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Pharmacological and Phytochemical Activity of *Luffa cylindrica* - A Review

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ABSTRACT

Luffa cylindrica, commonly referred to as sponge gourd or Loofa, is a versatile plant species with a rich pharmacological profile and diverse chemical constituents. This review delves into its extensive therapeutic potential, encompassing a wide range of actions such as antioxidant, anti-inflammatory, anti-cancer, antimicrobial, antiviral, antipyretic, hepatoprotective, wound healing, uterotonic, anti-emetic, sedative, and anti-epileptic properties. Its bioactive compounds, including triterpenoid saponins, flavonoids, and peptides, are distributed across different parts of the plant, including the fruits, leaves, and seeds. Originating in sub-tropical regions, *L. cylindrica* is primarily cultivated in countries such as China, India, and Central America. Its significant traditional uses in folk medicine for treating various ailments further underscore its medicinal importance and potential for modern therapeutic applications. The plant's pharmacological richness, coupled with its wide distribution and traditional medicinal uses, positions *Luffa cylindrica* as a promising candidate for further exploration in drug discovery and healthcare product development. With ongoing research into its bioactive compounds and mechanisms of action, there is potential for the identification of novel therapeutic agents. Additionally, advancements in cultivation techniques and processing methods may facilitate the development of innovative pharmaceutical formulations and natural remedies. Overall, L. cylindrica represents a valuable botanical resource with vast therapeutic potential and implications for both traditional and modern medicine.

Keywords: *Luffa cylindrica*, Pharmacological action, Phytochemical constituents, Distribution.

INTRODUCTION

Luffa cylindrica or Loofa is a unique vegetable which belongs to a family of cucumber and marrow. It is also known by various names like sponge gourd, vegetable sponge, bath sponge or dish cloth gourd [1]. Loofa finds its use in various aspects of human life like industrial, medical and cosmetic needs. Dry fibre obtained from fruit of the plant is useful as a component of shock absorbers, bathroom sponge, linings in sound proofing, cleaning sponge, craft making and packing material [2]. It finds major use in factories as a filter [3] and in industries it finds its use in biosorption of various metals [4] and chemical extraction [5]. *Luffa cylindrica* also finds its use as a bio-diesel [6].

Luffa cylindrica fruit is cylindrical in shape with vertical lines outside the fruit and reticulate inside the flesh. It is smooth and produces 30 or more seeds on maturation [1]. The sponge obtained from the dried fruit is a complex organic material composed of cellulose 60%, hemicellulose 30%, and lignin 10% [7]. The leaf of this plant is acute-end lobed and its size is 12cm in length and 30cm in width. Its flower is yellow in colour,

monoecious and blooms in the month of August-September. *Luffa cylindrica* is a climber and requires a solid support. This plant can grow upto 12 cm [1].

The genus Luffa consists of 5 or more species in which 2 are domesticated and 2 are wild. The domesticated species include *Luffa acutangula* and *Luffa cylindrica* while *Luffa graveolens* and *luffa echinata* are wild species. Loofa is a diploid species and a crop that is cross-pollinated [7].

PLANT PROFILE

Synonyms of the Plant

Luffa aegyptiaca, *Luffa acutangula var. subangulata*, *Luffa cylindrica var. insularum*, *Luffa cylindrica var. leiocarpa*, *Luffa cylindrica var. minima*, *Luffa fricatoria*, *Luffa insularum, Luffa pentandra*, *Luffa petola*, *Luffa subangulata*, *Luffa sylvestris*, *Melothria touchanensis*, *Momordica cylindrica*, *Momordica luffa* and *Momordica luffa* [8].

Taxonomic Classification [9]

Table 1: Taxonomic Classification

Kingdom	**Plantae**
Division	Mangoliophyta
Class	Mangoliosida
Order	Cucurbitales
Family	Cucurbitaceae
Genus	Luffa
Species	Cylindrica

Regional Names [9]

Table 2: Regional Names

Hindi	**Ghiatarui**
Sanskrit	Rajakoshataki
Bengali	Dhundul
Tamil	Pikku
Telugu	Guttibira
Mumbai	Ghosali

DISTRIBUTION

Luffa cylindrica, classified as a sub-tropical plant, thrives in environments characterized by warm summer temperatures and an extended frost-free growing season, particularly in temperate regions. This annual climbing plant bears fruit with a fibrous vascular system, making it a valuable commodity in the realm of agriculture. Its cultivation typically occurs during the summer season. Despite the challenge of precisely delineating its indigenous regions, luffa species boast a rich history of cultivation across various tropical countries in Asia and Africa. Indo-Burma emerges as a focal point of diversity for the sponge gourd, contributing significantly to its genetic variations. Notably, the primary commercial production of *Luffa cylindrica* occurs in nations such as China, Korea, India, Japan, and Central America [1,9]

TRADITIONAL USES

Luffa was used traditionally in the treatment of respiratory diseases (sinusitis, asthma and chronic bronchitis pain), inflammation, urinary bladder haemorrhage, haematuria, jaundice, leprosy, menorrhagia, anthelmintic, carbuncles, abscesses, heat rashes. It was also used as emmenagogue, galactagogue and antiseptic [10-13]. In traditional Korean medicine fruit pulp of loofa was used to induce haemostasis, treat fever and phlegm resolution [14].

PHARMACOLOGICAL ACTIVITY

1. Antimicrobial Activity

Antibacterial Activity

Studies on the petroleum ether extract obtained from the fruit demonstrate significant antibacterial action against a diverse group of bacteria [15]. The crude methanol and n-hexane extracts of the plant demonstrate antibacterial activity against *B. subtilis*, whereas the butanol extract exhibits relative activity against *S. flexenar* [16]. The chloroform and n-hexane extract of *Luffa cylindrica* leaves showed potent antibacterial activity against gram-positive and gram-negative bacteria [17].

Antifungal Activity

The ethyl acetate extract from *Luffa cylindrica* leaves exhibits antifungal activity against *Candida albicans, Candida tropicalis, Trichophyton rubrum*, and four clinical isolates of *C. albicans, C. tropicalis,*

Microsporum canis, and Epidermophyton flocossum [18]. The ethyl acetate portion of the crude methanol extract significantly suppressed the growth of *Microsporum canis*, while the butanol extract shown significant antifungal efficacy against *Trichophyton longifusus* and *Fusarium solani* [16]. The crude ethyl acetate extract of *Luffa cylindrica* leaves demonstrates in vivo antifungal activity in laboratory animals, promoting the healing of infected skin [18].

Anti-Viral Activity

Luffa cylindrica, recognized for its diverse medicinal properties, has shown notable effectiveness in fighting viral infections. Research suggests that the plant's vine offers considerable defense against the Japanese B encephalitis virus [19]. Similarly, Luffin P1, a ribosome-inactivating peptide found in *Luffa cylindrica* seeds, demonstrates both anti-cancer and anti-HIV-1 properties. This peptide has shown promising effects against cancer cells and has potential in inhibiting HIV-1, highlighting its dual therapeutic capabilities [20].

Analysis of air-dried fruits of *Luffa cylindrica* uncovered a novel δ-valerolactone and sixteen known compounds. In silico studies, particularly focusing on saponins like Lucyoside H, revealed substantial binding affinity to the substrate-binding pocket of SARS-CoV-2 Mpro, akin to that of established protease inhibitors. This suggests a promising direction for developing antiviral therapies [21].

2. Anti-Cancer Activity

Aqueous-ethanol extract of loofa leaves displayed anti-cancer action against various cell lines which embodied the sub-types of breast cancer [22]. The presence of phytochemicals like apigenin and luteolin is attributed to its anti-cancer activity [23]. Similarly, luffin present in seeds is responsible for its anti-tumor activity [24].

3. Anthelmintic Activity

Luffa cylindrica alcoholic leaf extracts exhibit anthelminthic activity against *Pheretima posthuman* [9,25]. Similarly, the ethanolic extract demonstrates comparable efficacy to the standard drug mebendazole [25].

4. Anti-Inflammatory Activity

In vivo studies of chloroform extract of whole plant on carrageenan induced rat paw oedema in experimental animal exhibited significant anti-inflammatory activity [26]. Similarly peel and pulp of the fruit displayed anti-inflammatory activity against LPS induced inflammation in RAW 264.7 cells [27]. Lucyoside B present in the fruit exhibited anti-inflammatory activity by suppression of various pro-inflammatory mediators [28].

5. Anti-Pyretic Activity

The methanol extract derived from *Luffa cylindrica* leaves demonstrates antipyretic effects by lowering the rectal temperature in experimental animals across different doses. Additionally, it inhibits abdominal wall contraction in animals experiencing pain, with the degree of inhibition varying according to the dose administered. [29].

6. Antioxidant Activity

Various leaf extracts of *L. cylindrica* exhibits dose-dependent antioxidant activity [30]. Similarly, free radicle scavenging activity is exhibited by both methanolic and ethanolic extract of *L. cylindrica* fruit [31]. In vivo antioxidant studies on fruit extract of the loofa in rat model of cataract demonstrated delayed initiation and progression of H_2O_2-induced cataract [32].

7. Anti-Diabetic Activity

The methanol extract of *Luffa cylindrica* fruit exhibits significant hypoglycemic effects in alloxan-induced rat models, effectively lowering blood glucose levels [33]. Furthermore, both hydro and ethanol extracts of the fruits show comparable β-cell regeneration in alloxan model of diabetes in rats [34]. El-Fiky et al. investigated the action of ethanolic seed extract of the plant in streptozocin rat model which showed drastic

reduction in blood glucose levels in diabetic rats [35].

8. Anti- Emetic Activity

Ethanol extract of *Luffa cylindrica* fruit peel demonstrated significant antiemetic properties in a chick emesis model [36].

9. Hepatoprotective Activity

Various extracts of *Luffa cylindrica* leaves like methanolic [37] and hydro-alcoholic [38] displayed significant hepatoprotective activity in paracetamol model of hepatic injury and erythromycin estolate-induced hepatic injury model. Furthermore *L. cylindrica* fruit extracts reduced liver enzyme levels in paracetamol induced rat model along with conservation of structural integrity of liver membrane [39].

10. Anti-Epileptic Activity

Sunil et al. investigated the sedative and anti-epileptic properties of the alcohol extract from *L. cylindrica* fruits in rats. The extract decreased sleep induction time, prolonged sleeping time, lengthened latency time, reduced seizure time [40].

11. Anti-Alzheimer's Activity

Luffa cylindrica contains various phytochemicals, with its highest alkaloid content at 21.39 ± 1.47 mg of AE/g. LC–MS analysis identified 80 compounds in the ethanolic extract. Screening bioactive compounds against receptors related to oxidative stress in Alzheimer's disease was done following Lipinski's rule of five, and perlolyrine was chosen for in-silico docking studies. In vitro tests showed the highest cholinesterase inhibition at 500 µg/ml. Subsequent in-silico docking studies indicated that perlolyrine had excellent binding affinity, especially with amyloid beta, showing the highest binding energy of −46.1 kcal/mol, suggesting its potential as a therapeutic agent for Alzheimer's disease [41].

12. Wound Healing Activity

Various components of *Luffa cylindrica* are known to aid in wound healing. The chloroform extract from the whole plant has shown significant wound healing properties in a rat model, as indicated by a decrease in both wound size and the time needed for epithelization [26]. Besides the chloroform extract from the entire plant, extracts from *Luffa cylindrica* seeds have also demonstrated wound healing properties in rat models. Of these, the diethyl ether extract exhibited the most potent wound healing activity, whereas the chloroform extract showed the least effectiveness [42].

13. Uterotonic Activity

In an isolated rat uterus model, aqueous extract derived from *Luffa cylindrica* leaves demonstrated a notable increase in uterine motility, suggesting its potential as a uterotonic agent [43]. This finding highlights the pharmacological relevance of *L. cylindrica* in traditional medicine, particularly in contexts where enhancing uterine contractions may be beneficial, such as in facilitating labour. Further research into the specific mechanisms underlying this effect could provide valuable insights into its therapeutic applications.

14. Hematological Effects

Methanol extract from loofa leaves increased hematological parameters in rats. This shows that different parts and preparations of *L. cylindrica* can affect blood parameters differently, highlighting the importance of considering these factors in studies [44].

15. Skin Care

Umehara et al. [45] studied the effects of *Luffa cylindrica* fruit extract on UVB-induced dry skin in mice. They found that the extract and isolated phenylpropanoids significantly reduced trans-dermal water loss. Specifically, p-coumaric acid from the extract enhanced mRNA expression of aquaporin 3 (AQP3), aiding water permeability. The extract also prevented atopic dermatitis-like lesions in mice exposed to *Dermatophagoides farinae*. These findings suggest the plants potential for treating dry skin and atopic dermatitis,

highlighting its therapeutic value in skincare [46].

16. Anti-Ulcer Activity

Luffa cylindrica leaf extracts show significant gastroprotective and antiulcer effects against ethanol-induced gastric ulcers. These benefits stem from the plant's free radical scavenging, inhibition of gastric acidity, and enhancement of the gastric mucosal barrier. Phytosterols and citronellol in the extracts promote cell proliferation and prevent apoptosis, further supporting its antiulcer properties [47].

17. Anti-Cataract Activity

In a study on the plant fruit extract, different concentrations of the extract were used on goat lenses with hydrogen peroxide-induced cataracts. The results showed that higher concentrations of the extract increased levels of protective enzymes and antioxidants, while reducing harmful compounds (MDA). None of the lenses treated with the extract developed severe cloudiness after 24 hours, unlike 80% of the untreated lenses [32].

PHYTOCHEMICAL CONSTITUENTS AND ITS ACTIVITY

Luffa cylindrica is a plant rich in phytochemicals. Its leaves, fruits and seeds are rich in carbohydrates, protein, fiber, fats, amino acids and minerals [48,49].

Chemical analysis of the leaves showed a varied composition of compounds. Methanolic and ethyl acetate extracts contained carbohydrates, sterols, saponins, flavonoids, alkaloids, and phenols [18]. The aqueous methanol extract contained sugars (glucose, fructose, and galactose) and amino acids [50]. Moreover, alcoholic extracts were found to contain phytate and oxalate [51]. Polyphenols and phenolics, including 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, were also detected [22].

Similarly, study on the fruit extracts of the plant identified various phenolics and flavonoids like hyperoside, kaempferol-3,7-O-bis-α-L-rhamnoside, quercetrin, tiliroside, acacetin, datiscin, fortunellin, linarin, luteolin, bobin, vitexin, vitexin-2”-O-rhamnoside, and saponarin [40]. The methanolic extract of the fruit was found to contain gallic acid, caffeic acid, cinnamic acid, ferulic acid, ellagic acid, rutin, quercetin, myricetin, and catechin [52].

A study on seed extracts identified triterpenoid saponins such as lucyoside O, lucyin A, lucyosides G, N, O, Q, P, R, ginsenosides Re and Rg1, 21β-hydroxyoleanoic acid, and 3-O-β-D-glucopyranosyl-maslinic acid [22].

Table 3- Pharmacological Activity of some Phytoconstituents in *Luffa cylindrica*

COMPOUND	PHARMACOLOGICAL ACTION
Apigenin 7-glucuronide	Anti-inflammatory [53]
Kaemferide	Anti-cancer [54]
Quercetin	Tumors, Cardiovascular diseases, Depression, anti-diabetes and antioxidant [55]
Luteolin	Anti-cancer [56]
Gallic acid	Anti-inflammatory, gastroprotective, cardioprotective, antioxidant [57]
Diosmin	Anti-inflammation, anti-oxidation, anti-diabetes, anti-cancer, anti-microorganism, liver protection, neuro-protection, cardiovascular protection, renoprotection, retinal protection [58]

CONCLUSION

Luffa cylindrica emerges as a versatile botanical resource with diverse pharmacological activities, making it a valuable candidate for therapeutic applications. From its traditional uses in folk medicine to its modern scientific exploration, *L. cylindrica* has showcased remarkable potential in treating various ailments, including cancer, viral infections, inflammatory conditions, and dermatological issues. Its rich chemical composition,

comprising triterpenoid saponins, flavonoids, and unique peptides, underscores its multifaceted pharmacological profile. Moving forward, future prospects for *Luffa cylindrica* are promising. Continued research into its bioactive compounds could unveil novel drug candidates, addressing unmet medical needs. Additionally, advancements in cultivation, processing, and formulation techniques may facilitate the development of innovative healthcare products, spanning from skincare formulations to natural antiviral agents. Integrating *L. cylindrica* into traditional medicine practices and exploring its potential in sustainable biofuel production further enhances its significance in promoting human health and environmental sustainability.

Declaration by Authors

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