Chapter

A Review on the Ethnobotanical Uses, Phytochemistry and Pharmacological Effect of *Luffa cylindrinca*

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Abstract

Luffa cylindrica, popularly known as sponge gourd is a tropic and sub-tropical fibrous plant with fruits containing black seeds. The fruit is consumed by humans as a vegetable in many parts of Asia, while different parts of the plant are used for cosmetics and as medicine in many parts of the globe. The plant has been used in the treatment of many ailments including nose cancer, snake venom, wound healing, edema, enterobiasis, filaria, whooping cough, stomach upset, stomach pain and malaria. Many health-promoting compounds such as flavonoids (apigenin-7-glucuronide luteolin-7-O-β-D-glucuronide methyl ester, -O-feruloyl-β-D-glucose, luteolin-7-O-β-D-glucuronide methyl ester), phenolics acids (p-Coumaric, gallic, caffeic, chlorogenic), triterpenoids (oleanolic acid and echinocystic acid), saponins (Lucyoside A-M), tannins (catechin), ribosome-inactivating proteins (α- luffin), carotenoids (9 -cis neoxanthin, all-trans-lutein, all-trans-β-carotene), chlorophylls (chlorophyll a and b, pheophytin), cucurbitacin B and gypsogenin have been detected or isolated from different parts of the plants. Extracts of the plant and isolated compounds have wide spectrum pharmacological activities and have been shown to possess antiemetic, antidiabetic, antiviral, wound healing, anticancer, antipyretic, anti-inflammatory, antifungal, anti-bacteria, anthelmintic, hypoglycemic and antihyperglycemic, anti-inflammatory, antioxidant activity, and hepatoprotective effects in animal models. However, further information is needed on its safety and mechanisms of action. The present article is an updated review of the ethnobotanical uses, pharmacological actions, phytochemistry, safety, and future application of *Luffa cylindrica* in translational medicine.

Keywords: *Luffa cylindrica*, medicinal plants, phytochemicals,antioxidant

1. Introduction

Luffa cylindrica is an important edible and medicinal plant that belong to the Cucurbitaceae family. It has many common names including smooth luffa, sponge luffa, vegetable sponge gourd, climbing okra, dishcloth gourd, and Chinese okra [1]. Locally in Nigeria, it is commonly referred to as kankan or kankan oyibo in Yoruba, while the Hausas call it soosoo. The Igbos named it Asisa. The plant is a

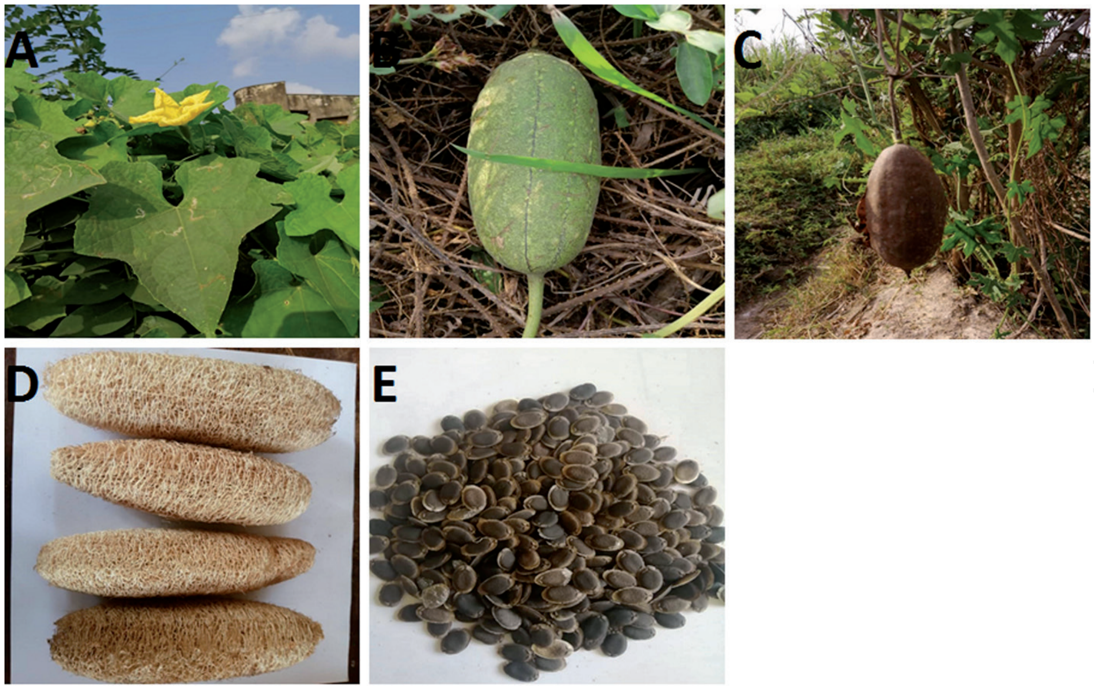

Figure 1.
Different parts of Luffa cylindrica *(A) leaves with flower (B) matured fruits (C) dried fruits (D) Luffa sponge (E) seeds.*

sub-tropical crop which when planted in northern latitudes warrants hot and humid climates as well as prolonged chilly planting conditions. Also, a vast abseiling shrub with such a greenish, scrumptious vine that is slender but very stiff, extending to a length of 30 feet is *Luffa cylindrica.* It has a fleshy egg –shaped dehiscent fruit with a green papillary dermis, transversely characterized with black crevasses which generally range from 10 to 15 in total. A taut piny filament is discovered under each one of these protrusions [2]. Its leaves are 7–20 cm across and have three lobes. Flowers are bright yellow in color. The fruits which grow to about 60 cm in length are oval-shaped, smooth and, are made up of many seeds. The fruit is brown when matured and dries on the vine to resemble an inedible sponge-like structure. The picture of different parts of the plant is shown in **Figure 1.**

2. Distribution

Luffa cylindrica is commonly found in the humid tropics and Asia. Although the plant is of medieval or primitive origin, it is difficult to decide if Africa or Asia is the ancestral home. In West Africa, the plant grows naturally, but this is also presumed to be a consequence of evasion from planting since the crop is known in many cultures in the area as 'white people's sponge.' Proof of Asian ancestry is however scarce. It is also not clear how well the vine has dispersed over the vast coastal area. Many dispute that rising temperatures are a detonation factor, but the likely cause of the extensive distribution of *Luffa cylindrica* is most often human dispersal. It is documented to have evolved from India but it extensively grows as a weed in Nigeria and many other African countries.

3. Traditional and medicinal uses

Luffa cylindrica has diverse ethnomedicinal uses especially in Africa and Asia. The thawed fiber is used in Ghana for the filtration of water and palm wine [3]. Leaf formulations are used topically for oedemas and for treating malaria in Togo. The fruit is used on tumor and inflammation in Guinea, while the pulp of the fruit is used as a desiccant in Guinea and Nigeria. There are culinary conifers cultivated in Guinea and Côte d'Ivoire. Zulu people in South Africa take a leaf decoction to treat stomach pain. The root formulation and leaf syrup were documented to be ingested in Tanzania to decrease the probability of pregnancy termination. The leaves are used for the stimulation of wound healing and abscess cognitive development. The leaves are grounded with water and the juice is used for stomach upset medication in Rwanda. Leaf decoctions are used to make childbearing smoother in Uganda. Pulverized leaves are anally inserted for enterobiasis therapy in the Central African Republic. Decoction of the leaves is fully viable against filaria and a colloidal solution of fresh leaves is used to combat whooping cough in Congo-Brazaville. Root formulation is used in Gabon as medicine for nose cancer. A root and leaf aqueous extract is documented to be consumed and used as an aborticide in an enema in the Democratic Republic of the Congo. The seed is used in Egypt for managing diabetes. The pulp of the whole crop is often used as a remedy for acid reflux in African

Country	Local name	Medicinal value	Plant part used	Preparation/application
Togo	Bassarii-Bindumpo, Gudscha, Tem	Oedema and malaria treatment[a]	Leaf	Formulation/ oral
Guinea	Manding-Mandinka	Treatment of tumor, inflammation and as an emollient[a]	Fruit Fruit pulp	
Nigeria	Kan-kan oyibo (Yoruba), Ihion-osa (Edo), sooso (Hausa), asisa (Igbo)	Use as an emollient.[a]	Fruit pulp	
South Africa		Treatment of Stomach pain[a]	Leaf	Decoction/oral
Uganda		Aiding child birth[a]	Leaf	Decoction/oral
Rwanda		Treatment of stomach upset and wounds[a]	Leaf	Decoction/oral Decoction/topical
Tanzania		Anti-abortion[a]	Leaves/root	Formulation/oral
Central African Republic		Enteriobiasis therapy[a]	Leaves	Pulverization/Rectal insertion
Congo-Brazaville		Filaria and whooping cough treatment[a]	Leaves	Decoction/oral
Gabon		Treatment of nose cancer[a]	Root	Formulation/oral
DR Congo		Aborticide[a]	Leaf	Formulation/oral
Egypt		Managing diabetes	Seed	

[a]*Available at https://uses.plantnet-project.org.*

Table 1.
Local names and medicinal uses of L.cylindrica *in Africa.*

indigenous medication. The traditional uses of *Luffa cylindrica* in different parts of Africa are summarized in **Table 1**.

Production of edible forms has taken place in India and the Philippines where the crop is mainly bred. A brand of curry which is produced from the fruit is stripped, chopped and, fried in China and India. The fruit is consumed fresh or diced and processed in Japan for later consumption. The fruit is also employed as a therapy for the treatment of cynocy-tous and flu in Asia. Traditional medicine practitioners in China use the seed and sponge of the old fruits of the plant as stomachic, antipyretic and anthelmintic medicine. In addition, dried fruit is used as therapy for abdominal, chest, muscle, and joint pains [4]. Moreover, the fruits are employed in the treatment of rheumatism, dyspnea, cough and skin inflammation in Chinese folk medicine [5]. The fruit reduces breast swellings and it is combined with other Chinese herbs as a remedy against cancer. The fibrovascular bundle of *Luffa cylindrica* dried fruit is officially listed as a treatment for paralytic diseases in Chinese pharmacopeia. In Korea, *Luffa cylindrica* fruit pulp is used to treat fever, induce hemostasis, stimulate menstrual flow, strengthen the network vessels, invigorate blood and clear phlegm [6]. In Japan, the water extract of the vascular bundle of the plant, 'Hechimasui' is used as diuretic, antitussive and skin lotion [7]. In Java-Indonesia, the leaf juice is used for amenorrhea, while it is used for treating snake bites and dysentery in India [8]. The Santals people of Indian, use the plant in treating cramps, convulsion, tetanus, leprosy and syphilis [9]. Oil extracted from the seed is used for treating skin infection, while the fruit or its tincture is used as a therapy against intestinal and biliary colitis, jaundice, hepatomegaly, splenomegaly, dropsy, nephritis, bronchitis, tuberculosis and ascites in Indian herbal medicine practice [9]. The Filipinos used the leaves for orchitis and skin diseases [8].

4. Other ethnomedicinal uses

Raw or prepared as a vegetable, the new fruit can be consumed, but it must be selected before entrenching the spongy cotyledons and before generating the extinguishing substances. The leaves are also consumed as a vegetable, while the charred seeds contain edible oil that is safe for consumption. The gritty and hazardous seed cake is not ideal for livestock feed but could be used as a compost since the plant is rich in nitrogen and phosphorus [3]. The plant is used for treating bowel and bladder hemorrhage, hemorrhoids, toothache, scarlet fever and smallpox [8]. *Luffa cylindrica* seeds are used for treating fever and respiratory disorders including sinusitis, bronchitis and asthma [10, 11]. The seed oil is used as a lubricant and atopically applied to the skin in the treatment of leprosy, shingles, boils and other skin diseases. The oil also found application in several cosmetic products including sunscreens, anti-aging creams, moisturizers, sunless tanners, facial cleansers and sunscreens. The oil is used in sunscreens because of its toxicity to skin cancer cells.

Goats feed on the fruits and leaves [3], while bees prey on their flowers. The root formulations are also used to relieve of stomach pain and as a muscle relaxant. The leaves are used for stimulation of wound repair and echogenic cognitive development. The fruit sag is consumed as a powerful prophylactic, while the seeds are consumed for their anti-parasitic and relaxing properties. The fruit is also used in the treatment of piles and hematuria [12]. Additionally, the fresh fruit is demulcent, cooling and beneficial to the intestine, stomach and genital organs [8]. The flower of *Luffa cylindrica* is used as a therapy against migraine [13].

5. Pharmacological activities

5.1 Antioxidant activity

The methanol and chloroform *Luffa cylindrica* leaves extract exhibited antioxidant property via enhanced scavenging of DPPH and superoxide radicals in a dose-dependent fashion [14]. Similarly, its methanol extract displayed free radical scavenging ability against hydrogen peroxide, hydroxyl and nitric oxide radicals. Ethanol extract of the fruit of *Luffa cylindrica* was earlier reported to possess strong antioxidant activity against DPPH radical [15]. Methanol extract of *Luffa cylindrica* vegetable thermally processed by different methods was recently found to show varying degrees of antioxidant properties as measured by thiobarbituric acid, DPPH, ferric thiocyanate and ferric reducing antioxidant power radicals scavenging assays [16]. Similarly, Bulbul *et al.* [17] using DPPH scavaging assay obtained IC_{50} values of 50.32, 56.27 and 61.24 μg/m for ethyl acetate, n-hexane and chloroform extracts of the leaves of *Luffa cylindrica* respectively as compared to an IC_{50} value of 43.22 μg/ml obtained for ascorbic acid, which was used as a standard. *In vivo*, antioxidant capacity of the fruit extract of *L.cylindrica* was recently demonstrated in a rat model of cataract. The extract delayed the initiation and inhibit the progression of H_2O_2- induced cataract by inhibiting lipid peroxidation and modulating cellular antioxidants and antioxidant enzyme activity [18].

5.2 Anti-inflammatory activity

Anti-inflammatory activity was exhibited by chloroform extract of *Luffa cylindrica* whole plant through marked reduction of carrageenan-induced rat paw edema in experimental animals that received 50 mg/kg body weight of the extract [19]. Ethyl acetate and ethanol extracts of *Luffa cylindrica* peel and pulp displayed anti-inflammatory action against LPS-induced inflammation in RAW 264.7 cells by modulating NO, IL-6, PGE2, iNOS, pIκβα and p-ERK expression [20]. Moreover, two fractions from the petroleum ether and benzene extracts of the seed exhibited anti-inflammatory activity in the same experimental animal model [9]. Lucyoside B, a triterpenoid saponin extracted from the fruit of *Luffa cylindrica* also exhibited anti-inflammatory effects through subdual of proinflammatory mediators such as iNOS, IL-6 and MCP-1 at the transcriptional and translational levels coupled with the production of NO [21].

5.3 Anticancer activity

The aqueous-ethanol extract of *Luffa cylindrica* leaves displayed anticancer effects against MCF-7, BT-474, and MDA-MB-231 cell lines which epitomize three sub-types of breast cancer: luminal A, luminal B, and triple-negative [22]. The observed effect was attributed to the presence of phytochemicals such as apigenin and luteolin. The hot water extract of *Luffa cylindrica* whole plant also exhibited anticancer activity against circulating tumor cells of hepatocellular carcinoma especially the cells subpopulation CD133+ /CD44+ with little effect among CD133+ /CD44- subpopulation [23]. Aqueous-ethanol extract of *Luffa cylindrica* leaves showed anticancer activity on three different subtypes of breast cancer including luminal A, luminal B and Her2/neu enriched through reduction of total cell viability, CD44+/24- and total CD24+ cell sub-populations percentages after treatment with the extract [24]. More recently, the anti-cancer activity of hydro-ethanol extract of *Luffa cylindrica* against CD34+/CD38+ and CD34+/CD38+ leukemic stem cells obtained from patients with acute lymphoblastic leukemia was investigated by Yehia *et al.* [25]. The extract effectively induced cell cycle arrest and apoptosis in both populations of cells as well as exert inhibitory effects against proliferation and colonogenicity of leukemic cells. Aqueous extract of the whole plant displayed cytotoxicity against blood-derived cancer stem cells [23, 24]. The cytotoxic activity of the whole plant ethanol extract to the HT-29 and HCT-15 cell lines has also been documented [26]. The anti-tumor activity of *L. cylindrica* seeds was linked to its luffin content [27].

5.4 Anti-viral effects

The *L. cylindrica* vine demonstrated 66.7–80% protection against Japanese B encephalitis virus when given has pre-treatment to mice before viral infection, while the protection diminished when given 210 minutes post-infection to the virus [28]. Luffin P1, a ribosome-inactivating peptide isolated from *Luffa cylindrica* seeds displayed anti-HIV-1 activity in infected C8166 T-cell lines by binding HIV reverse response element and possibly via charge complementation with cellular or viral proteins [29, 30]. Recently, *in silico* analysis revealed that four saponins namely lucyoside H, lucyoside F, 3-O-β-D-glucopyranosyl-oleanolic acid and 3-O-β-D-glucopyranosyl-spinasterol from air-dried fruits of *L. cylindrica* showed strong affinity for the substrate-binding pocket of SARS-CoV-2 Mpro with docking energy scores of–7.54, 7.47, −7.29 and − 7.13 kcal/mol, respectively as compared with the binding ability equivalent of N3 protease inhibitor (−7.51 kcal/mol), which is an established inhibitor [31]. Therefore, suggesting that *L. cylindrica* and these aforementioned compounds could find application in the prevention and treatment of SARS-CoV-2.

5.5 Antifungal activity

The ethyl acetate extract of *Luffa cylindrica* leaves displayed antifungal activity against *Candida albicans*, *Candida tropicalis*, *Trichophyton rubrum* together with four clinical isolates of *C. albicans, C. tropicalis, Microsporum canis* and *Epidermophyton flocossum* [32]. Some compounds isolated from the benzene and petroleum ether of *Luffa cylindrica* seeds also displayed anti-fungal properties against *Candida albicans* [9]. The petroleum ether crude extract of *Luffa cylindrica* fruits exhibited anti-fungal property against *Candida albicans* and *Aspergillus niger* [33]. The butanol extract displayed profound antifungal action against *Trichophyton longifusus* and *Fusarium solani,* while the ethyl acetate fraction of the crude methanol extract markedly inhibited the growth of *Microsporum canis* [34]. *In vivo* antifungal activity was also exhibited by crude ethyl acetate extract of *Luffa cylindrica* leaves in laboratory animals by promoting plodding healing of the infected skin of experimental animals [32].

5.6 Antibacterial activity

The petroleum ether extract obtained from *Luffa cylindrica* fruit showed potent antibacterial activity against bacteria *Bacillus cereus, Bacillus megaterium, Bacillus subtilis, Staphylococcus aureus, Sarcina lutea, Escherichia coli, Salmonella typhi, Pseudomonas aeruginosa, Salmonella paratyphi, Shigella dysenteriae, Vibrio mimicus,* and *Vibrio parahemolyticus* [33]. Crude methanol and n-hexane fraction of *Luffa cylindrica* also exhibited antibacterial activity against *Bacillus subtilis*, while the butanol fraction exhibited relative activity against *S. flexenari* [34]. The chloroform and n-hexane extract of *Luffa cylindrica* leaves showed potent antibacterial activity against gram-positive and gram-negative bacteria [17].

5.7 Anthelmintic activity

Both crude ethanol and methanol extracts of *Luffa cylindrica* leaves displayed anthelminthic activity against *Pheretima posthuma* [1, 14]. In fact, the anthelminthic activity of the ethanol extract was comparable to the standard drug mebendazole [14].

5.8 Anti-pyretic activity

Methanol extract of *Luffa cylindrica* leaves displayed antipyretic activity by decreasing the rectal temperature of experimental animals at the studied doses and also impeding the compression of abdominal walls in experimental animals, which were induced with agony sensation depending on the dose [35].

5.9 Hypoglycemic and anti-diabetic activity

Methanol extract of *Luffa cylindrica* fruit exhibited excellent hypoglycemic properties in alloxan-induced rat models by decreasing blood glucose level [36]. A significant reduction in blood sugar of glucose-loaded mice after administration of methanol extract of *Luffa cylindrica* fruit further demonstrated the antihyperglycemic activity of *Luffa cylindrica* fruit [37]. Moreover, hydro and ethanol extracts of the fruits exhibited comparable β-cells renegeration with glibenclamide in the alloxan model of diabetes in rats [38]. El-Fiky *et al.* [39] also investigated the effect of oral administration of ethanol seed extract of *Luffa cylindrica* on a streptozotocin rat model of diabetes. The results showed the extract drastically reduced blood glucose level in diabetic rats within three hours of treatment and the efficacy of the extract in reducing blood glucose was similar to a standard anti-diabetic drug, metformin. Tryptic and alcalase protein hydrolysates from the seed have strong inhibitory action against angiotensin-converting enzymes, α-amylase and α-glucosidase [40]. The authors therefore opined that plant holds strong potential in the treatment of hypertension and diabetes.

5.10 Hepatoprotective activity

Methanol extract of *L.cylindrica* leaves displayed hepatoprotective effects through the reduction of serum liver enzymes in a paracetamol model of hepatic injury [41]. The hydroalcoholic extract of *Luffa cylindrica* leaves also exhibited a similar hepatoprotective property in the erythromycin estolate-induced model of liver damage [42]. Increased serum liver enzyme levels in paracetamol-induced rats reduced drastically on treatment with alcohol and aqueous extracts of *Luffa cylindrica* fruits coupled with conservation of the structural integrity of liver membrane [43].

5.11 Sedative and anti-epileptic effects

The sedative, anti-epileptic and anti-convulsant activities of alcohol extract of *L cylindrica* fruits were investigated in rats by Sunil *et al.* [44]. The results showed that the extract at 400 mg/kg body weight lessened the sleep induction time and prolonged the sleeping time in rats exposed to diazepam. At the same dose, the extract lengthened the latency time, but reduced the time of seizure in the pentylenetetrazole-induced model of convulsion, while it decreased total seizure time as well as clonic tonic time in the maximal electroshock model of convulsion. These effects were however lower than that of standard drugs, diazepam and phenytoin.

5.12 Skin protection

Umehara *et al.* [7] investigated the effect of *L.cylindrica* fruit extract on UVB-irradiation-induced mice model of dry skin and demonstrated that the extract and isolated phenylpropanoids inhibited trans-dermal water loss in hairless mice. The extract and p-coumaric acid isolated from the extract stimulated dome formation by MDCK I cells. Additionally, p-coumaric acid increased mRNA expression of water permeability and reabsorption protein, AQP3. The authors, therefore, concluded that p-coumaric was responsible for *L. cylindrica* related water permeability and that *L. cylindrica* could contribute to the treatment of disease relating to the inability to retain moisture including dry syndrome. Furthermore, an extract obtained from the fruit pulp prevented the development of atopic dermatitis-like skin lesions in mice exposed to *Dermatophagoides farinae* [6].

5.13 Anti- emetic activity

The ethanol extract of the fruit peel of *L.cylindrica* showed significant anti-emetic activity in young chicks at a dose of 150 mg/kg body weight [45]. The ethanol and hexane extracts of leaves and male flowers of *L. cylindrica* exhibited anti-emetic effect against chick emesis facsimilia. The anti-emetic effects of hexane extract of male *L. cylindrica* flowers and leaves were at 71.5% and 43.5% inhibition of reteches respectively, whereas the ethanol extract of leaves and male flowers of *L. cylindrica* was at 68.66% and 68.46% inhibition of reteches respectively [46].

5.14 Wound healing activity

Different parts of *L. cylindrica* have been reported to possess wound healing capacity. Chloroform extract of the whole plant showed wound healing activity in a rat model by reducing the wound area and time of epithelization [19]. Diethyl ether, n-hexane, chloroform, ethyl acetate, butanol and methanol seed extract also promoted wound healing in rats [47]. Diethyl ether extract showed the highest wound healing activity, while the weakest activity was displayed by chloroform extract [47].

5.15 Effects on hematological parameters

Raw and thermally processed *Luffa cylindrica* seed meal fed to albino rats had no adverse effects on the hematological indices of the experimental animals [48].

However, administration of methanol extract of *L.cylindrica* leaves to rats produced an elevation in the hematological parameters in experimental animals [49].

5.16 Oxytocic activity

Aqueous extract of *L.cylindrica* leaves increased uterine motility in an isolated rat uterus [50]. Thus suggesting that *L.cylindrica* is oxytocic and giving credence for its use in Uganda to facilitate labour and treat postpartum issues.

6. Chemical composition

L.cylindrica is rich in nutrients and phytochemicals. Several recent studies have revealed that *L. cylindrica* leaves, fruits, and seeds are a rich source of carbohydrates, protein, fiber, fats, amino acids and minerals [48, 51]. The mineral found in the seeds of *Luffa cylindrica* plant include sodium, iron, phosphorus, calcium, zinc, potassium, manganese, copper, chromium, magnesium [51]. Moderate amounts of K (13.86 mg/100 g) and Na (8.18 mg/100 g) were found in the seed, but the concentration of Cr (0.25 mg/100 g) was low [50]. *L.cylindrica* fruit is an excellent source of Vitamins A, B5, B6, C, and dietary fiber.

According to the preliminary phytochemical screening test carried out on different extracts of *L.cylindrica* leaf and seed extracts, all the extracts were found to contain saponin, alkaloids and cardiac glycosides [52]. Only the seed extracts contained the steroidal rings, while anthraquinones, tannins and phlobatinnins were not detected in any of the extract [52]. Reducing carbohydrates, flavonoids, tannins, saponins and glycosides were also detected in the plant extract [2]. The phytochemical screening carried out on the methanol and ethyl acetate extract of the leaves of *L.cylindrica* indicated that the extracts of leaves of *L.cylindrica* contain carbohydrates, sterols, saponins, flavonoids, alkaloid and phenols, while resins, tannins, terpenes, balsams and anthraquinones were not found [32]. Another preliminary phytochemical screening of aqueous methanol extract of *L.cylindrica* leaves revealed the presence of sugar molecules including glucose, fructose and galactose as well as the presence of amino acids such as phenylalanine, glycine and tyrosine [53]. Moreover, phytate and oxalate were found in the methanol extract of flowers and leaves of *L. cylindrica* [54]. The *L. cylindrica* seeds contain high amount of saponins, alkaloids and phlobotannins. The butanol extract of *Luffa cylindrica* seeds contains alkaloids and deoxy sugars, while the diethyl ether extract contains deoxy sugars, cardiac glycosides, alkaloids and carbohydrates [47]. The chloroform extract contains deoxy sugars and cardiac glycosides [47]. Quantitative analysis of the sponge revealed that it contains 1.2, 0.5, 17.94 and 20.74 mg/g of ascorbic acid, total anthocyanins, flavonoids and phenolics respectively [55]. The total flavonoid and phenol in the aqueous and ethanol extracts of Luffa pulp and peels were reported to range from 0.94–14.02 mg/g GAE and 0.33–18.09 mg/g QE respectively, while olenolic acid, carotenoids, and chlorophylls were in the range 0.01–25.79,0.01–14.87 and 0.04–37.29 mg/g extract respectively [20].

A penotacyclic triterpenoid saponin, lucyoside O was isolated from the leaves of *L.cylindrica*. Lucyin A, lucyosides G, N, O, Q, P, R, ginsenosides Re and Rg1, 21*β*- hydroxyoleanoic acid and 3-O-*β*-D-glucopyranosyl- maslinic acid, were also identified in the leaves of *Luffa cylindrica* [22]. In addition, Lucyoside K was isolated from the hydro-ethanol extract of the leaf extract, while Lucyoside A-M were identified in the fruit extract of the plant [22]. A peptide with luffacyclin that possessed antifungal activity was also isolated from *L. cylindrica* seeds. Sapogenins (I & II) were isolated from ethanol extract of the seeds and were both found to exhibit immunomodulatory effects [56]. Some triterpenoids and fibrinolytic saponins were isolated from seeds and fruits of the plant [47]. Moreover 22, 23-dihydroxy spinasterol and 3-hydroxy-1-methylene-2,3,4,4-tetrahydroxynapthalene-2-carbaldehyde were separated from the petroleum ether extract of the fruit [57]. Very recently [31] isolated lucyoside F, lucyoside H, 3-O-β-d-glucopyranosyl-spinasterol and 3-O-β-d-glucopyranosyl-oleanolic acid from the dried fruits.

L. cylindrica is very rich in polyphenols. Aqueous ethanol extract of *L. cylindrica* leaves contains phenolics such as apigenin 7 glucuronide, eriodictyol −7 glucoside, kaemferide, luteolin-O-diglucoside, neodiosmin, diosmin and kaempferol 3 - [2″‘,3″‘,4″‘-triacetyl - α - L -arabinopyranosyl -(1–6) -glucoside] or its isomer kaempferol 3 -[2″‘,3″‘,5″‘- triacetyl - α - L -arabinofuranosyl -(1–6) –glucoside [22].

Similarly, Sunnil *et al.* [44] recently used LC-ESI-MS/MS to identified several flavonoids and polyphenol including hyperoside, kaempferol-3,7-O-bis-α-L-rhamnoside, quercetrin, tliroside, acacetin, datiscin, fortunellin, linarin, luteolin, bobin, vitexin, vitexin-2"-O-rhamnoside, saponarin from the alcohol extract of the whole fruit of *L. cylindrica.* In addition, Yadav *et al* [16] also identified the following phenolics and flavonoids: gallic acid (0–26.8 μg/ml), caffeic acid (0.23–18.4 μg/ml), cinnamic acid (1.52–8.6 μg/ml), ferulic acid (9.31–49.6 μg/ml), ellagic acid (0–78.8 μg/ml), rutin (0–79.3 μg/ml), quercetin (45.18–55.42), myrecetin (20.95–35.79 μg/ml), catechin (66.24–77.87 μg/ml) from methanol extract of *L. cylindrica* fruits thermally processed by different methods. Furthermore, Hlel *et al* (2017) using HPLC/TOF-MS identified chlorogenic acid, gentisic acid, gallic acid, vanillic acid, salicylic acid, ferulic acid, 4-hydroxy benzoic acid, p-coumaric acid, naringenin, catechol and rutin in *L. cylindrica* fruits at different stages of maturation. The amount of quercetin, luteolin and myrictin in the sprout extract of *L. cylindrica* was quantified using UPLC-MS/MS as 32.5, 12.5 and 32.4 μg/g respectively. Meanwhile, five derivatives of cinnamic acid including 1-O-p-coumaroyl--D-glucose, 1-O-feruloyl-,-D-glucose, 1-O-caffeoyl--D-glucose and p-coumaric acid well as three flavonoids glycosides namely: apigenin-7-O-,-D-glucuronide methyl ester, diosmetin-7-O--D-glucuronide methyl ester, and luteolin 7-O--D-glucuronide methyl ester) were earlier identified in *Luffa cylindrica* [15]. A phenylpropanoid glucoside, 4-O-feruloyl-glucose was isolated from a natural source for the first time in *L. cylindrica* fruit [7]. Other phenylpropanoid glucosides that were isolated from the edible part of *Luffa cylindrica* are 4-O-caffeoyl-glucose, 1-O-caffeoyl-β-glucose, 6-O-caffeoyl-glucose, 4-O-p-coumaroyl-glucose, 1-O-p-coumaroyl-β-glucose, 6-O-p-coumaroyl-glucose, 4-O-feruloyl-glucose, 1-O-feruloyl-β-glucose, 6-O-feruloyl-glucose [58].

Other compounds there were recently isolated from the dried fruits of L.*cylindrica* includes: 3,5-dihydroxy-δ-valerolactone, phenanthrene,1,2-naphthoquinone, cinnamic acid, (S)-dehydrovomifoliol, 2,6-dimethyl-1,4-benzenediol, litchiol B, pinoresinol phthalic acid, 4-(hydroxymethyl)benzene-1,2-diol, tridecan-7-one, apigenin and henicosan-11-one [31]. Similarly, fifty-three volatile compounds including aromatics (10.1%), acids (15.1%), ketones (38.2%), alcohols (51.6%) and aldehydes/furans (66.2%) were recently identified by [59] in young and matured fruits of *Luffa cylindrica* using headspace SPME-GS-MS and UPLC-MS. Hydrocarbons including noctacosane, n-heptacosan, n-hexacosane n-tetracosane, n-tricosane, tetraeicosane-6-ol, nanodecane-6-ol, dieicosane-6-ol and eicosane-6-ol have earlier been identified in the fruit of *L. cylindrica* [12]. The diverse types of phytochemicals found in *L. cylindrica* have various biological effects (**Table 2**) and could account for its wide pharmacological activities.

6.1 Acute toxicity studies

Etim *et al* [49] administered methanol leave extract of *L. cylindrica* to Swiss albino mice at doses up to 4000 mg/kg body weight. Treated animals did not die nor display signs of toxicity. In addition, there was no mortality in animals exposed to *L. cylindrica* fruit extracts at doses between 100 and 2,000 mg/kg body weight [145]. Similarly, Oyeyemi *et* al. [146] reported that administration of 5000 mg/kg of both hydro-methanol and aqueous extracts of *L. cylindrica* leaves did not induce acute toxicity in mice. However, the extracts given at doses between 200 and 1600 mg/kg increased bone marrow micronucleated polychromatic erythrocytes formation, but of a lower degree to the positive control, methyl methanesulfonate (Oyeyemi *et* al, 2015). An LD50 of 450 mg/kg body weight was reported for crude petroleum ether extract of the fruit [123].

Phyto chemicals	Compounds	Pharmacological action	Ref.
Flavonoids	Apigenin 7 glucuronide,	Anti-oxidant, anti-complement, anti-inflammatory, and aldose reductase inhibitory activities	[60]
	Kaempferol 3 - [2″‘;3″‘;4″‘-triacetyl - α - L -arabinopyranosyl -(1–6) -glucoside],	NRPA	
	Kaempferide,	Anticancer, cardioprotective and Osteo-protective, anti-oxidant, anti-inflammatory, anti-bacterial anti-viral	[61, 62].
	Diosmin,	Anti-ulcer, anti-inflammation, anti-oxidation, anti-diabetes, anti-cancer, anti-microbial, hepato- protective, neuroprotective cardio-protective, nephroprotective, and retinal protection.	[63, 64]
	Neodiosmin, Eriodictyol –7 glucoside,	NRPA Antioxidant, anti-inflammatory, anti-cancer	[65]
	Quercetin	Antioxidant, anti-inflammatory, anticancer, cardio-protective, neuroprotective, pneumo-proective, hepatoprotective	[66, 67]
	Myrecetin	Antioxidant, antitumor, anti-inflammatory, neuroprotective, immunomodulatory, antimicrobial, antiviral, hepatoprotective, anti-obesity, cardiovascular protection	[68, 69]
	Rutin	Antioxidant, anti-inflammatory neuroprotective, antitumor, sedative, anti-convulsant, anti-Alzheimer, anti-cholesteremic, anti-asthmatic, antiosteoporotic, anticataract, immunostimulatory, antimicrobial, antiviral, antihypertensive	[70]
	Catechin	Anticardiovascular, antioxidant, neuroprotection, hepatoprotection, anti-infectious, anti-diabetic	[71]
	Luteolin	Antioxidant, anti-inflammatory, antitumor, antiapoptotic, anti-allergy,	[72]
	Hyperoside	Anticancer, anti-inflammatory, Anti-oxidant, antiparasite, anti-cholesterolemic, cardioprotection, antidepressant, anti-aging.	[73–75]
	Kaempferitrin	antioxidant, anti-inflammatory, antitumor, anti-angiogenic	[76]
	Quercetrin	Antioxidant, antitumor,	[77]
	Tiliroside	Antioxidant, antidiabetic, anti-obesity, anti-inflammatory, hepatoprotective, anti-allergy, anti-thrombotic, neuroprotective osteogenic, antiobesity, antimicrobial, antiviral, antiprotozoal, antihypertensive antiaging	[78, 79]
	Acacetin	antioxidant, anti-inflammatory, anti-depressant, antinociceptive antitumor, neuroprotective	[80–82]
	Datiscin Fortunellin	NRPA Antioxidant, anti-inflammatory, antidiabetic, cardioprotective	[83]
	Linarin	Antioxidant, anti-inflammatory, osteogenic, anti-cholinesterase neuroprotection, analgesic cardioprotective,	[84, 85]
	Robinin	NRPA	
	Vitexin	Antioxidant, neuroprotective anti-inflammatory,antidiabetic, anti-tumor, hepatoprotection, cardio-protective, amtiviral, antibacteria	[86, 87]
	Vitexin-2”-O-rhamnoside	Antioxidant	[88]
	Saponarin	Hepatoprotective, antioxidant anti-lipid peroxidation	[82, 89]

Phyto chemicals	Compounds	Pharmacological action	Ref.
Phenols	p- coumaric acid,	Antioxidant, antiviral, anti-inflammatory, anti-cancer, anti-lipidemic, anti-gout, antimicrobial, immunomodulatory, antiplatelet aggregation, anti-diabetic, anxiolytic, anti-arthritis, antipyretic, analgesic.	[90, 91]
	1-O-feruloyl-β-D-glucose,	Anti-adipogenic	[92]
	1-O-(4- hydroxyl benzoyl) glucose.	NRPA	
	Gallic acid,	Antioxidant, antiobesity, antihyperglycaemic, antidiabetic, anti-lipid peroxidative, wound healing, anti-inflammatory, 10.1016/j.phrs.2018.08.002 neuroprotective, cardioprotective, antimicrobial, gastroprotective	[93]
	Gentisic acid	Antioxidant, anti-inflammatory, neuroprotective, antigenotoxic, hepatoprotective, antimicrobial, anticancer, analgesic, skin-lightening, muscle relaxation, cardioprotective	[94]
	Chlorogenic acid	Antioxidant, cardioprotective, neuroprotective, renoprotective, antidiabetic, antitumour, Gasto-intestinal protection, antitumour	[95]
	4 -hydroxy benzoic acid Vanillic acid,	NRPA Anti-obseity, anti-inflammatory, antioxidant, neuroprotective cardioprotective	[96–98]
	Salicylic acid,	Anti-inflammatory, analgesic	[99]
	Naringenin,	Antioxidant, antibacterial, antitumor, anti-inflammatory, cardioprotective, antiadipogenic immunomodulatory, antiviral	[100]
	Catechol	Antioxidant, anticancer	[101]
	Caffeic acid	Antioxidant, anticancer, antiviral, antimicrobial, anti-inflammatory, Antidiabetic, cardioprotective, immunostimulatory,	[102]
	Ferulic acid	Antioxidant anti-inflammatory, anticancer, antidiabetic, antimicrobial, antithrombotic, anti-arrhythmic, antidiabetic, immunostimulatory, anti-aging, neuroprotective, photoprotective	[103]
	Cinnamic acid	Antioxidant, antidiabetic, antimicrobial, anti-melanogenesis, UV-protective	[104, 105]
	Ellagic acid	Antioxidant, hepatoprotective antitumor, antiangiogenic, antimetastatic, anti-inflammatory ,neuroprotective, antidiabetic, anti-atherogenic	[106, 107]
Triterpenoids	Oleanolic acid	Antioxidant immunomodulatory, antiviral, antimicrobial, hepatoprotective, cardioprotective anti-inflammatory, analgesic antihypertensive, anticancer, immunostimulatory	[108, 109]
	Echinocystic acid	Antioxidant, anti-inflammatory, antibacterial, antiapoptotic, antiviral, antitumor antioxidant, Immunostimulatory	[110, 111]
	Gypsogenin 3-O-β-D-glucopyranosyl-maslinic acid,	Antitumour Immunostimulatory	[112]
	Dehydrovomifoliol	Anticancer, anticholinesterase	[113, 114]

Phyto chemicals	Compounds	Pharmacological action	Ref.
Saponin	Lucyoside K, Lucyoside O,	NRPA	
	Lucyoside B	Anti-inflammatory	[21, 115];
	Lucyosides N &P Lucyosides A,C-M,R Ginsenosides Re Anti-arrhythmic, modulation of insulin resistance [116–118]	Fibrinolytic activity NRPA	[119]
	Ginsenosides Rg1	Neuroprotective, anti-depressant, anti-inflammatory, anti-sepsis	[27, 120–122]
	21β-hydroxyoleanoic acid	NRPA	
Cucurbitacins	Cucurbitacin B	Anticancer	[123]
	Cucurbitacin E	Immunomodulatory, anti-inflammatory, neuroprotective anti-tumorigenic,	[124].
Peptides	Luffacyclin	Antifungal	[125]
	Luffin –a Luffin -b	Abotificient, Antitumour, Abotificient, Antitumour	[27, 125] [27, 125]
	Luffins P1,	Anti-HIV, antitumour, antifungal	[29, 30, 125]
	Luffin B	Antitumor, Antiviral	[8]
	Luffins S,	Antitumor, Antiviral	[29, 30, 125]
	Luffin –α	Antitumor	[27]
	Bryonolic acid	Inhibits passive cutaneous anaphylaxis and delayed hypersensitivity	[126]
Phenyl propanoid glucosides	1-O-feruloyl-β-D-glucose, 1-O-caffeoyl-β-D-glucose 4-O-caffeoyl-glucose.	Antioxidant NRPA	[15, 127]
	6-O-caffeoyl-glucose 4-O-p-coumaroyl-glucose 1-O-p-coumaroyl-β-glucose	Antiradical and antioxidant NRPA NRPA	[128]
	6-O-p-coumaroyl-glucose 6-O-feruloyl-glucose 1-O-feruloyl-β-glucose 4-O-feruloyl-glucose	NRPA Antioxidant NRPA	[129]

Phyto chemicals	Compounds	Pharmacological action	Ref.
Volatiles and other compounds	3-hydroxy1-methylene-tetrahydroxy-napthalene-2-carbaldehyde	Antimicrobial	[57]
	22, 23-dihydroxy spinasterol	Antimicrobial	[57]
	Phenanthrene	Antimicrobial, spasmolytic, anti-inflammatory, antiplatelet aggregation, antiallergic activities and phytotoxic effects	[130, 131]
	Litchiol B	Antioxidant,anti-bacteria	[132]
	Pinoresinol	Anti-proliferative, antioxidant	[133]
	Pentanoic acid	NRPA	
	Nonanoic acid	Bioherbicides	[134]
	1-Octen-3-ol	Pesticides	[135]
	β-linalool	Antioxidant, antibacterial	[136]
	α-terpineol Nonanal	Antioxidant, insecticidal, anticancer, anti-nociceptive, anticonvulsant, antihypertensive, antiulcer Antifungal, antidiarrheal	[137, 138]
	Nonadienal	Anti-bacteria	[59]
	Decanal	Antimicrobial	[139]
	Eugenol	Mosquito repellant, antifungal, antibacterial, antiinflamatory antioxidant	[140]
	Limonene	Antitumour, anti-inflammatory, antioxidant, antiviral,antibacterial	[141]
	Trihydroxy-octadecadienoic acid	Antifungal *a*nd bacteria	[141, 142]
	Trihydroxy-octadecenoic acid	Antiviral	[143]
	Octadecadienoic acid	Antidiabetic	[144]

NRPA = no reported pharmacological action

Table 2.
Some phytochemicals in Luffa cylindrica *and their pharmacological action*.

7. Conclusion and future perspective

The review provides an up-to-date and comprehensive summary of the traditional uses, pharmacology and phytochemical composition of *Luffa cylindrica*. *Luffa cylindrica* has been eaten as food and used in folk medicine for several years especially in Africa and Asia for the treatment of many diseases including malaria, stomach disorders, whooping cough, oedemas, wounds, tumor, filarial, rheumatism, dyspnea, inflammation, leprosy, syphilis, bronchitis, tuberculosis, dysentery and amenorrhea. In the last few decades, the plant has attracted attention due to its potential pharmacological actions including anti-inflammatory, anticancer antioxidant, anti-viral, antimicrobial, anti-diabetic, hepatoprotective, sedative, anthelmintic, anti-pyretic, anti-epileptic, hypoglycemic, skin protection. Anti-emetic and wound healing. The repertoire of beneficial and health-promoting phytochemicals that are present in *Luffa cylindrica* could be responsible for diverse ethnomedicinal uses and pharmacological activity recorded for the plant. However, like many other medicinal plants, efforts should be made to standardize its usage in different disease models through activity-guided bioassays and isolation of active principle(s). Formulated standardization of *Luffa cylindrica* extract is needed to have reproducible results that can be integrated into translation medicine. In addition, more mechanistic and comprehensive safety studies on *Luffa cylindrica* are needed to enhance its pharmaceutical potentials and know the long-term effects of consumption of *L. cylindrica* as medicine since most of the studies found in literature only addressed its acute toxicity. Moreover, more clinical studies are warranted to confirm the pharmacological activities of *Luffa cylindrica* extracts and its constituents in order to translate results obtained from animal studies into human.

Taken together, *Luffa cylindrica* holds great potential as a repository of beneficial phytochemicals that can be leveraged on for the betterment of human health. Research efforts should therefore be directed at optimizing the bioactive extracts and/or phytochemicals for health promotion and improving the quality of life.

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