
Review Article

Edible Cucurbitaceae species as natural sources of antimicrobial compounds

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Abstract: The rapid emergence of antimicrobial resistance (AMR) has become a major global health concern, demanding the search for alternative antimicrobial agents from natural sources. Members of the Cucurbitaceae family, widely recognized for their nutritional and medicinal value, possess a diverse array of secondary metabolites with promising antimicrobial properties. Phytochemicals such as cucurbitacins, flavonoids, phenolic compounds, tannins, alkaloids, terpenoids, saponins and glycosides have been reported to exhibit inhibitory activity against a broad spectrum of bacterial and fungal pathogens. The review has been compiled using available flora references and online databases. The objective is to summarise current knowledge of antimicrobial compounds isolated from various edible species of this family, emphasising the relationship between phytochemical composition and antimicrobial activity. Although considerable progress has been made in identifying antimicrobial constituents from Cucurbits, further studies on bioactive compound isolation, molecular mechanisms, toxicity, pharmacokinetics and clinical validation are required. Collectively, the available evidence suggests that Cucurbitaceae species represent a valuable reservoir of antimicrobial compounds and hold significant promise for the development of novel plant-derived therapeutics to combat antimicrobial resistance.

Keywords: Antimicrobial resistance, climbers, Cucurbitaceae, plant-derived antimicrobials

Introduction

Herbaceous and rarely shrubby, prostrate or climbing with the aid of tendrils, members of the Cucurbitaceae family comprise one of the most economically and nutritionally important plant families worldwide (Ma et al., 2022). These plants are widely cultivated for their edible fruits, young shoots, seeds and leaves and are recognized as nutritional powerhouses owing to their high-water content,

essential vitamins, minerals and diverse phytochemicals (Krishnamoorthi et al., 2025). Besides their nutritional importance, several Cucurbitaceae species have traditionally been used in traditional medicine for the treatment of infections, inflammation, gastrointestinal disorders and other ailments (El-Sayed et al., 2026). The climbing habit and adaptability of Cucurbitaceae species (Singh et al., 2024a) reflect their ability to thrive under diverse environmental conditions. Exposure to climatic fluctuations, environmental stresses and anthropogenic disturbances triggers a range of physiological and biochemical responses, including the synthesis of secondary metabolites (Khan et al., 2025). Unlike primary metabolites, which are directly involved in plant growth, development and reproduction, secondary metabolites primarily function in ecological interactions. These compounds play important roles in plant defense against herbivores and microbial pathogens, protection against abiotic stress, attraction of pollinators and seed dispersers and overall adaptation to changing environmental conditions (Xu et al., 2023). Secondary metabolites such as phenolic compounds, flavonoids, tannins, alkaloids, terpenoids, saponins and glycosides have attracted considerable scientific interest because of their broad spectrum of biological activities including antioxidant, anti-inflammatory, anticancer, antiviral and antimicrobial properties (Riaz et al., 2023). Among these, antimicrobial activity has gained particular attention due to the alarming increase in infectious diseases and the rapid emergence of antimicrobial resistance. The widespread misuse and overuse of antibiotics in human healthcare, veterinary medicine and agriculture have accelerated the evolution of multidrug-resistant microorganisms (Singh et al., 2024b), reducing the effectiveness of many conventional antimicrobial drugs. In that context, plants represent an invaluable reservoir of structurally diverse bioactive compounds that differ significantly from synthetic antimicrobial agents. Owing to their chemical diversity and multiple mechanisms of action, plant-derived compounds have the potential to inhibit microbial growth while reducing the likelihood of resistance development (Jubair et al., 2021). Species belonging to the Cucurbitaceae family are particularly promising in this regard, as they produce a wide array of bioactive metabolites, including cucurbitacins, flavonoids, phenolic acids, terpenoids and other phytochemicals that have shown antimicrobial activity against a range of bacterial and fungal pathogens (Borecka and Karaś, 2025). This review aims to provide a comprehensive overview of antimicrobial compounds reported from members of the Cucurbitaceae family. It summarizes the common names of the plants, their edible parts, traditional medicinal uses, major classes of bioactive phytochemicals reported from them, their antimicrobial activities against clinically relevant microorganisms and the challenges associated with their development as plant-based antimicrobial agents. Through consolidating existing knowledge, the present review highlights the potential of Cucurbitaceae species as an important source of novel antimicrobial compounds for addressing the growing challenge of antimicrobial resistance (AMR).

Methodology

The present review is based on a comprehensive survey of published literature on the family Cucurbitaceae, with particular emphasis on its antimicrobial compounds and associated phytochemicals. Scientific information was retrieved from major online databases, including Google Scholar, Scopus, PubMed, Web of Science, and Plants of the World Online (POWO), to obtain up-to-

date taxonomic information and relevant peer-reviewed research articles, review papers, ethnobotanical records, and pharmacological studies. Literature searches were performed using keywords such as 'Cucurbitaceae', 'secondary metabolites', 'antimicrobial compounds', 'antibacterial agents', 'antifungal properties' and 'traditional medicine'. In addition, regional flora literature, books and published reports documenting species distribution and traditional medicinal uses were consulted to supplement the available information. Only studies containing authentic scientific evidence and validated ethnomedicinal data were included in the present review. The retrieved information was critically examined, compiled and categorized into relevant themes to provide a systematic and comprehensive overview of the antimicrobial potential of the Cucurbitaceae family (Kumar, 2025; Sahu et al., 2026).

Traditional medicine and bioactive compounds from Cucurbitaceae with anti-microbial potential

Plants in the Cucurbitaceae family are highly versatile, serving as vital functional and seasonal foods, traditional medicines, ornamentals and valuable economic crops. Various studies have covered the ethnomedicinal and antimicrobial aspects of numerous members of this family (Table 1). Plant parts of *Trichosanthes cucumerina* are rich in bioactive compounds like curcumin, lectin, steroids and terpenoids that have reported activity against various Gram-positive and Gram-negative pathogenic bacteria and certain *Aspergillus* species (Nanna et al., 2017). Purified protein extracts from *Cucumis sativus* seeds have been scientifically researched to be effective against numerous bacterial strains and for their potential use in herbal and food products as additives (Al Akeel et al., 2018). *Citrullus lanatus*, though highly regarded for its abundant primary metabolites, has also been researched to contain a broad spectrum of bioactive compounds responsible for its antimicrobial activity against microbes associated with diarrhoea, dysentery and urinary tract infections, such as *Vibrio cholerae*, *Salmonella typhi*, *Shigella dysenteriae* and *Proteus mirabilis* (Harith et al., 2018). *Luffa acutangula* has been studied in preliminary setups to assess its pharmacological potential against microbial inhibition and in most of the studies; its chloroform extract has exhibited good results (Shendge and Belemkar, 2018). Also, many of the *Luffa* species are known to contain alkaloids, flavonoids, glycosides, steroids and saponins that have reported antimicrobial potential (Kumari et al., 2019). *Cucurbita pepo* or pumpkin, is used worldwide as a multipurpose food as almost all its parts are edible and it also has antimicrobial components that are potent against a wide range of bacterial and fungal infections (Salehi et al., 2019). *Coccinia grandis* is a valued seasonal vegetable in Asian countries that has both medicinal value and is traditionally used against various skin, gastrointestinal and respiratory ailments, which validates its reported activity against various bacterial strains like *Escherichia coli*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Bacillus cereus* and *Salmonella pyogenes* (Neetu et al., 2020). Similarly, *Solena amplexicaulis* has been reviewed to be rich in various secondary metabolites that can be associated with its activity against 15 human pathogenic bacteria, both Gram-positive and Gram-negative species (Karthika and Subramanian, 2021). Bitter gourd (*Momordica charantia*) is considered a functional food due to its key components like cucurbitane,

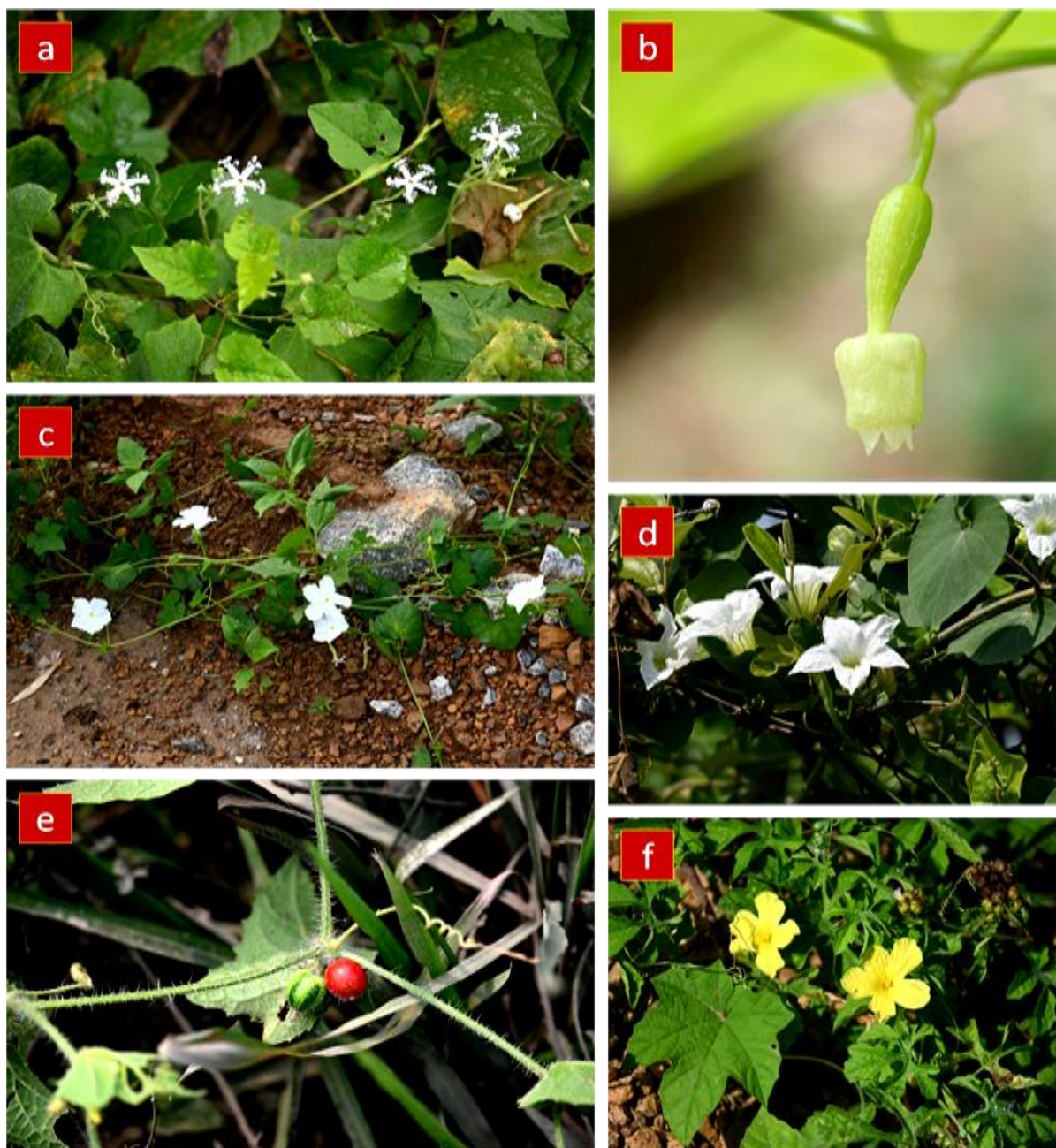


Plate 1: Plant species of Cucurbitaceae (a) *Trichosanthes cucumerina*, (b) *Solena amplexicaulis*, (c) *Trichosanthes costata*, (d) *Coccinia grandis*, (e) *Cucumis maderaspatanus* and (f) *Momordica charantia*

triterpenoids and alkaloids that contribute to its activity against various gastrointestinal and hepatic diseases causing microbes like *E. coli*, *S. aureus*, *Bacillus subtilis*, *Pseudomonas aeruginosa*, *Salmonella typhi* and *K. pneumoniae* (Gayathry and John, 2022). Compounds like cucurbitacins (H, D, B and G), fucosterol and campesterol present in the fruit of *Lagenaria siceraria* have reported antimicrobial and anti-diarrhoeal properties (Saeed et al., 2022). *Cucumis maderaspatanus* (plate 1e) leaves have been especially consumed as a leafy vegetable by indigenous people and both leaves and shoots have been used in the preparation of South Indian cuisines. The presence of various bioactive compounds must contribute to its antimicrobial activity (Astalakshmi et al., 2023) against

bacterial species like *S. aureus*, *B. subtilis*, *P. aeruginosa*, *E. coli* and fungal species like *Candida tropicalis* and *Trichophyton rubrum*. While less studied species like *Trichosanthes costata* have been reported through preliminary phytochemical screening to contain tannins, saponins, flavonoids, terpenoids, phenolic compounds and reducing sugars (Jena et al., 2025) that can be used as valuable data for further investigation regarding its pharmacological potential.

Table 1: Antimicrobial agents from the Cucurbitaceae family

Plant name	Common name	Edible part(s)	Ethnomedicinal value(s)	Antimicrobial bioactive(s)	Source(s)
<i>Citrullus lanatus</i> (Thunb.) Matsum. & Nakai	Watermelon	Endocarp, rind, seeds and leaves	Roots are laxative, but at higher doses can induce vomiting (emetic).	Tannin, terpenoids, alkaloids, saponin and flavonoids.	Harith et al., (2018); Masih et al., (2021); Wahid et al., (2022)
<i>Coccinia grandis</i> (L.) Voigt (Plate 1d)	Ivy gourd	Young shoots and fruits	Roots are used against diabetes, skin diseases, joint pain and urinary tract infection.	Triterpenoid, saponin, flavonoids, taraxerone, taraxerol and alkaloids.	Neetu et al., (2020); Lobo and Satish, (2022)
<i>Cucumis maderaspatanus</i> L. (Plate 1e)	Madras pea pumpkin	Leaves and tender shoots are used in making South Indian pancakes called 'dosa'.	Used in the treatment of fever, gastrointestinal and hepatic disorders.	Tannins, saponins, alkaloids, steroids and glycosides.	Petrus, (2013); Astalakshmi et al., (2023)
<i>Cucumis sativus</i> L.	Garden cucumber	Fruit and seeds	Seeds are known in unani medicine as a diuretic,	Cucurbitacins, flavonoids, phenolic acids and triterpenoids.	Saeedi et al., (2020); Uthpala et al., (2020)

			blood purifier and used for bronchitis, cystitis and renal-related problems.		
<i>Cucurbita pepo</i> L.	Pumpkin	Fruit, seeds, flowers, young leaves, shoots and storage roots	Fruit pulp is used in diarrhoea and dysentery.	Carotenoids and polyphenols.	Roy and Chakrabarti, (2003); Salehi et al., (2019)
<i>Lagenaria siceraria</i> (Molina) Standl.	Bottle gourd	Fruit and seeds	Leaf juice is used in urinary and digestive disorders, jaundice, constipation and heart-related disease.	Cucurbitacins, flavones, sterols and triterpenoids.	Saeed et al., (2022)
<i>Luffa acutangula</i> (L.) Roxb.	Ridge gourd	Immature fruits and seeds	Seed kernels are used for dysentery.	Luffaculin, anthraquinone, saponin-triterpene and volatile compounds.	Manikandaselvi et al., (2016); Shendge and Belemkar, (2018)
<i>Luffa aegyptiaca</i> Mill.	Sponge gourd	Immature fruit	Its dried fruit sponge has anti-microbial quality and is used for bathing purposes.	Tannins, flavonoids, alkaloids and saponins.	Mankilik et al., (2014); Kumari et al., (2019)
<i>Momordica charantia</i> L.	Bitter gourd	Fruits, aril and young	Fruit is used against	Cucurbitane triterpenoids,	Kumar et al., (2010);

(Plate 1f)		shoots	diabetes, malaria, sores, wounds, stomach-related disorders and fever.	phytosterols, phenolic compounds and alkaloids.	Gayathry and John, (2022)
<i>Solena amplexicaulis</i> (Lam.) Gandhi (Plate 1b)	Creeping cucumber	Leaf, stem and tubers are used in salads and curries.	It is used against ailments like gonorrhoea, asthma, appetizer, spermatorrhoea and hemorrhoids.	Steroids, triterpenoids, tannins, anthraquinones, saponins, forskolin and isoquercetin.	Karthika and Subramanian, (2021)
<i>Trichosanthes costata</i> Blume (Plate 1c)	Ribbed orange gourd	Deseeded unripe fruits are used as a condiment and leaves are used as vegetables.	Plant is used in the treatment of diseases like rheumatism, tetanus and ophthalmia.	Tannin, saponin, flavonoids, terpenoids and phenolic compounds.	Mukherjee et al., (2024); Jena et al., (2025); Perumal and Mahendradas, (2025)
<i>Trichosanthes cucumerina</i> L. (Plate 1a)	Snake gourd	Young fruits and shoots	Leaves and stems are used for bilious disorders and skin diseases. Fruits are used as anti-helminthics.	Triterpenoids, steroids, galactose-specific lectin and trichoanguin (ribosome-inactivating protein).	Sandhya et al., (2010)

Future aspects

Numerous studies have researched the antimicrobial potential of Cucurbitaceae species but several gaps remain before their bioactive compounds can be developed into therapeutic agents. Future research should focus on the isolation and characterization of active compounds using advanced

analytical techniques such as High-Performance Liquid Chromatography (HPLC), Gas Chromatography-Mass Spectrometry (GC-MS), Liquid Chromatography-Mass Spectrometry (LC-MS), Nuclear Magnetic Resonance (NMR) spectroscopy and metabolomics. Focusing on the molecular mechanisms of antimicrobial action, including effects on microbial cell membranes, metabolic pathways, quorum sensing and biofilm formation, will further strengthen their therapeutic potential. Studies evaluating synergistic interactions between Cucurbitaceae-derived compounds and conventional antibiotics are also needed, as such combinations may enhance antimicrobial efficacy and reduce the development of resistance. Moreover, standardized extraction methods, toxicity and pharmacokinetic studies, *in vivo* validation and clinical investigations are essential to establish their safety and effectiveness. Sustainable cultivation and biotechnological approaches for improving phytochemical production should also be explored to support the future development of plant-based antimicrobial agents.

Conclusion

The Cucurbitaceae family is a rich source of diverse secondary metabolites with significant antimicrobial potential. It is especially their adaptation to harsh and changing climatic conditions. Bioactive compounds such as cucurbitacins, flavonoids, phenolics, tannins, alkaloids, terpenoids and saponins found in plants like *Solena amplexicaulis*, *Luffa acutangula*, *Trichosanthes cucumerina*, etc., have shown inhibitory activity against a wide range of human pathogens, showing their potential as natural antimicrobial agents. However, most of the studies remain limited to preliminary phytochemical screening and *in vitro* evaluations. Future research should focus on the isolation of active compounds, understanding their mechanisms of action, toxicity assessment and clinical validation. With the growing threat of antimicrobial resistance, Cucurbitaceae species offer a very sustainable resource for the development of novel plant-based antimicrobial therapeutics.

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