane, chloroform and ethyl acetate extracts of leaves of *Luffa cylindrica* was studied using brine shrimp lethality assay. All extracts displayed considerable general toxicity towards brine shrimps. The LC_{50} values of the extracts were of 15.92 to 33.69 µg/ml compared to vincristine sulphate (LC_{50} = 0.91 µg/ml)[82].

The anticancer activity of the hot water extract of the whole *Luffa cylindrica* was studied using circulating tumor cells and cancer stem cells isolated from the peripheral blood of hepatocellular carcinoma patients *in vitro*. *Luffa cylindrica* hot water extract showed cytotoxic activity against circulating tumor cells of hepatocellular carcinoma especially the cells sub-population $CD133^+/CD44^+$ with little effect among $CD133^+/CD44^-$ sub-population. The authors postulated that the hot water extract of *Luffa cylindrica* whole plant could decrease the ratio of cancer stem cells in blood of HCC patients and may be used to minimize recurrence and metastasis in hepatocellular carcinoma patients[93].

The anticancer effects of the aqueous ethanol extract of *Luffa cylindrica* leaves were studied in different types of breast cancer cell lines representing different molecular subtypes of the disease. Cell cycle analysis, and molecular analysis of apoptotic and proliferative markers showed that the ethanol extract of *Luffa cylindrica* leaves possessed antticancer effects. The major active constituents of the extract were identified as phenolic compound derivatives and saponin that may be responsible in part for the anticancer activity of the extract[(94)].

Anticancer activity of the leaves extracts of *Luffa aegyptiaca* was assayed *in vitro* against acute myeloid leukemia (AML) and acute lymphocyte leukemia (ALL); and *in vivo* against Ehrlich ascites carcinoma cells (EACC). The extracts possessed anticancer effect, ethanol extract from leaves of *L. aegyptiaca* showed the highest activities against AML and ALL. On the other hand, the extracts did not induce significant differences in mortality after tumor transplantation compared with control[(88)].

Aqueous- alcoholic (50:50) whole extracts of cucurbits: *Lagenaria siceraria, Luffa cylindrica* and *Cucurbita pepo* were evaluated in colon cancer cells (HT-29 and HCT-15) and were compared with isolated biomolecule, cucurbitacin-B (Cbit-B). MTT and LDH assays revealed that the cucurbit extracts and Cbit-B, in a concentration dependent manner, decreased the viability of HT-29 and HCT-15 cells substantially. The viability of lymphocytes was only marginally decreased, yielding a potential advantage. Caspase-3 assay revealed maximum apoptosis with the using of *Lagenaria siceraria* extract, it also decreased secretion of IL-8, which indicated anti-inflammatory capability[(95)].

A triterpenoid sapogenin, echinocystic acid extracted from *Luffa cylindrica* was tested for anticancer effects. MTT assay results showed that echinocystic acid inhibited the cell viability of human breast cancer cell lines. Both MCF7 and MDA-MB 231 cell lines showed dose dependent inhibition of cell growth after treatment with echinocystic acid. Both MCF7 and MDA-MB were significantly inhibited at the dose of 60 µM. Calculated IC_{50} value for MCF7 cell line was 41.72 µM and for MDA-MB 231 cell line was 48.17 µM[(83)].

Many glycoproteins (luffin-a, luffin–b, luffin P1 and luffacyclin) were isolated from seeds of *Luffa cylindrica*. These ribosome inactivating proteins also inhibiting protein synthesis in a cell-free system, and suppressing thymidine uptake by human choriocarcinoma cells[(59)].

Luffin b-Ng76 showed 4 000-fold more cytotoxic to target melanoma cells than free luffin B. The IC_{50} of luffin B-Ng76 for M21 cells and non-target HeLa cells was $2.5x10^{11}$ mol/L and $3.0x10^{8}$ mol/l, respectively [(59)].

Antiemetic effect:

The ethanol extract of *Luffa cylindrica* fruit peel was evaluated for antiemetic effect using chick emesis model. The anti-emetic effect was determined by calculating the mean decrease in number of retching in contrast with those of control after 10 minutes of copper sulfate (50mg/kg orally) administration. The antiemetic effect was achieved at a dose of 150 mg /kg bw ($p< 0.001$)[(72)].

Wound healing activity:

The wound healing activity of chloroform extract of whole plant of *Luffa cylindrica* was investigated using excision wound model in rats. Significant wound- healing activity (reduction in the wound area and period of epithelization) was observed in animals treated with the chloroform extract of *Luffa cylindrica* compared to the control treated groups[(52)].

Immunological effects:

The petroleum ether fraction of the ethanol extracts of fruits, leaves and stems of *Luffa cylindrica* potentiated the cytophagic action and acid phosphatase activity of peritoneal macrophages when administered orally in mice[(96)]

Two triterpenoids (sapogenins 1 and 2) isolated from *Luffa cylindrica* were tested for immunomodulatory activity in male mice (10, 30 and 100 mg/kg for for 15 days). Immune responses to T-dependent antigen SRBCs were observed using parameters like HA, PFC, DTH, lymphocyte proliferation and phagocytosis. Sapogenins 1 and 2 elicited a significant increase in the HA, PFC and DTH response at dose of 10 mg/kg ($p< 0.01$) and 100 mg/kg ($p< 0.001$), respectively. Sapogenins 1 and 2 also showed significant dose-dependent decrease of lymphocyte proliferation and significant dose-dependent increase of phagocytic activity of macrophages [(69)].

Effect on female reproductive functions:

The oxytocic effect of *Luffa cylindrica* was studied in rats. The *in vitro* experiments using rat uterus showed that the aqueous extracts of *Luffa cylindrica* leaves increased rat uterine motility. The authors concluded that these results confirmed the traditional usage of this plant to hasten the labour process, expulsion of retained placenta and control postpartum bleeding in Uganda[(96)].

Many glycoproteins (luffin-a, luffin–b, luffin P1 and luffacyclin) were isolated from seeds of *Luffa cylindrica*. These ribosome inactivating proteins also possessed abortifacient activity, they were capable of inducing mid-term abortion in mice. The abortifacient activity of these proteins was possibly the result of their inhibitory effects on the biosynthetic activity of implanting embryos and endometrial cells[(59)].

Bronchodilating effect:

The bronchodilator effect of petroleum ether, benzene, chloroform and alcohol extracts of *Luffa cylindrica* seeds was investigated using Guinea pig trachea compared to standard aminophylline. The petroleum ether and benzene extracts were mixed and chromatographed, by using solvents n-hexane, petroleum ether, benzene, ethylacetate and methanol. Four compounds isolated (Cu-1, Cu-2, Cu-3 and Cu-4). Cu-4 has significant bronchodilator activity[(73)].

Effects in cataract:

The ability of *Luffa cylindrica* fruit extract (5, 10, 15, 20, 25, and 30 µg/ml) to modulate biochemical parameters and to delay the onset and/or prevent the progression of cataract was investigated *in vitro* in hydrogen peroxide induced cataract on isolated goat lenses. SOD, GSH, and TPC levels were found to increase proportionally with the concentration of *Luffa cylindrica* fruit extract. However, MDA levels were found to be inversely proportional to the concentration of *Luffa cylindrica* fruit extract. Morphological examination suggested that *Luffa cylindrica* fruit extract (25 µg/ml) maintained a vision for 44 h. No lens developed dense nuclear opacity after 24 h in *Luffa cylindrica* fruit extract groups in comparison to 80% in negative control[(97)].

Toxicity:

The methanolic extract of the leaves of *Luffa cylindrica* was safe in rats up to dose of 2g /kg orally. The methanolic extract of the fruits was safe up to 3g/kg in rats. Aqueous and alcoholic extracts of the fruits were safe up to 2g/kg in mice. The LD_{50} of ip administration of petroleum ether extract of *Luffa cylindrica* fruit in rats was 0.45 g/kg bw[(53, 62, 91, 98)].

II. CONCLUSION

The current review discussed the chemical constituents, pharmacological effects and therapeutic importance of *Luffa cylindrica* as a promising medicinal plant with wide range of pharmacological activities which could be utilized in several medical applications because of its effectiveness and safety.

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