Chapter

Overview of *Cucurbitaceae* Families

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Abstract

The family *Cucurbitaceae* has a wide range of vegetable or fruit crops that are very important to the national or local economy. Ancient agricultural and medical texts as well as these folktales frequently refer to cultivated members of the *Cucurbitaceae* families. The plants of *Cucurbitaceae* family are rich in phytochemicals such as terpenoids, glycosides, alkaloids, saponins, tannins, and carotenoids responsible for the therapeutic effect. Various parts of these plants exhibit an excess pharmacological activity such as hypolipidemic, anticancer, antidiabetic activity, antimicrobial, anti-inflammatory, and immunomodulatory activities. Among the members of the *Cucurbitaceae* family, pumpkins and squash (*Cucurbita moschata* Duch., *Cucurbita pepo* L., and *Cucurbita maxima* Duch. ex Lam), cucumber (*Cucumis sativus* L.), watermelon (*Citrullus lanatus* L.), and melon (*Cucumis melo* L.) are particularly nutritious due to their beneficial vitamins and minerals. Consumption of some species as food or medicine without proper identification could be dangerous, as some poisonous wild species share a close resemblance with edible ones. A complete, safe, efficient, and cost-effective global conservation system for *Cucurbitaceae* genetic resources should be available, with germplasm and specific accession level information easily accessible, ideally in centralized global databases like Genesys.

Keywords: antimicrobial, antioxidant, *Cucurbitacin*, germplasm, therapeutic

1. Introduction

The *Cucurbitaceae* family is well defined but taxonomically isolated from other plant families. The family contains 115 genera and 960 species that make up this family and are predominantly herbaceous annual vines or perennial lianas and frequently with tendrils [1]. They can be monoecious or dioecious, and occasionally, they are hermaphrodites. They are primarily found in tropical and subtropical zones, and very rarely in temperate zones. The *Cucurbitaceae* are known for their bicollateral vascular bundles, which have phloem on both the outer and inner side of the xylem. *Cucurbitacin*, which is primarily responsible for the bitter flavor, is typically present in *cucurbits* [2]. The family of *Cucurbitaceae* has a wide range of vegetable or fruit crops that are very important to the national or local economy. The vegetables include cucumber (*Cucumis sativus*), zucchini (*Cucurbita pepo*), pumpkin (*Cucurbita maxima*, *C. moschata*, and *Cucurbita argyrosperma*), wax gourd (*Benincasa hispida*), bottle gourd (*Lagenaria siceraria*), bitter gourd (*Momordica charantia*), ridge gourd (*Luffa*

acutangula), sponge gourd (*Luffa cylindrica*), chayote (*Sechium edule*), and snake gourd (*Trichosanthes anguina*), and the fruits include melon (*Cucumis melo*), horned cucumber (*Cucumis metuliferus*), watermelon (*Citrullus lanatus*), and luo-hanguo (*Siraitia grosvenorii*). Among these, the bitter gourd (*M. charantia*) and luo-hanguo (*S. grosvenorii*) both have significant culinary and medicinal uses, while snake gourds (*Trichosanthes anguina*) and bottle gourds (*Trichosanthes anguina*) can be utilized both as food and decorative items [3].

2. Origin and history

Plant cultivation started early in northern China. Some domesticates were developed from native species, while others were imported from Southeast Asia. Ancient Chinese myths and stories contain references to numerous vegetable species. Ancient agricultural and medical texts as well as these folktales frequently refer to cultivated members of the *Cucurbitaceae* family. Some of them appear to be indigenous to Indochina, while others were imported from Western Asia and the New World. A recent journey to China and a review of Chinese literature revealed that several cucurbits are consumed in their immature condition as vegetables, some are eaten as fruits, and various species are used for medicinal [4]. In the New World, Africa, the Middle East, the Near East, Asia, and New Guinea, 11 geographical areas have been recognized as the origins of cultivation [5]. Asia is where the cucumis melo originated, and there are many different wild and primitive melons there, especially in India, and wild Melons have been seen in northern Australia, southern America, and northeastern Africa. While archaeobotanists have described the significance of *Cucurbitaceae* plants in prehistoric societies, new molecular data have improved hypotheses about the timing and places of crop domestication as well as revealed the wild ancestors and close relatives of many crops [6].

3. Therapeutic importance of *Cucurbitaceae*

The *Cucurbitaceae* family has several health advantages. Pumpkin has stimulating properties, making it a potential alternative treatment for diseases associated with vertigo [7]. Some nations use the fruits of the *Cucurbita ficifiola* plant, commonly known as leaf gourd, in medicine to treat wounds and hemorrhoids. Phytosterols and tannins are abundant in cucumber. Tannins have astringent qualities, speed up wound healing, and may be able to chelate metal ions [8]. Many phytochemicals in the *Cucurbitaceae* family, including as saponins and cardiac glycosides, frequently used in the treatment of heart problems, have an impact on the circulatory system. Triterpenes, sterol, and alkaloids are among the many bioactive substances they contain high concentrations. Six isoprene units make up the fundamental structure of terpenoids, which are biogenetically descended from active isoprene [9]. The majority of *Cucurbitaceae* family vegetables are high in carotenoids, which are bioactive substances that give them their yellow-red blue. Carotenoids like lutein and zeaxanthin can be found in cucurbits [10]. Saponins have the capacity to coagulate red blood cells, and as a result, they aid in the reduction of bleeding. Due to its ability to suppress lipid oxidation products, primarily malonaldehyde and hydroxynonenal, cucurbitacin also has an anti-atherosclerotic effect. Glycosides are usually used in the treatment of cardiac and heart illness and are present in the leaves and seeds of

momoridace balsam. This chemical causes a greater calcium-induced calcium release, which increases the force of heart contraction [11].

3.1 Antioxidant activity

Oxidative stress results from an imbalance between prooxidant and antioxidant levels that favors the former. It is a dangerous state for the entire body and shows signs of human diseases such as cancer or obesity [12]. Cucurbits exhibit antioxidant properties because of a variety of bioactive components, such as cucurbitacins B and E and ellagitannins, which are tannins and have the ability to scavenge free radicals. The majority of vegetables in the *Cucurbitaceae* family are also high in carotenoids, which increase the nutritional value and safety of food due to their antioxidant capacity. A good source of squalene is pumpkin oil. Due to its antioxidant capabilities, this linear triterpene is crucial in preserving the oil's oxidation stability. Bitter gourd seeds, pulp, and its constituent compounds have antioxidant action *via* preventing lipid peroxidation.

3.2 Antidiabetic activity

Diabetes affects more than 380 million individuals in worldwide. There is a significant financial and health load on the health care system. Recent researchers start to look at plants as remedy to treat diabetes including the cucurbit family. Pumpkin has shown that remarkable antidiabetic effects. Pumpkin seed protein-bound polysaccharides had hypoglycemic effects, such as raising plasma insulin levels. Other biologically active substances found in pumpkin include sterols and paraaminobenzoic acid [13]. It also contains a lot of pectin, which helps patients who eat foods high in fiber to control their blood sugar levels and use less insulin. Triterpenoid, steroids, saponins, and alkaloids are only a few of the bioactive phytochemicals that *Momordica charanita* produces. Due to property of polysaccharides in the immature fruits characteristics, the plant is often used in the treatment for diabetes. Even some of the chemicals found in this fruit, such as vicine and charatin, have antidiabetic properties [14].

3.3 Anticancer property

Cancer has several diverse types and one of the most public diseases in the world. Saponins antimutagenic and anticancer properties reduce the risk of cancer. Because they stop a cancer cell's cycle, cucurbitacins produce apoptosis, which has an anticancer effect [15]. Polysaccharides have an antitumor action in addition to acting as hypoglycemic agents. Ergosterol, found in *Mukai maderaspatana*, has anticancer properties. The capacity of *Cucurbita andrena* to inhibit cyclooxygenase demonstrates its anticancer properties. According to [16] who confirmed *C. moschata's* anticancer efficacy against human leukemia cells by acting similarly to ribosome-inactivating proteins, compounds derived from *Curcurbitaceae* family can prevent the formation of cell tumors.

3.4 Anti-inflammatory activities

Cucurbitacins, which are found in cucurbits and are poisonous, have the potential to treat a variety of diseases like inflammation and autoimmune disorders when used in the proper dosage. The most promising *cucurbitacins* B and E have

anti-inflammatory activity because they suppress inflammatory mediators including tumor necrosis factor and nitric oxide synthase [17]. In the diet, cucurbits can serve as a source of polysaccharides. These substances have the ability to alter an organism's biological processes because they control macrophages, which in turn affect the immune system and lessen inflammation. *Momoridace balsamina* leaves and seeds contain cardiac glycosides, which protect against fatal endotoxemia and have anti-inflammatory properties. The plant contains ergosterol, a substance with anti-inflammatory and anticancer properties [18].

3.5 Antimicrobial activity

Terpenoids found in abundance in cucurbits damage membranes and limit the growth of bacteria and fungi, which is harmful to them. *Cucumbertacins* is stimulated the stomach secretion. These constituents use an anti-feedant for insects. *Cucurbitacin* have antimicrobial activities that effectively inhibit the growth of *Pseudomonas aeruginosa*, *Escherichia coli*, *Staphylococcus aureus*, and *Bacillus subtilis*. According to [19] the compound isolated from *C. moschata* leaves has an antifungal activity. This significantly reduced *Fusarium oxysporum* growth. As a result of its synergistic interaction with the chitin syntheses inhibitor nikkomycin, isolated protein also reduced the growth of *Candida albicans* [18].

3.6 Hypolipidemic activity

There are numerous reports of plants in the *Cucurbitaceae* family being used therapeutically to treat hyperlipidemia. The lipid-lowering properties of these plants reduce clinical issues associated with lipid metabolism, such as insulin resistance, diabetes, hypertension, and dyslipidemia. By exhibiting lipolysis, decreased lipid content, and decreased mRNA expression of adipocyte transcription factors, *M. charantia* (bitter gourd) fruit juice addresses hyperlipidemia. By controlling the expression of the genes for adipocytokine and adipogenic transcription factors, the accumulation of lipid in primary human adipocytes was reduced.

4. Modern cultivation and production

Citrullus, *Cucumis*, *Cucurbita*, and *Lagenaria* are four of the 115 genera in the *Cucurbitaceae* family that have commercial significance. About half of the world's watermelon (*C. lanatus*) production (29.9 million tons) is produced by four nations: China, Turkey, Iran, and the United States [12]. The watermelon (*C. lanatus*) is an African fruit that was just recently brought to Europe. The second-largest crop grown among the cucurbits is the cucumber (*C. sativus*), and the four nations China, Iran, Turkey, and United States account for 66% of global production. Cucumber was likely domesticated in India and brought to Europe at an early date (during the ancient Greek period). In terms of global production, the top four producers China, Ukraine, Argentina, and Turkey account for 45%. In several different tropical nations, *Lagenaria* has most likely been independently domesticated [12]. In general, productivity is a key factor in determining how much money can be made, but like other vegetable crops, quality, and product availability during times of shortage are also crucial factors in determining how much money can be made. Therefore, efforts should be made to create hybrids and types that are more adaptable during the

off-season. Utilizing the known genetic pathways for hybrid seed development would also be relevant to lower the cost of hybrid seeds. High-frequency pistillate lines are encouraged in this regard.

4.1 Germplasm and varieties

Plant viruses are highly reducing crop production globally. There are various ways for crop plants to develop viral resistance. One method is traditional plant breeding, which entails introducing virus-resistance genes from related agricultural plants. Genome editing is a different approach that enables the introduction of genes imparting resistance directly into agricultural plants without the several backcrosses necessary with traditional breeding [20]. As "gene edited crops" do not always contain transgenic portions, they most likely do not require considerable regulation, opening up a new, socially acceptable way to grow crops that are immune to viruses. Among the members of the *Cucurbitaceae* family, pumpkins and squash (*Cucurbita moschata* Duch., *C. pepo* L., *C. maxima* Duch. ex Lam), cucumber (*C. sativus* L.), watermelon (*C. lanatus* L.), and melon (*C. melo* L.) are particularly nutritious due to their beneficial vitamins and minerals. Understanding the information in the genome is crucial for breeders who want to use biotechnology to boost the level of nutrition and the quality of features in *Cucurbitaceae*. Breeding methods that are unconventional can help traditional breeding by reducing costs, prices, and selection effectiveness [21].

4.2 Breeding

Four species of cucurbits the bitter gourd (*M. charantia*), the ridge gourd (*L. acutangula*), the sponge gourd (*L. cylindrica*), and the tropical pumpkin (*C. moschata*) are the focus of current breeding efforts. The choices of species are carefully weighed in a number of variables, such as their economic significance in the targeted geographic areas, nutrient density, and access to genetic resources [22]. The improvement in the crops status on a global scale, production constraints, and the world comparative advantage in resolving them compared to the private sector [23]. For the systematic maintenance and use of the abundance of vegetable crop germplasm, including cucurbits, the Indian Institute of Vegetable Research is a National Active Germplasm Site. Germplasm collection, evaluation, maintenance, and dissemination are the main activities. World Vegetable program stopped cucumber breeding due to the significant private sector investment in this crop, the lack of realistic opportunities for World Vegetable to address production issues, and the low nutritional value of cucumbers in comparison to other vegetable crops. The genetic diversity of current crop species has declined because of domestication and crop improvement bottlenecks. Breeders trying to create superior variations with resilience to both abiotic and biotic stress face a major difficulty due to the limited genetic foundation of many cucurbit crop cultivars. Such genetic diversity may come from crop landraces and wild relatives, which mean they need to be preserved outside of their natural habitat [24]. The comprehensive characterization of gene bank collections is required to speed up the exploitation of conserved diversity in breeding operations. Cucurbits are quite sensitive to a variety of biotic and abiotic stressors. Usually, landraces and their wild cousins contain reservoirs of resistance. Snap melon has been reported to be resistant to fruitfly, downy mildew (*Pseudoperonospora cubensis*), etc. The majority of cucurbit-resistant cultivars were created through straightforward selection. Breeders will be able to create resilient cultivars that are suited to quickly changing

environmental conditions by mobilizing a large crop gene pool, which will increase agricultural production and ensure the security of food and nutrition.

5. Poisonous species in the *Cucurbitaceae* family

Without correct identification, it may be unsafe to use some species as food or medication because they may resemble both poisonous and edible wild species. Because incidents of food poisoning in both people and domestic animals have been documented, care must be taken when gathering members of the *Cucurbitaceae* family for food or medicine. In certain instances, species are so similar in vegetative morphology that the flower and fruit characters are the solely means to differentiate between species. Not all of the member of species have had their potential toxicity and safety for human ingestion evaluated. Cucurbitacins are tetracyclic triterpenoids, which are dangerous naturally occurring substances. They are present in several additional *Cucurbitaceae* species as well as *Lufa cylindrica* (L.) M.J. Roem. In the scientific literature, several identified and well-characterized cucurbitacins, including cucurbitacin, have been described. In addition to serving as an insect repellent for the majority of bug species, cucurbitacin is utilized to protect plants from herbivores. The general population needs to be made aware of the dangers of drinking bitter bottle gourd juice and fruit, as the taste is a sign that cucurbitacins are present [25].

African nations such as Botswana, Namibia, Nigeria, Senegal, South Africa, and Swaziland are among those where *C. metuliferus* grows naturally. But in shallow or deep places with well-drained sand, riverbeds, or food plains, this species can thrive. According to certain studies, the unripe fruit of *C. metuliferus* is poisonous, but when completely ripe, it is edible and toxin-free. The fruit's flavor has been compared to a blend of cucumber and banana. When ripe, the fruit is brilliant orange, coated in sharp spikes, and has a bright green, gelatinous flesh. It is frequently used in cooking, as a snack, or eaten raw. In market places in southern African nations such as Zimbabwe, Zambia, Mozambique, Malawi, and South Africa, *C. metuliferus* are frequently found [26].

6. Storage and preservation techniques

A global strategy for protecting *Cucurbitaceae* plant genetic resources should focus on enhancing the effective, economical conservation and utilization of *Cucurbitaceae* plant genetic resources. Ex situ conservation, initiatives deeply on keeping conventional seeds (that can endure long-term freezing or drying) in storage. Although preserving many seeds is an economical conservation technique, it still costs money because they need to be enough infrastructure and staff, especially for the regeneration of old accessions. Optimizing seed viability, seed health, seed storage conditions, and regeneration frequencies is necessary to reduce expenses and the consumption of stored seed. Cucumber, watermelon, and *Cucurbita spp*. seeds, for instance, show less than a 5% reduction in viability in a study of 42 species preserved for 10 years under medium-term conditions (4°C, 30–40% relative humidity, whereas muskmelon showed an 80% decline [26]. The *Cucurbitaceae* strategy survey found that the frequency of such tests varies greatly among gene banks, with the majority-taking place every 5–25 years; however, one gene bank stated that testing took place only extremely infrequently. The ideal testing schedule will vary somewhat

depending on the seed storage conditions, which may also affect seed lifetime. A complete, safe, efficient, and cost-effective global conservation system for *Cucurbitaceae* genetic resources should be available, with germplasm and specific accession-level information easily accessible, ideally in centralized global databases like Genesys.

7. Conclusion

The *Cucurbitaceae* family is well known and widely cultivated. Cucumber and pumpkin are the vegetables from this family that are widely consumed, but zucchini and squash are also becoming more common in cooking. Cucurbits have purgative qualities and were used in traditional medicine to cure kidney and bladder stones. In addition to being a good source of vitamins, cucumbers also have medicinal benefits, such as hepatoprotective and anti-inflammatory properties. The *Cucurbitaceae* family, in particular the pumpkin, is known for its antidiabetic properties. In order to cure diabetes, for instance, cucurbits are increasingly being employed for their pharmacological qualities. When it comes to inflammation and low urinary tract disease, some isolated substances, like *M. charantia*, can be *pharmacotherapeutic*. It is essential to do a systematic postharvest analysis of the ideal storage settings and food preparation or processing techniques that will help to maximize the vegetables fruit and lower the levels of cucurbitacin. These actions will assist in maximizing the potential of *Cucurbitaceae* species as a source of local food and medicine. The improvement of the thorough, secure, efficient, and cost-effective conservation and usage of *Cucurbitaceae* plant genetic resources should be the main objective of a global strategy for conserving *Cucurbitaceae* plant genetic resources. Initiatives for ex situ conservation mainly rely on maintaining conventional seeds in storage (seeds that can withstand prolonged freezing or drying).

Conflict of interest

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Data availability

The data used to support the finding of this study are included in the chapter.

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