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#### **REVIEW ARTICLE**

# **Cucurbitaceae - the family that nourishes** and heals

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#### **ABSTRACT**

A review of the activities of members of the Cucurbitaceae was carried out. Many of them are confirmed nutritious and therapeutical. Their global spread, diverse genera and phytochemical profile further confirm them as an attraction for the growth and survival of humanity. The need for alternative control measures to address resistance has heightened the passion for Cucurbitaceae in bioprospecting.

Keywords: Cucurbitaceae; Therapeutic; Nutritional; Extraction; Bioprospecting.

#### **INTRODUCTION**

The Cucurbitaceae is known to be the largest family of vegetable crops [1]. The origin of Cucurbitaceae is tropical, and most of its genera originated from Asia, America and largely Africa. Generally, referred to as cucurbits, they are categorize mainly into Zanonioideae and Cucurbitoideae. The subfamily Cucurbitoideae is mainly food plants and particularly vegetables [2] having all the essential constituents required for good human health [3, 4]. The number of the genera is still mired in controversy. Purseglove [5] reported that the family Cucurbitaceae comprised 9 genera and 15 species of vegetables and fruits with different varieties being cultivated throughout the world while Chakravarthy [6] reported 117 genera and 825 species and Yamaguchi [7] confirmed 100 genera and more than 750 species. Also, Subrahmanyam [8] reported 100 genera and 800 species along with Mabberley [9] who indicated 122 genera and 940 species that are distributed in tropical and warm temperate regions of the world. Despite these disagreements, the cucurbitaceae has been an interesting and an outstanding family of dicotyledons, distributed widely over the tropical parts of the world [10].

#### **NUTRITIVE IMPORTANCE**

These Cucurbitaceae are known also for their nutritive and medicinal values. For example, *Cucumis sativa* are in treating indigestion and constipation [11]. Cucumber is a widely cultivated plant of gourd family which is eaten in the unripe, green form. The aqueous extract of fruits from same plants revealed the presence of glycosides, steroids, flavonoids, carbohydrates and tannins. High water content and they contain vitamin A and C, flavone glycosides such as isovitexin, saponarin and various acylated flavones [11, 12]. The important genera belonging to the family are *Trichosanthes, Lagenaria, Luffa, Benincasa, Momordica, Cucumis,* 

Citrullus, Cucurbita, Bryonopsis and Corallocarpus. Some species that have attracted scientific investigation include Momordica charantia, Cucurbita pepo, Cucumis sativus, Cucumis melo, Citrullus colocynthis, Luffa echinata, Trichosanthes kirilowii, Lagenaria siceraria, Beninca sahispida [13]. Water melon (Citrullus lanatus) contains almost 95% water, small amounts of protein, fat, minerals and vitamins. The major nutritional components of the fruits are carbohydrates, vitamin A and lycopene. Lycopene content of the new dark red watermelon is higher than in tomato, pink grapefruit or guava. Lycopene is a red pigment responsible for watermelon flesh colour, which is an anticancer agent. High amount of water content of watermelon makes it a powerful diuretic diet [14]. The watermelon fruit is widely consumed and rich in water and pectin. Pectin is a substance used in jams for thickening and is believed to offer protection from radiation. It is also traditionally used to treat cardiovascular disease and kidney problems, fever, pain, and inflammation [15].

## **MEDICINAL USES**

Cucurbit plants were used actively as traditional herbal remedies for various diseases. They have demonstrated anti-inflammatory, antitumor, hepatoprotective, cardiovascular andimmune-regulatory activities [13, 16]. Members of this family have always been considered as a subject of research due to the fact that they have a lot of biological activities like anti-fungal, anti-bacterial, anti-viral, anti-diabetic, anti-tumor and anti-AIDS [17] from Cuba through the gulf of Mannar [18] to Nigeria. Ethanolic extract of leaves and stems of *Cucumis sativus* possessed many phytoconstituents such as alkaloid, glycoside, steroid, saponin and tannin except gum, flavonoid and reducing sugars. Its fruit extract has shown free radical scavenging and analgesic activities in mice. The seeds can be used to expel parasitic worms. The juice from the leaves induce vomiting and aid digestion [15].

Trichosanthes cucumerina also called snake gourd, is mainly consumed as a vegetable being rich in protein and vitamin C, carbohydrate, fibre, iron, phosphorus, vitamin B1, vitamin B2 and niacin [19]. The major active constituents of the drug are triterpenoids, saponins, cucurbitacins. The plant is richly constituted with a series of chemical constituents like flavonoids, carotenoids, phenolic acids which makes the plant pharmacologically and therapeutically active [20]. Anti-inflammatory activity is exhibited by the root tubers and antidiabetic activity by the seeds. Both the root and fruit are considered to be cathartic. It is used in the treatment of bronchitis, headache, fever, abdominal tumors and skin allergy. Seeds have antibacterial, antispasmodic, insecticidal and gastro protective properties. Momordica charantia has been used in various Asian traditional medicine systems for a long time, originally for non-communicable diseases like asthma, burning sensation, constipation, colic, diabetes, fever (malaria), gout, helminthiases, inflammation, and ulcer. It has also been publicized to have hypoglycaemic (antidiabetic) properties in animal as well as human studies. The juice of Momordica charantia were leaves used to treat piles totally, treating and preventing liver damage, menstrual troubles, burning sensations, constipation and blood purification due to its bitter tonic properties damage. Also, the leaves of Momordica charantia are used in treatment of menstrual troubles, burning sensation, constipation, fever (malaria), worms and parasites.

## ANTI-WORMS AND ANTI-PARASITIC ACTIVITY

Worms and helminthiases are treated with infusions from *Momordica charantia*, *Cucumis sativa*, and *Praecitrullus fistulosus* capsules and tinctures are widely available in the United States for the treatment of many morbidities. In India, *Momordica charantia* used by tribal people for abortions, and as anthelmintic [21, 22]. The snake gourd called *Trichosanthes cucumerina* is very common in Srilanka and India. All parts of the plant have their medicinal value. The root of the plant has been used for curing boils, headaches, bronchitis. The fruit and seeds are used for anthelmintic and stomach disorder respectively. Kar et al. [23] found out also that the root extract has anti-inflammatory activity while the seed has antidiabetic activity. The antihelminthic potentials of the family were revealed with the experiment on *Lagenaria siceraria* Mol having a cidal effect on earthworm and tapeworm [24]. Earlier in 1987, Elisha et al. investigated the action of *Cucurbita maxima*,

Cucumis sativus and Lagenaria siceraria on Hymenolepis nana (tapeworm) and Aspicularis tetraptera (pinworm) infections in mice in Iraq. The seed extracts of these plants were very effective in controlling the helminthes

## **ANTIFUNGAL ACTIVITY**

The leaves and stem extract of *Cucumis sativus* were investigated for the antifungal potential and found to be effective on *Aspergillus niger* with the dermal mycotic fungus *Microsporum* sp having the least sensitivity [25]. *Momordica charantia* was effective tool in antifungal activity [26]. Many notorious plant pathogens like *Fusarium* have been controlled by the *Momordica* seed extract (MSE) making it a sustainable alternative to synthetic fungicide [27].

Sometimes, the solvent effect was noted in the efficacy of extracts of Cucurbitaceae on fungi. The n-hexane and ethyl acetate extract of *M. charantia* were effective against *Saccharomyces cerevisiae* while chloroform and ethyl acetate produced the best sensitivity against *Candida albicans* [28]. The antifungal activity assay four phytopathogenic fungal species included *Pythium aphanidermatum*, *Botryosphaeria dothidea*, *Fusarium oxysporum f.sp. cucumerinum* and *Botrytis cinerea* was performed on the stem of *Cucumis sativus*. Results revealed an appreciable sensitivity arising from the ethanol fractions of the sphingolipids derived from the plant [29].

Lagenaria siceraria called Bottle Gourd is a vegetable which is commonly consumed in India. It is a good tonic especially for the heart [30]. It is effective against diseases such as fever, pectoral cough, bronchia disorders, ulcers and pain [31]. It also has diuretic activity [32]. Acetone has high throughput when the matrix is Lagenaria siceraria. Another species of therapeutic importance is Wibrandia ebracteata which has been effective for traditional medicines. Studies have shown that both tuber and roots have analgesic and antitumor properties. It also has anti-inflammatory and arthritis properties [33].

# ANTIBACTERIAL ACTIVITY

The increasing rate of resistance to common antibiotics among bacterial and fungal species calls for a concerted effort at combating communicable diseases in animals and man. Antibacterial effects have been investigated using ethanolic extract of some leaves. The result showed that *Bacillus subtilis* and *E. coli* were sensitive to the intervention [34].

Bacterial-mediated infections are controlled by many species in the family using local infusions and concoctions or by laboratory activities involving other solvent extractions antimicrobial activities of petroleum ether, chloroform, ethyl acetate and methanol extract of the leaves of *Momordica charantia* were effective against various pathogenic bacteria such as *Bacillus cereus*, *Enterobacter faecalis*, *Salmonella paratyphi*, *Staphylococcus aureus* and *Escherichia coli*. The antimicrobial potency of this plant extract is due to the presence of phenolic compounds flavonoids and carotenoids [19]. *Momordica charantia* root is used in the treatment of syphilis, rheumatism, ulcer, boils, and septic swellings. In the gulf of Manna, Gurudeeban et al. [35] confirmed the efficacy of *Citrullus colocynthis* on some bacterial species. The wax gourd, also called *Benincasa hispida* has useful seeds, peel and pulp particularly in inhibiting disease causing microbes. The interest in the antimicrobial activity of *B. hispida* was ignited by the success recorded on *Serratia spp.*, *Shigella boydii*, *Pseudomonas aeruginosa* and *Salmonella typhimurium* [36]. The plant also has the potential to serve as preservative. *Benincasa hispida* also called wax gourd is a known vegetable in most of the tropical countries that has a high medicinal value. Particularly in curing internal bleeding, epilepsy, cough, asthma, diabetes and nervous disorders [37].

Spectacular performance was recorded *Momordica charantia*, bitter melon, on many bacterial species most of which are plant and human pathogens [38].

In Nigeria, a lot of the members of this family have been exploited locally to treat infectious diseases. Osuagwu and Ejikeme [39] had reported the inhibition of growth of *Salmonella typhi*, *Enterococcus faecalis* 

and *Pseudomonas aeruginosa* from extracts of *Trichosathes cucumerina*. Aqueous extracts were less effective than ethanolic fractions on the tested microbes *Trichosanthes tricuspidata* has been used as a laxative and for migrane treatment. Its root extract has anti-oxidant properties [40]. Generally, bacteria were more sensitive to the extracts from this *M. charantia*, than fungi just as Gram negative bacteria were more susceptible than the Gram positive strains [41].

Cucurbita pepo popularly called pumpkin is an example of medicinal cucurbits like the other cucurbits; ripe fruit of Cucurmis pepo are eaten in many parts of the world where it is cultivated. Pumpkin seeds a moderate to very good source of a variety of nutrients, including minerals, protein and healthy fats [42]. They are good source of important minerals such as copper, zinc, iron and magnesium. Also, the seeds are used in nutrition in various forms. The seeds can be eaten raw, and they are good sources of lipids and proteins [43]. Seeds oil of pumpkins is a good raw material for the production of oil used in preparation of food and also for medicinal use [44]. Cultivation of pumpkin is not only for food only but also for their medicinal properties. Medicinal properties particularly have been attributed to all the part of the fruit and the plant. Pumpkin seed aids with appetite stimulation, and it's beneficial for the teeth, nerves, hair and nails [45]. It is a climbing herb and cultured mostly in America and tropical India. It is used for increasing appetite, blood purification, and leprosy. It also helps in proper management of benign prostatic hyperplasia which is heavily related to prostate cancer [46, 47].

*Cucumis melo* also called musk melon has been linked to the cure for chronic eczema. It is diuretic, diaphoteric, laxative, good tonic and has anti inflammatory properties. The bitter apple whose botanical name is *Citrullus colocynthis* is grown in arid places and good for hypoglycemia, tumors, ulcers, asthma, bronchitis, constipation; it's an analgesic and has anti-inflammatory activities [48, 49, 50].

In 2017, the antimicrobial activity of *Cucurbita moschota* and *Lagenaria siceraria* was investigated by Dash and Gosh [51] on *Acinetobacter baumanii*. The lethal concentration  $LC_{50}$  of *C. moschata* and *L. siceraria* was 70 and 135 respectively. The candidate control agent was their seed protein hydrolysate making it both of high nutritional and antimicrobial importance in the food security and safety system. Using the disc diffusion method on some bacteria, Hansanuzzanan et al. [17] carried out preliminary evaluation of the root extract of *Coccinia grandis* on *Staphylococcus aureus*, *Bacillus cereus* and *E. coli*. In comparison with standard ciprofloxacin, the ethanolic extracts resulted in 9-12 mm zone of inhibition with an equally significant cytotoxicity at  $LC_{50}$  of 2.49 mg/ml. Of all the solvents tested - carbon tetrachloride, n-hexane, water and dichloroethane, the latter was most effective.

## **ANTIVIRAL ACTIVITY**

The protease inhibitors were reported to incite a significant antimicrobial action [52]. Extracts from the leaves of *Momordica charantia* was also effective against hepatitis. Some ribosome inactivating protein RIPs were once isolated from *Momordica charantia* opening ways for antiviral therapy [53]. Puri et al. [53] had investigated the mechanism of action of ribosome inactivating protein (RIPs) of M charantia and concluded that the RIPs are not only very effective against both HBV and HIV, it is also non-toxic to host's normal cell. The RIPs have a future in anti-cancer and anti-viral therapy as they target specifically, hosts protein synthesis. The expression of hypoglycaemic peptide MC6 from *M. charantia* in *E. coli* was investigated by Wang et al. [54]. The research revealed the ease of modification of the bacterial biochemistry by this plant, a characteristic that can exploited to achieve both in vivo and in vitro pathogenic therapy. In *C. balsamina*, substrate specificity is a common property binding all members of cucurbitaceae. Also peptide bioavailability can be determined by the distribution of the molecular weight of peptides in seed protein hydrolysates which are the main sources of bioactive peptides [54].

Many extracts have comparable antimicrobial profile as the standards antibiotics. For example, piperacillin (100  $\mu$ g/disc) and gentamicin (10  $\mu$ g/disc) recorded similar sensitivity pattern when some bacterial and fungal strains were challenged with the leaf extracts of *Citrullus colocynthis*. The combined effects of the

flavonoids, phenols and tannins present had significant antimicrobial activity, a situation that invites its possible use in plant disease control [55].

*Telfaria occidentalis* common in Nigeria has the ability to be hepato-protective and antimicrobial. Some of the attributes of this plant have been linked to its antioxidant value [56].

Luffa cylindrica another Cucurbitaceae very common in Nigeria, was investigated for the properties of its seed oil. It was discovered that the seed oil exhibited significant antimicrobial activity against *S. aureus*, Candida albicans and E. coli. The report also confirmed that the efficacy of the extract was on par with that of afloxacin, the synthetic antibiotic [57].

Luffa echinata which is also known as bundal has been recommended for treating liver related diseases due to the presence of saponins, echinatol A and B which are active for curing such disease [58]. Some of the Curcubitaceae are used as an anti-inflammatory agent and expectorant. An example of such is Chinese cucumber which has also been reported to be potential anti-tumor promoters. [59]. Cucurbita ficififolia has been used in the preparation of dishes for eating and also for candies preparation. It can also be used for curing wounds and ailments like fever and hemorrhoids. It is also linked to be a good drug for treating diabetes type 2 [60].

The extracts of acetone water and ethanol were very effective against uropathogenic *E. coli* being particularly effective against the extended spectrum of beta lactamase (ESBL) producing species [61].

The window of members of this family was further opened by the discovery of the phytochemicals from *Icacina trichantha* and the antimicrobial activity of the extract. The potentially therapeutic significance of the bioactive compounds in this leaf extract was proven when cells of *Klebsiella* and *Candida* were controlled when challenged [62].

# ANALYTE EFFICACY IN RELATION TO METHOD OF EXTRACTION

Solvent efficacy plays a vital role in extracting the phytochemicals. As demonstrated by Fidrianny et al. [63] on the leaves of *Luffa acutangula*, *Sechium ledule*, and *Momordica charantia*, polarity of solvents can dictate the ease of recovery. There were differences in extraction using n hexane, ethanol and ethyl acetate. This is a factor to be considered in determining the choice of plant for antimicrobials and antioxidant [64]. The mode of determination of active ingredients also matters. For example, the total flavonoid methods were used with success on *Momordica charantia* [65].

Using the GC MS method, the major components of Cucurbita pepo were 9,12-octadecadienoic acid (47.17%) [66]. When the bark of Cucumis was retained it had a better antibacterial effect than when removed. This suggests that the bark is concentrated with the desired analytes for antibiosis [67]. It was also shown that different organs of the plant have different concentration levels of various. The total polyphenol contents of squirting cucumber (Ecballium elaterium) differed remarkably in all the organs tested [68]. With precision analyses, many antifungal products have been extracted from many plants in the family [69]. Using different polarity extracts, that employed DPPH (2.2-diphenyl-1-picrylhydrazyl) and FRAP (Ferric Reducing Antioxidant Power) fractions, and correlation of total phenolic, flavonoid and carotenoid content the antioxidant capacities were measured using the leaves. It was discovered that the ethanolic extract of Luffa acutangula leaves had the highest DPPH scavenging capacity ethyl acetate extract of Sechium edule leaves had the highest FRAP capacity; n-hexane extract of Momordica charantia leaves had highest flavonoid and carotenoid contents [63]. The implication of this is that there always a correlation between the profiles of ingredients extracted and the polarity of the solvent used. Using affinity chromatography on alpha agarose lactose matrix, lectin was isolated from M. balsamina seeds with high throughput resembling the yield from other members of the family [70]. Quercetin, a flavonoid and an important therapeutic component of the leaf, stem and root of Citrullus colocynthis was successfully purified through series of solvents involving chloroform, ethyl acetate diethyl ether and run through a TLC and subsequently HPLC process [71]. The pressurized boiling system through gas Chromatography mass spectrometry gave a high yield of extracts from Momordica charantia [72]. This method was more effective than the conventional Soxhlet method. Amino acid profile and the antimicrobial content are co related when studied on *Cucurbita moschata* and *Lagenaria siceraria* [51] suggesting one serving as an indicator to the other.

#### THE FUTURE OF THERAPY WITH CUCURBITS

The increasing rate of resistance to common antibiotics among bacterial and fungal species calls for a concerted effort at combating communicable diseases in animals and man. With the WHO raising alarm on the increasing level of resistance among bacterial strains, bioprospecting into the world of cucurbits becomes an attraction. Many of the developing worlds recognise the need for phytotherapy [73, 74] however, the original native interventions involving concoctions and infusions of this group invites better embrace. With the embrace come refining and developing better products regarding mode of extraction, toxicity studies and overall efficacy. With some members identified and confirmed as toxic to mice [75] issues bordering on concentration purity, species of mammal involved and stability at administration make good research directions.

With a report stating that many Nigerian plants, including all Cucurbitaceae are disappearing fast [76], it has become necessary for governments in Nigeria and other African countries to recognize the need for vigilance towards traditional medicine. Even when molecular analyses expose the possibility of new species and apparent relationship with others [77], conscious efforts at replacing and massive tree planting is a critical response to the present scare

It is noted that phytoremediation is carried out using members of the Cucurbitaceae. For example, they can to up take organochlorines. Seven cultivars of the *Lagenaria siceraria* species were used to determine their capacity to remediate heptachlor- and heptachlor-epoxide-contaminated soil. The seven *Lagenaria* cultivars were grown in contaminated and uncontaminated soil for 13 weeks. The results showed that all the plants tolerated heptachlor and heptachlor epoxide in the soil and were able to bear a limited number of immature fruits during the short study period. All seven *Lagenaria* cultivars showed some ability to up take heptachlor epoxide into their vines with bioaccumulation factors [78]. The molecular approach to the ultrastructure of *Momordica* sp. opened the window of the possibility of igniting modifications in the cells *E. coli* [54].

#### **CONCLUSION**

In spite of the difficulties recorded in purification and administration of crude extracts of cucurbits for human and animal use, the family still remains a rich and reliable therapeutic resource particularly in the developing countries and therefore, a family of hope and promise.

# **AUTHOR CONTRIBUTIONS**

This research work is a product of agreement and collaboration among all authors. SOF suggested the work and designed it. Extensive literature research was done by SOF, DOJ and AAA. All authors were involved in the writing, review and approval of the manuscript. All authors read and approved the final manuscript.

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