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Bioresource Potential and Environmental Food Security Perspectives of Two Underutilized Cucurbit Vegetable Crops, *Momordica balsamina* L. and *Trichosanthes cucumerina* subsp. *cucumerina* L.

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ABSTRACT

Wild vegetables related to cultivated crops have not been given enough attention and use. Such underutilized species are *Momordica balsamina* (African pumpkin, bitter cucumber, or bitter melon) and *Trichosanthes cucumerina* subsp. *cucumerina* (locally called kattupatavalam, chichinga, potlakaaya, pudalankaai, aduvalakaayi, snake tomato) are members of the Cucubitaceae family. *M. balsamina*, which is closely related to *Momordica charantia*, is a highly climbing annual to perennial herb with tendrils that bears fruit, exhibits dual attributes, showcasing both medicinal and nutritional properties. All the parts of *M. balsamina* are home to a variety of medicinally significant substances, and have anti-HIV, anti-plasmodial, shigellocidal, anti-diarrheal, antiseptic, anti-bacterial, anti-viral, anti-inflammatory, anti-microbial, hypoglycemic, antioxidant, analgesic, and hepatoprotective properties. *T. cucumerina* subsp. cucumerina is a plant used in ayurvedic medicine and is one of the key components of many herbal products sold today. The phytochemicals that are present in the *T.cucumerina* subsp. *cucumerina* influence its pharmacological activity and potential for therapeutic use. The ecological, morphological, and nutraceutical features of these two underutilized wild cucurbits are covered in this review and to popularize the highly valued plants having high health benefits for its conservation in its natural habitat and make people to encourage their cultivation in their kitchen gardens.

Keywords: *Momordica balsamina, Trichosanthes cucumerina* subsp. cucumerina, Cucurbitaceae, Underutilized food crops, Nutraceuticals

Introduction

Vegetables have played a key part in human diets for millennia and its delivers essential vitamins and minerals required for preserving health and boosting immunity.

Wild veggies have a higher nutritional density and are more robust which requires low maintenance than traditionally farmed crops. They have the potential to significantly contribute to improving food security and alleviating nutritional shortages. Regrettably, little thought and attention have been paid to wild vegetables that are connected to farmed crops (Flyman and Afolayan, 2006). Uncommonly used, underutilized wild plants have served as important food and medicine sources and contributed significantly to the improvement of food security, a diverse diet, and the reduction of malnutrition (Nirmala et al. 2022). In the past, communities that relied on hunting and gathering relied mostly on wild animals and plants for food (Bharucha and Pretty, 2010). These plants are widespread in tropical and subtropical areas and are referred to as "wild vegetables" since they grow unrestricted in the wild vicinity (Omokhua Uyi and Van Staden, 2020). Cucurbitaceae is a large plant family that includes 965 species and 125 genera, usually known as cucurbits (Mukherjee et al. 2022). Benincasa, Bryonopsis, Citrullus, Cucumis, Cucurbita, Luffa, Momordica, and Trichosanthes are a few of the genera in the cucurbitaceae family that are particularly significant in the functional ecosystem and food values (Ramalhete et al. 2022).

The name Momordica was derived from the Latin word 'mordeo', meaning 'to bite'. Due to their medicinal and nutritional properties, the plants within the Momordica genus are highly valued (Chinthan et al. 2022). The Momordica balsamina also known as southern balsam pear, African pumpkin, balsam apple (Silva et al. 2022) is a non-tuber vegetable with a genus name Momordica, which belongs to Cucurbitaceae family and is considered as one of the most unused crop and not popularized in any cuisine is found in South Africa, tropical Africa, tropical Asia, Arabia, India, Australia and some regions of Oceania. In addition to being an invasive species in India and Northern Australia, it has been introduced to North America and Pakistan (Chinthan et al. 2022). The miraculous herb, tendril-bearing annual vine, M. balsamina is renowned for its astonishing medicinal powers, but its fruit is rarely ingested because of its uncommonness and insufficient production (Thakur et al. 2009). Other species besides M. charantia are frequently harvested from the wild and sold in local Indian markets in a variety of forms, including fruits, seeds, dried pulps, and conventional herbal medicines for the treatment of diabetes (Kumar et al. 2020). Through interbreeding, it is possible to use the Momordica species found in the wild to improve the yield and quality characteristics of cultivated crops. The collection and characterization of germplasm, together with the use of techniques like selection, mutation, polyploidy, and heterosis breeding, may result in the creation of higher yielding varieties or cultivars since these wild species carry genes that are resistant to biotic and abiotic stress (Chinthan et al. 2022).

Trichosanthes cucumerina subsp. cucumerina also similar as T. cucumerina var. cucumerina is a slender hispid climber (Kumar et al. 2009), and is another wild variety of Cucurbitaceae family in the Trichosanthes genus. Chemical compounds such as flavonoids, carotenoids, lignin, glycosides, tannins, alkaloids, phenols, and terpenoids are abundant in the Trichosanthes species. T. cucumerina L. is an annual monoecious climbing plant mainly found in most Asian nations, including India, Sri Lanka, Bangladesh, Burma, Malaysia, and Australia. It has two variations, T. cucumerina var. anguina L. is one of them and is produced as a vegetable and T. cucumerina var. cucumerina L. is a wild variation with short fruit. T. cucumerina is used as an antioxidant, hepatoprotective, gastroprotective, anti-inflammatory, antibacterial, analgesic, antidiabetic, diuretic, deworming, and antiproliferative product. It is also used as a purgative and treatment for indigestion, bile, fever, boils, blisters, rashes such eczema, dermatitis, psoriasis, ulcers, and malaria. The leaf sap is applied topically to the liver to reduce liver congestion (Shabna and Kumar, 2018). In India, particularly in Bengal, Gujarat, Konkan, Deccan, and Kerala, T. cucumerina subsp. cucumerina is found growing in the wild. It is a vigorously climbing annual herb with slender, pentagonal, serrated stems that are somewhat young or downy. It is observed as climbing on suitable supports, such as small trees and hedges (Venugopalan and Indulekha, 2018). The fruit goes through various changes as it ripens, including the synthesis of pigments, the development of flavour and aroma compounds, and the biosynthesis of carotenoids, particularly lycopene (Badejo et al. 2016). Additionally, the naturally occurring cucurbitacins belong to a class of triterpenoids that are highly recognised for their toxicity and bitterness. It has been reported that sheep and cattle that ate bitter fruits

from cucumis and cucurbita suffered from severe poisoning and even died. Humans can become toxically affected by three grams of bitter zucchini containing 50–600 ppm cucurbitacins (Devendra et al. 2011).

In this review, the current knowledge on M. balsamina and T. cucumerina subsp. cucumerina is highlighted, aiming at summarizing the contribution of these vegetable crop species as a valuable bio resource potential in the category of a nutritious vegetable with medicinal importance with a wide range of functional components. Furthermore, recommendations for future studies can be done with the plant residues of both the plants which relates to sustainable use of all plant parts as a potential natural bio resource. For achieving the sustainable development goals without any pollution and waste generation, compost preparation with plant residues can be done for improving soil micro deficiencies apart from the nutritional and pharmaceutical applications.

Taxonomical Hierarchy of Plants

The taxonomic hierarchy including the species to kingdom levels of M. balsamina and T. cucumerina is given in Table 1.

Table 1. The taxonomic hierarchy of *M. balsamina* and *T. cucumerina subsp.cucumerina* (Chinthan et al. 2022; Shabna and Kumar, 2018)

Kingdom	Plantae	
Sub kingdom	Viridiplantae	
Infra kingdom	Streptophyta	
Super division	Embryophyta	
Division	Tracheophyta	
Sub division	Spermatophytina	
Class	Magnoliopsida	
Super order	Rosanae	
Order	Cucurbitales	
Family	Cucurbitaceae	
Genus	*Momordica*	*Trichosanthes*
Species	*balsamina*	*cucumerina*
Sub species	-	*cucumerina*

Morphological Characters

A monoecious annual or short-lived perennial herb, *M. balsamina* has stems up to 5 metres long, simple alternate palmately 3-5 lobed, glabrous, orbicular leaves, and tendrils for attachment. It produces single trumpet-shaped, light yellow flowers and brilliant orange to red, constricted at both ends, tuberculate fruits that are 2.5-7 cm long. The seeds of *M. balsamina* are grey in colour, compressed, ellipsoid-shaped, and slightly verrucose. Fruits mature when they change colour from green to orange to scarlet red and split open at the base to reveal the seeds. From July to November in the desert region, the fruits are collected from pristine locations and sold for high prices. Throughout the entire season, a single vine bears 162-212 marketable fruits, yielding 0.7-1.0 kg of fruit (Ramalhete et al. 2022; Choudhary et al. 2022). After 39 days of seed sowing, the first staminate flower's blooming can be seen. The harvest of *M. balsamina* fruits begins in 48 days after planting. These morphological descriptions can be used to better understand the breeding behaviour of this underutilized vegetable, to plan pollination, to choose propagation methods that preserve germplasm, and to improve the genetic makeup of *M. balsamina* and other members of the genus *Momordica* in upcoming breeding programs (Chinthan et al. 2022). *M. balsamina* is very similar to *M. charantia* except its size and it has bracts towards the top of the flower stalks.

T. cucumerina subsp. *cucumerina* has thick, brownish, sculptured seeds that range in length from 1 to 1.5 cm (Okonwu and Muonekwu, 2019). Unripe fruits are green to dark green in hue, with an acute or acuminate fruit apex, and flowers are white. The leaves are staminate and range in colour from green to dark green. It is exceedingly uncommon for *Trichosanthes cucumerina* subsp. *cucumerina* to be found in the northeast, despite reports of the subspecies occurring throughout India and at heights of up to 1000 m. The majority of collections found in north-eastern India under this designation were either misidentified as *T. cucumeroides* Maxim. or were likely caused by the cultigen *T. anguina* (Pradheep et al. 2015). Detailed morphological characters of *M. balsamina and T. cucumerina* subsp. *cucumerina* were given in Table 2. The plant, edible stage, its ripened form and seeds of M. balsamina and T.cucumerina subsp. cucumerina were given in Figure 1.

Table 2. Morphological characters of *M.balsamina* and *T.cucumerina* subsp. *cucumerina*

Crop name	Part of plant	Morphological characters	References
M.balsamina	Leaves	Pale green colour, lobed, simple, waxy, alternating, and with three to five distinct lobes that cover up to half of the leaf blade and able to attain a 12 cm length.	Ramalhete et al. 2022; Choudhary et al. 2019; Thiaw et al. 2023
	Flowers	Monoecious, solitary, light yellow. Their pedicel, which can reach a length of 0.5 cm, gives them a rounded, trumpet-like shape. The narrow sepals can grow up to 0.5 cm, while the receptacle measures 0.5-1 mm. A unicellular lower ovary is encircled by 0.5–1.5 cm long petals.	Choudhary et al. 2019; Thiaw et al. 2023
	Fruits	Look resembling a spindle, with hues that range from green to vivid red. These fruits have roughly rows of short, blunt, creamy colour, non prickly spines that can be regular or irregular. When fully ripe (orange to red), the 25–60 mm fruits split into three spiral valves, exposing a multitude of seeds covered in a bright, sticky scarlet red. This aril has a watermelon-like sweetness and is edible.	Ramalhete et al. 2022; Thiaw et al. 2023
	Seeds	There is a red pulp covering the seeds. The compressed seeds have an oval or ellipsoid shape and measure 9 to 12 mm in length.	
T.cucumerina subsp. *cucumerina*	Leaves	Simple, alternating, hairy on both surfaces, leaves measure 7-15 cm in length and 10-15 cm in width. 5-7 lobed, pubescent, denticulate, lobes either acute or obtuse and petiole ranging in length from 2 to 7 cm. The base is broad kidney or heart shaped form.	Shabna and Kumar, 2018
	Flowers	Male and female flowers are found in racemes with panicles, and are monosexual, axillary, and fimbriate. Female flowers are solitary. Oblong ovary with a style that is 1.5-1.8 cm long and a broadened calyx tube at the apex.	
	Fruits	Fruits are tapering, slender, and have an ovoid fusiform or cylindrical shape with a waxy surface having 5-7 cm long, 3.5-4 cm in diameter, pointed at both ends. Young specimens are white-striped, maturing yellow.	
	Seeds	The seeds are compressed and undulate, hard and rugose, almost a 1-1.5 long, greyish-brown, sculptured, with an ovate-oblong shape measuring 11–12 x 6-7 mm in width. The seeds are embedded in a soft foetid with red pulp.	Okonwu and Muonekwu, 2019; Devi 2017
	Roots	Roots are tuberous, whitish with long and thick tap root. The thickness of the root is due to the storage of food and water.	Shabna and Kumar, 2018; Sandhya et al., 2010

Plant with flowers and green fruits (a) *M. balsamina* (b) *T. cucumerina* subsp. *cucumerina*

Green Edible Fruits (a) *M. balsamina* (b) *T. cucumerina* subsp. *cucumerina*

Ripened Fruits (a) *M. balsamina* (b) *T. cucumerina* subsp. *cucumerina*

Matured Seeds (a) *M. balsamina* (b) *T. cucumerina* subsp. *cucumerina*

Figure 1. Morphological characters and different parts of (a) wild bitter gourd, *M. balsamina*, and (b) wild snake gourd, *T. cucumerina* subsp. *cucumerina*

Ecology, Environment and Distribution

The 60 species of the genus Momordica are indigenous to paleotropical regions, such as the tropics of Africa, Asia, and Oceania. Ten of these species are found in Asia and seven in India. *M. balsamina* species is native to South Africa, Tropical Asia, Arabia, India, and Australia (Ramalhete et al. 2022; Chinthan et al. 2022).

During emergence, germination, the vegetative stage, and flowering, *Momordica* species require a minimum temperature of 18°C, with the ideal temperature falling between 24ºC and 27°C. According to some researchers, the crops thrive and adapt well in deep, well-drained sandy loam and silt loam soils that are rich in organic matter and have an ideal soil pH range of 4.3 to 8.0. They can, however, acclimatise to alkaline soils with a pH as high as 8.0 (Muronga et al. 2021). It is spread by seeds and can be found in India up to 300 m in height (Choudhary et al. 2022; Singh and Devi, 2018).

During the rainy season, *M. balsamina* naturally flourishes in Indian forests (Thiaw et al. 2023). The majority of Momordica species are suited to regions with mild, frost-free winters and minimum annual rainfall, such as those that receive an average of 400 mm (Muronga et al. 2021).

Plants known as cover crops are mainly used to reduce soil erosion, boost soil health, increase water availability, suppress weed growth, aid in the management of pests and diseases, boost biodiversity, and provide a host of other advantages for our farm. *M.balsamina* aids in reducing the issue of soil micronutrient deficiencies and high protein and fat content combined with low fibre content (Thakur et al. 2009).

With 918 species, *Trichosanthes* L. is the largest cucurbitaecae genus (Osuagwu et al. 2022) and is indigenous to southern and eastern Asia, Australia, and islands in the WSestern Pacific (Sandhya et al. 2010). *T. cucumerina* subsp. *cucumerina,* an annual monoecious climber is primarily found in Asian nations like India, Sri Lanka, Bangladesh, Burma, and Malaysia (Shabna and Kumar, 2018). About 100 species make up the genus *Trichosanthes*; the most significant of these are the snake gourd, a few of which have been domesticated in Asia. In many tropical Asian countries, it is grown as a minor vegetable. In home gardens across Africa, it is locally grown as a vegetable (Devi 2017). In comparison to other edible cucurbits like pumpkin, melon, and cucumber, it's an herbaceous annual climber with perennial root stock that is primarily used for ornamental purposes. Snake guards are cultivated from seeds, and if not maintained, their tendril-bearing vines would sprawl. It thrives in nutrient-rich, organically dense soils (Okonwu and Muonekwu 2019). It can also found in the China, Northern Territory, Queens Land, Western Australia, Myanmar, Vietnam, Indonesia, and the Philippines (Okonwu and Muonekwu 2019; Devi 2017).

Food and Nutritional Values

Human diets might benefit from the customary ingestion of *M. balsamina's* leaves and fruit. Because of its nutritional composition, *M. balsamina* may be utilized to prevent diseases associated with malnutrition as well as to augment the diet of humans. This is explained by the high protein content (19.72–29.08%) in all samples. It should be mentioned that compared to other *Momordica* species, the leaves have the highest protein content (29.08% ± 0.77) (Jaichand et al. 2024). African and Asian rural populations have used the fruits and leaves of *M. balsamina* as food. While the bright red fruit pulp is consumed in Namibia, the unripe fruits and leaves are cooked and consumed in Southern Africa, Cameroon, Sudan, and India. There has been research linking for edible young fruits and the mature fruit that cause vomiting and diarrhoea and it's due to the presence of alkaloids, resins, and saponin glycosides for the toxicity of fruits. In various sauces and soups, the leaves and fruits are employed. The rural communities of Botswana prepare the leaves and feed them as porridge (Ramalhete et al. 2022). *M. balsamina* leaves exhibit higher mineral and dietary fibre contents (29%) when compared to those of other species. Because of their high potassium content, which supports the maintenance of normal blood pressure and other cardiovascular diseases, *M. balsamina* leaves are referred to as a heart-protective green vegetable. According to reports, the presence of trace mineral zinc is detected in the fruits and leaves of *Momordica* species (Nagarani et al. 2014). Due to its high protein and fat content and low fibre level, *M. balsamina* is found to be useful in the creation of dietary supplements. The leaves of *M. balsamina* are a significant source of nutrients, containing 17 different amino acids (Choudhary et al. 2022).

Estimated mineral nutrients and biochemical components of southern balsam pear include potassium, phosphorus, calcium, iron, sodium, zinc, and copper, among other abundant minerals. It is also a plentiful source of bioactive substances like lycopene, total carotenoids, and ascorbic acid. Particularly lycopene, prevents the oxidative damage of DNA, lipids and proteins. It is also found to be powerful antioxidant, modulated immune function and induces apoptotic cell death. It also prevents lipid peroxidation and hyperglycemia and play supporting role in brain health and neuroprotection. Further, due to their high potassium content, *M. balsamina* are effective in the treatment of hypertension. As a result, it becomes clear that the southern balsam pear has potential as a vegetable in the human diet, both as a source of mineral nutrition and as a potential vegetable rich in nutraceuticals. The species flavonoid concentration is comparable to that of *M. charantia* and *M. cymbalaria,* making it a potential replacement for bitter gourd in the human diet's vegetable intake (Chinthan et al. 2022). According to Nagarani et al. 2014; Venugopalan and Indulekha, 2018; Ojiako and Igwe 2008, when compared the *M. charantia, and T. anguina* with its wild species, wild have more valuable nutrient composition.

In comparison to *M. balsamina* raw leaves and cooked leaves in various methods, the concentrations of six phenolic compounds, rutin, cryptochlorogenic acid, pseudolaroside A, isorhamnetin 3-O-robinoside, quercetin 3-galactoside, and trans-4-feruloylquinic acid, were highest in stir-fried leaves. Of all household cooking methods tested, stir-frying increased the content of lutein, β-carotene, and zeaxanthin by 60.00%, 146.15%, and 123.51%, respectively. Moreover, stir-frying African pumpkin leaves increased the antioxidant activity (DPPH and ABTS) and the inhibition of α-glucosidase and α-amylase. Compared to all four methods of household cooking, stir-frying reduced the antinutritive compounds compared to raw leaves (Mashiane et al. 2022) given in Table 3.

The young, unripe fruits of *T. cucumerina* subsp. *cucumerina* are used as vegetables, whilst the older, ripe fruits are combined to prepare stew and broths once the seeds have been removed (Okonwu and Muonekwu 2019). *T. cucumerina* is a nutrient dense food. It contains a lot of proteins, fat, fibre, and carbohydrates. There are 46.8% and 78.0% of phenolics and flavonoids in total, respectively. The fruit is an excellent source of vitamins A, B, and C. Potassium, phosphorus, sodium, magnesium, and zinc are other elements that are present in a good proportion (Venugopalan and Indulekha, 2018). Many ayurvedic remedies use the wild bitter varieties (Devi, 2017). *Trichosanthes* fruit is frequently eaten as a vegetable due to its superior nutritional value. The plant is highly abundant in flavonoids, carotenoids, phenolic acids, soluble and insoluble dietary fibres, and essential minerals, which give it pharmacological, nutraceutical and therapeutic activity (Bobade et al. 2022).

The seeds of *T. cucumerina* are a rich source of nutrients, according to their proximate composition. This indicates that *T. cucumerina* seed is also an excellent source of protein and carbohydrates. Due to the existence of a robust seed coat, the low percentage of moisture content indicates that the seed can be stored for a longer time under ideal conditions. *T. cucumerina* seed's high concentration of vitamin A suggests that it can help to improve vision, especially in low light. Additionally, the presence of the vitamin B shows that they promote cellular metabolism by participating in the conversion of nutrients into energy (Okonwu and Muonekwu, 2019).

Table 3. The effects of different household cooking techniques on carotenoid components of African pumpkin leaves (*M. balsamina*) (Mashiane et al. 2022)

Household Cooking Methods	Lutein mg 100 g^{-1}	Zeaxanthin mg 100 g^{-1}	β-Carotene mg 100 g^{-1}	Total Carotenoids
Raw	34.13 ± 0.45	1.30 ± 0.20	9.05 ±0.01	44.48
Stir-frying	54.69 ± 1.0	3.20 ±0.29	20.68 ±0.10	78.57
Boiling	43.08 ±1.8	2.25 ± 0.25	12.41 ± 0.08	57.74
Steaming	44.51 ± 1.1	1.85 ±1.24	17.33 ± 0.03	63.69
Microwave	41.71 ± 1.2	0.64 ±0.20	7.97 ±0.03	50.32

The snake tomatoes are found to contain major bio-active components. Because of their low percentages, free fatty acid and acid values may be more stable and beneficial in industrial and nutritional applications (Sandhya et al. 2010). According to the Badejo et al. 2016, the lycopene and β-carotene contents were especially high in the ripe pulp and the ascorbic acid content was highest in the pulp of unripe fruit.

Nutraceutical Aspects Including Phyto and Bioactive Compounds

Antioxidants are known to be crucial for maintaining good human health, as they can help to prevent illnesses such as cancer, coronary heart disease, and altitude sickness. *M. balsamina* is thought to have therapeutic effects on mental illnesses. Research has shown that the fruit pulp of *M. balsamina* contains substances that inhibit the activity of certain enzymes in the body. Additionally, it has been shown that extracts from this plant's fruit and leaves contain anti-malarial properties. Research has found that mixing African pumpkin seeds with the sugars lactose and D-galactose causes a hemagglutinating reaction. Finally, past research has demonstrated that compared to those with other blood types, people with blood type 'O' are more likely to hemagglutinate when exposed to *M. balsamina*. It also contains phenyl propanoid esters, which have antibacterial, analgesic, and antihypertensive properties. The balsam apple is rich in seventeen different amino acids. (Chinthan et al. 2022). The people from Africa, Tsongas and Zulus, meantime, brewed the leaves into a tea to cure stomach issues and blood liver deficiencies. Portuguese physicians prescribed *M. balsamina* leaves for liver, stomach, and blood deficiencies as well as for herbal and culinary uses. In West Africa, *M. balsamina* is also used as a laxative, appetite stimulant, and medication for fever in both people and animals. Both humans and animals use the root of *M. balsamina* as an aphrodisiac to treat urinary discharges (Thakur et al. 2009).

M. balsamina can withstand a variety of severe biotic and abiotic conditions. The wild relative of bitter gourd, *M.balsamina*, has a genome that has been characterized. This will help us understand which gene pool bitter gourd can benefit from. To create high-quality, better-yielding, and stress-tolerant bitter gourd genotypes, it may be possible to transfer genes from *M. balsamina* to *M. charantia* that are linked to biotic resistance and medicinal significance (Vinay et al. 2024). The presence of cardiac glycosides could mean that the plant is capable of lowering blood pressure. Terpenoids have been reported to exhibit several biological activities, such as anti-inflammatory, immunomodulatory, and antimicrobial activities. Flavonoids and tannins have been reported as free radical scavenging molecules. Saponins are known to possess a significant ability to precipitate and coagulate red blood cells and exhibit anti-inflammatory activity (Mabasa et al. 2021). The entire *M. balsamina* plant should be used to treat skin conditions like scabies. The Pedi people of South Africa frequently utilised the leaves and vines of *M. balsamina* as a cure for motion sickness. Young girl's menstrual cramps are treated and relieved with an aqueous extract of *M. balsamina* leaf, and postpartum women's milk production is increased. In order to help mother for restoring blood lost during childbirth and purify breast milk, the leaves of *M. balsamina* are made as part of a green vegetable soup for postpartum women in the Hausa area of Nigeria and the Republic of Niger. Additionally, *M. balsamina's* hypoglycemic impact, cholesterol lowering effect, and low Na^+ or K^+ ratio protect the heart and help to prevent diabetes, hypertension, and other diseases. Numerous disorders, including dysmenorrhea, eczema, menstruation stimulants, stalactia, gout, jaundice, kidney stones, leprosy, leukaemia, pneumonia, psoriasis, rheumatoid arthritis, scabies, haemorrhoids, cancer, and coronary artery disease, fever, ulcers, asthma etc. can be treated with the *M. balsamina* (Thakur et al. 2009).

Cucurbitacin B, cucurbitacin E, isocucurbitacin B, 23, 24-dihydroisocucurbitacin B, 23,24-dihydro-cucurbitacin E, and sterols 2β-sitosterol stigmasterol 11 are the chemical components found in *T. cucumerina* (Sandhya et al. 2010). Natural bioactive compounds are rich in *M. balsamina and T. cucumerina* subsp*. cucumerina* are given Table 4.

According to analysis, *T. cucumerina* seeds have a high oil content of up to 42.5%. Aerial portions include the ribosome-inactivating protein trichoanguin and a lectin that is specific for galactose. The majority of lutein-derived carotenoids are concentrated around 15.6–18.4 mg/100g FW. *Trichosanthes* seeds were used to produce a new isoflavone glucoside known as 5,6,6'-trimethoxy -3', 4'-methylene -dioxy- iso-flavone 7-O-β-D-(2''-O-p coumaroylglucopyranoside) (Sandhya et al. 2010). Hepatomegaly, hepatic

dyspepsia, and infective hepatitis are all conditions that are treated by *T. cucumerina.* It is a key component of several significant ayurvedic preparations, including Gulgultiktakam Kasayam, Mahatiktaka ghratam, Vajrakam Kasayam, and Mahatiktaka Kasayam. It is used as an aphrodisiac, appetiser, digestive aid, and germicide. Additionally, it has been used traditionally to heal gastrointestinal problems, make poisons, and treat ailments brought on by pitta. The Konkani people used the leaf juice to rub on the liver or the entire body to alleviate remittant fever (Kumar et al. 2009).

While only the fruits are connected to storage, the stems play a role in the transportation of cucurbitacin. Even though the amount of cucurbitacins in the leaves was minimal, their function as antifeedants is still significant. The fruits cucurbitacin content, which is approximately 15 times higher than that of the leaves when the plant material is fresh, is sufficient to support and carry out a variety of pharmacological activities, such as the plant hepatoprotective, anti-inflammatory, cytotoxic agent, antifeedant, and antimicrobial qualities (Devendra et al. 2011). *T. cucumerina* subsp*. cucumerina* seeds are used to treat tonsillitis and fever, according to an ethnopharmacological survey conducted among the Gond Tribe in Maharashtra State's Gondia district (Tiwari, 2016). The nutraceutical applications of *M. balsamina and T. cucumerina* subsp.*cucumerina* are given in Table 5.

Table 4. Natural bioactive compounds are rich in *M.balsamina and T. cucumerina* subsp. *cucumerina*

M.balsamina	*T.cucumerina* subsp. *cucumerina*	References
• Aminoacids,calcium • potassium, magnesium • zinc,manganese,and iron • anthocyanins, Polyphenols • phosphorus,sodium, • chlorophyll, fibre • lipids, proteins, vitamins • Resins, alkaloids, • Carbohydrates, pectin • tannins, saponins • glycosides, quinines • cardiacglycoside, terpenes, • steroids, glycosides • flavonoids, • anthraquinones,	• Alkaloids, Glycosides • Phenols, Flavonoids • Carbohydrates, Tannins • Steroids, Saponins, Lignin • Fat and oils, cardiac glycosides • carotenoids, terpenoids • Vitamins, proteins • Potassium, phosphorus • Sodium, Magnesium,Zinc • oxalate, phytates • fiber	Thakur et al. 2009; Olalere et al. 2022; Mabasa et al.2021; Mukherjee et al. 2022; Shabna and Kumar 2018; Devi 2017; Devendra et al. 2009; Sandhya et al. 2010

Table 5. The nutraceutical applications of *M. balsamina and T. cucumerina* subsp.*cucumerina.*

M.balsamina		
Whole plant	• promoter for appetite or can assist digestion • wipe out fevers and yaws, stimulate lactation, relieve intercostal pains • treat vomiting associated with bile and fever (Africa) • ingredient in aphrodisiac preparations • treat externally malignant ulcers • treat stomach and intestinal complaints (South Africa) • As an anthelminthic (Asia) • treating skin problems • tranquilizer to treat mental illness • treating liver diseases (South African)	Thakur et al.2009; Bharathi and John 2013; Omokhua-Uyi and Van Staden, 2020; Ramalhete et al. 2022
Leaves	• To stabilize glycemia levels in diabetic patients (South Africa) • To treat burns Poultice • To treat malaria (Niger) • As an antibiotic (Nigeria) • To treat abdominal pain (Nigeria) • To induce lactation and regenerate the loss of blood during labor (Nigeria)	Mokganya and Tshisikhawe, 2019; Ramalhete et al. 2022

	• To treat extreme uterine bleeding (Asia)	
Root	• To induce abortion (India) • To treat fever • To treat stomach cramps • To treat diarrhea	Thakur et al. 2009; Bharathi and John, 2013; Ramalhete et al. 2022
Fruit	• To induce abortion • As a purgative agent • Used as a vermifuge (Senegal) • To treat wounds (Nigeria) • To treat chapped hands, burns and hemorrhoids • To treat AIDS	
T.cucumerina subsp. *cucumerina*		
Aerial plant parts	• Used for indigestion, bilious fevers, boils, sores • Relieves skin eruptions such as urticaria, eczema,dermatitis, psoriasis • For diabetes, ulcers and inflammation • Gastroprotective and Hepatoprotective	Arawwawala et al. 2010; Deepa, 2017; Tiwari, 2016; Rajith et al. 2012
Leaves	• Leaf juice is rubbed over the liver to relieve liver congestion, remittent fevers. • Dried leaf has antispasmodic property • alexiteric, astringent, diuretic and emetic • for painful menstruation(Dysmenorrhoea)	
Fruit	• good source of Vitamin A, Vitamin B and Vitamin C • Cathartic • Used as an anthelmintic in French Guiana • It improves the appetite and acts as a tonic and stomachic and cures biliousness • Cures blood pressure, heart diseases, rheumatism	
Root	• To cure bronchitis, headache and boils • used as a hydragogue and cathartic • used for diabetes, skin swellings like boils and furuncles • anticonvulsant • abortifacient, alexiteric, anthelmintic, anti-septic, • astringent, diuretic and emetic	
Seeds	• used for stomach disorders in Malabar Coast • antifebrile and anthelmintic • Seeds have anti-bacterial, antispasmodic, antiperiodic insecticidal and anti-diarrhoeal properties • used as abortifacient, aphrodisiac, astringent • Used as trichogenous, febrifuge • treat tonsillitis and fever	

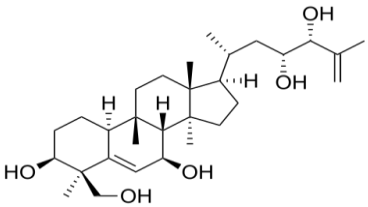
The most prevalent phenolic metabolite in the raw, undigested *Trichosanthes* leaves was cis-4-feruloylquinic acid (Mashiane et al. 2021). The peak of polyphenol oxidase, pectin methylesterase, and α-mannosidase activities was reached in coat and pulp at half ripeness, whereas the peaks of cellulase and polygalacturonase activities were reached in light green, light green with white stripe, and dark green with white stripe varieties at fully ripeness. The roles played by the enzymes in the softening (loss of firmness) of snake tomato fruit are established by the consistent increases in pectin methylesterase, polygalacturonase, and cellulase activity during fruit ripening (Dabesor et al. 2022).

Momordica spp. contains a variety of components that are abundant in primary and secondary metabolites. Gallic acid, gentisic acid (2, 5-dihydroxyl benzoic acid), catechins, chlorogenic acid, and epicatechin are all good sources of phenolic compounds in *Momordica* species (Muronga et al. 2021). The various bioactive compounds extracted from *M. balsamina* and their health benefits are given in Table 6 and the chemical structures of *Momordica balsamina* and *Trichosanthes cucumerina* subsp. *cucumerina* are given in Figure 2.

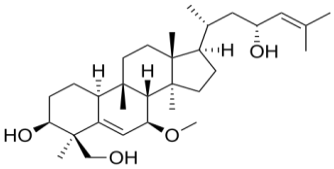
Table 6. Compounds extracted from *M. balsamina* L. and their health benefits (Choudhary et al. 2022; Olalere and Gan, 2020)

Health benefits	Compounds
Anti diabetic	Cucurbitane glycoside
Anti-malarial	Balsaminapentaol
Anti-viral	Momordin I Momordin II
Anti-cancer	Kuguacin J Karavilagenin C Balsaminagenin A Balsaminoside B
	Tellimagrandin II Thannilignan 2,7-Dihydroxy-4-methoxyphenanthrene-2- O-glucoside
Anti diabetic	Cucurbitane glycoside
Anti-malarial	Balsaminapentaol
Anti-viral	Momordin I Momordin II
Anti-cancer	Kuguacin J Karavilagenin C Balsaminagenin A Balsaminoside B
	Tellimagrandin II Thannilignan 2,7-Dihydroxy-4-methoxyphenanthrene-2- O-glucoside
Schistosomicidal activity against Schistosoma mansoni	Balsaminol F
Anti-parasitic	Cucurbalsaminol
Antioxidant, Anti-inflammatory	Decaffeoylacteoside Geraniin Mallotinic acid 1-O-Galloylpedun-culagin Agrimol E
Anti-Angiogenic	Yakuchinone A
Antimalarial and Antiherpetic	Flavanthrinin
Antioxidant	Methyl-5-O caffeoylquinate Terchebin Laevigatin A Kukoamine A

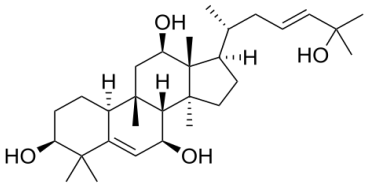
M. balsamina



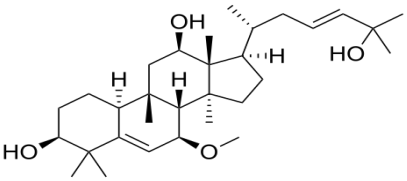
Balsaminapentaol



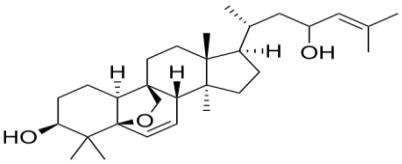
Balsaminol B



Cucurbalsaminol A

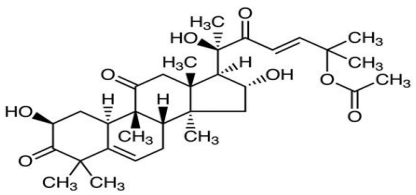


Cucurbalsaminol B



Karavilagenin E

T. cucumerina subsp. *cucumerina*

	Cucurbitacin B

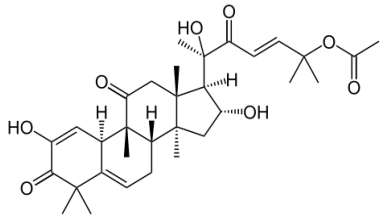
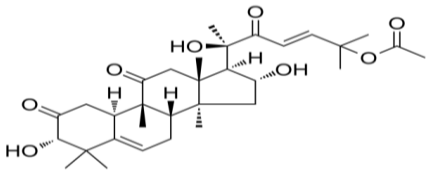
	Cucurbitacin E
	Isocucurbitacin B

Figure 2. The chemical structures of some novel compounds isolated from *M. balsamina* and *T. cucumerina* subsp. *cucumerina*

Antioxidant and Antiinflammatory Activities

Quercetin rutinoside, known as rutin, in *M. balsamina* has high antioxidant activity potential attributed to biological activities such as the protection of liver cells and suppression of haemoglobin oxidation. Stir-frying improved the release and accessibility of beta carotene and enhanced the antioxidant activities compared to boiling (Mashiane et al. 2021). In most villages, *Momordica* paste is used to eliminate intestinal worms in children and prevent irritation in the anus. This is done by applying the paste externally on the anus. Leaves may be used to treat gut related infections. Isorhamnetin is a methylated form of quercetin, and has been reported to exhibit an anti-inflammatory activity (Mabasa et al. 2021). The pulp of *M. balsamina* is combined with oil and used as an anti-inflammatory in West Africa (Thakur et al. 2009).

At 1000 mg/kg, *T. cucumerina* lessened the degree of cardiac damage brought on by doxorubicin, particularly in the heart (Shah et al. 2012). Combining the antioxidant carotenes and vitamin C content of the vegetable with the antibiotic qualities of the snake gourd can greatly improve general health. The antioxidant characteristics of snake tomatoes, which they compare with other lycopersicon tomatoes, along with their stronger inhibition of α-glucosidase activity and milder inhibition of α-amylase activity, indicate that they may be used in place of or in addition to lycopersicon tomatoes (Devi, 2017).

A high-resolution and accurate mass spectrometer was used, and the results confirmed the presence of flavonoid aglycones, such as quercetin, isorhamnetin, and kaempferol, as well as pseudolaroside A and dicaffeoylquinic and feruloyl isocitric acids. This is the first report of pseudolaroside A dimer and feruloyl isocitric acid in *M. balsamina* leaves. *In vitro* cytotoxicity assay showed that the extract was nontoxic against humancolorectal adenocarcinoma. However, the extract showed anti-inflammatory activity and the study confirmed that *M. balsamina* leaves contain nontoxic secondary metabolites that may play a pivotal role in human health as anti-inflammatory agents (Mabasa et al. 2021).

The methanol fraction (MEF) and aqueous fraction (AQF) of *T.cucumerina* shows inhibition against carrageenan induced hind paw oedema. The anti-inflammatory effect of MEF was equivalent to that of the reference medication indomethacin and hot water extracts (HWE). *T.cucumerina* anti-inflammatory properties are likely mediated through inhibition of nitric oxide (NO) production and membrane stabilisation activities (Arawwawala et al. 2010). Significant anti-inflammatory activity was demonstrated by the hot aqueous extract of T. *cucumerina* root tubers when used to treat carrageenin-induced mouse hind paw oedema (Devi 2017). The aerial portions of *T. cucumerina* have antihistamine properties when extracted in hot water. Therefore, the HWE's antihistamine activity might help to hinder the early stages of paw oedema caused by carrageenan (Bobade et al. 2022).

Antidiabetic Properties

In vitro assay of aqueous and organic extracts from stems and flowers of *M. balsamina* stimulate glucose utilization in hepatocytes and myocytes in Chang liver and Murine C2C12 myoblasts. However, treatment

with extracts exhibited some degree of toxicity (Ramalhete et al. 2022). Studies showed that ethyl acetate, hexane and ethanol *MB* fruit extracts have the capacity to enhance glucose uptake and stimulate insulin synthesis and secretion by cultured RIN-m5F pancreatic beta cells. Furthermore, these same three *MB* fruit extracts were able to upregulate gene expression levels of GLUT2, glucokinase enzyme, MafA and PDX-1 in cultured beta cells (Kgopa et al. 2020). Leaves are used to stabilize glycaemia levels in diabetic patients of South Africa preparing decoction (Ramalhete et al. 2022) In vivo studies performed with methanol extract from stem, roots, leaves and seeds in alloxan induced diabetic rabbits treated with 200 mg/kg of extract during 24 h induces a reduction in blood glucose levels (Sani et al. 2019) Chloroform fruits extracts performed in streptozotocin–nicotinamide-induced diabetic animals lowers elevated blood glucose level through in vivo models (Kaushik et al. 2017). Rats with diabetes induced by alloxan showed a significant ($P<0.05$) reduction in blood glucose levels twelve hours after the *M. balsamina* extract was administered. When the extract was administered at 1000 mg/kg, the results were similar to those of the standard medication, chlorpropamide. The management of diabetic sores and its traditional use as an anti-infective herb are supported by these results for *M. balsamina* (Otimenyin et al. 2008).

It has been suggested that snake gourd may help mitigate the effects of diabetes. Although snake gourd is frequently used in Chinese medicine to treat diabetes, the vegetable is typically low in calories. Because of this, it's the perfect food for helping people with Type II diabetes maintain a healthy weight while still giving them the nutrition they need. Using hot water extract of the aerial parts of *T. cucumerina* in rats has been shown to increase tissue glycogen and glucose tolerance indicating that the medication had antidiabetic properties, improving peripheral tissue glucose uptake and oral glucose tolerance (Devi, 2017). The polysaccharide derived from the aqueous extract of *Trichosanthes* peel by the processes of alcohol precipitation, deproteinization, and decolorization has the potential to serve as a novel natural active ingredient for treating hypoglycemia in diabetic mice (Chen et al. 2016). *Trichosanthes dioica* leaf aqueous extract has a strong hypoglycemic potential and a strong anti-diabetic profile; in fasting blood glucose (FBG) studies in normal rats (Rai et al. 2008).

Antimicrobial Characteristics

Methanolic extracts of *M. balsamina* from South Africa have shown clinically significant antibacterial activity against an isolate of *A. Baumannii* that produces carbapenemase (Nogbou et al. 2022). Methanol (MeOH) extracts of different *M. balsamina* plant parts showed activity against *Staphylococcus aureus and Escherichia coli* during the investigation of this plant's antibacterial properties employing extracts from the same plant to exhibit activity against *Proteus mirabilis, Klebsiella pneumoniae, and Bacillus subtilis* (Otimenyin et al. 2008) *Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, and Staphylococcus aureus* were all susceptible to the antibacterial properties of *T. cucumerina subsp. cucumerina extract* (Devendra et al. 2009). After the polyherbal extracts of *Trichosanthes* synergistic activity was examined, it was discovered that the crude herbal medicine that was produced from it was effective against *Proteus mirabilis, E. coli, Pseudomonas aeruginosa, Staphylococcus aureus, and Enterbacter sp.* (Seshadri et al. 2020).

'Momordins' present in the plant is capable of inhibiting the growth of HIV and other viruses (Thakur et al. 2009). Momordin II, a ribosome inactivating protein, is known for *M. balsamina.* It is a potential novel antiviral compound (Chinthan et al. 2022). *M. balsamina* exhibits higher levels of antiviral activity in the aqueous phases of the ethyl acetate, chloroform, and diethyl ether extractions and the direct water and acetonitrile extractions (Coleman et al. 2022). The methanolic extract of *M. balsamina* shows promise as a safe drug candidate for ethno pharmacological interventions against the paramyxovirus-1 (the virus that causes Newcastle disease in broiler chickens) (Ampitan et al. 2023)

Trichosanthes, because of their ribosome inactivating activity, are thought to be the plants of the future within the Cucurbitaceae family because of their strong anti-HIV properties. Purified trichosanthin, an antiviral protein, is obtained from *T. kirilowii* Maxim's root. It is still used as an active ingredient in Chinese medicine for treating carcinoma and performing midterm abortions (Devendra et al. 2009).

Anticancer Action

Kaempferol plays a major role in both preventing oxidative stress and treating conditions related to cancer. Compounds from *M. balsamina* exhibited no cytotoxicity towards MCF-7 human breast cancer cell lines. Moreover, in vivo investigations have revealed that *M. balsamina* extracts exhibit a very low level of toxicity, or inactivity (Mabasa et al. 2021). *Momordica balsamina* (MBE) extract shows cytotoxicity against HT-29 cells and is composed of a variety of chemicals that do not have any known anticancer action in colorectal cancer (CRC) cells. Moreover, MBE inhibited the production of reactive oxygen species as well as cell adhesion, invasion, and migration (Serala et al. 2021). Strong p-glycoprotein inhibitors in resistant cancer cells, synergistic interactions with doxorubicin, and the ability to eradicate specific resistance in cancer cells are just a few of the properties identified in *M. balsamina*. They were also discovered to be efflux pump inhibitors in bacteria that were resistant (Ramalhete et al. 2022). The existence and relative quantity of flavonol glycosides, cucurbitane-type triterpenoid aglycones, and cucurbitane-type glycosides may be responsible for the anticancer activity and antioxidant capacity of the *M. balsamina* MeOH leaf extract (Malemela 2021).

Cucurbitacin B from *T. cucumerina* exhibits cytotoxic actions against the breast cancer cell lines MCF-7 and SKBR-3 (Bobade et al. 2022). According to Seshadri et al. 2020 the cytotoxic potential of the polyherbal extract of *T. cucumerina*, two cell lines, the HeLa and MCF cell lines were chosen. These two cell lines were cytotoxically affected by the polyherbal fraction's methanol extract. The root extract of *Trichosanthes cucumerina* L. and bryonolic acid, its main constituent, as well as the fruit juice and cucurbitacin B, its main constituent, were evaluated. The two lung and three breast cancer cell lines (SKBR3, MDA-MB435, and MCF7) were more substantially inhibited by the root extract than by the fruit juice. Compared to the other studied human cancer cell lines, bryonolic acid inhibited MDA-MB435 somewhat more effectively. Compared to the root extract, the fruit juice more potently suppressed the colon cancer cell line (Caco-2). Compared to bryonolic acid, cucurbitacin significantly suppressed human cancer cell lines, particularly Caco-2 (Kongtun et al. 2009). Certain natural substances present in *Trichosanthes cucumerina L*. have an antiproliferative effects in hormone-dependent prostate cancer cells, whereas punicic acid functions as an aromatase inhibitor during the steroidogenesis process in human adrenocortical H295R cells (Mollik, 2013).

Hepatoprotective and Wound healing Activities

According to the histopathological analysis was conducted on the livers of rats administered *M. balsamina* extract. The extract was well shielded from the hepatotoxic effects of carbon tetrachloride by the hepatocytes normal appearance. Every outcome was juxtaposed with the reference hepatoprotective medication, Silymarin. *M. balsamina* is a highly effective medicinal herb in the management of liver hepatotoxicity (Thakur et al. 2009). Olarewaju et al. 2021 state that mashed fruit can be used as a poultice and that a liniment made by infusing the fruit of *M. balsamina*, but not its seeds, in olive or almond oil is used to relieve haemorrhoids, chapped hands, and burns. In various regions of Europe and Africa, soaked *balsamina* leaves are used to cure wounds. In addition, the berries and leaves are utilised in Nigeria and Syria as a hemostatic antiseptic for wound healing. The fruit of *M. balsamina* is used to make an ointment by combining it with olive or almond oil to cure haemorrhoids, ligament pain, and hand injuries (Thakur et al. 2009)

T. cucumerina whole plant methanolic extract demonstrated strong hepatoprotective activity against heapatotoxicity induced by carbon tetrachloride (Devi 2017). Serum tuberculosis levels were considerably reduced by oral treatment of TCME (Methanol extract of *Trichosanthes cucumerina*) (Bobade et al. 2022). The methanolic (MeOH) extracts of *Trichosanthes dioica Roxb* (TDR) fruits shown a considerable healing ability. All the criteria, including tensile strength, hydroxyproline content, wound contraction, epithelialization duration, and histological examinations, demonstrated notable variations in comparison to the control group (Shivhare et al . 2010). To cure liver problems, juice from fruits and leaves is employed. Pachanabheda churana contains *T. cucumerina*, which is used to cure liver enlargement at a dose of 10 to 15 grams (Kumar et al. 2009).

Pest resistantant Activity

M. balsamina exhibits a high level of tolerance to major cucurbit diseases and insect-pests like ladybird beetle (*Epilacna septima)*, pumpkin caterpillar (*Margaronia indica*), red pumpkin beetle (*Aulocophora fevicoli*), gall fly (*Lasioptera falcata*), root-knot nematode

(*Meladogyne incognita*), and cucurbit yellow mosaic, little leaf disease (Rathod et al. 2021). Cucurbitacin is used to protect plants from herbivores and is used functions as a repellent to most insect species (Olarewaju et al. 2021) found in the aerial parts of the plant(leaves and stems) (Ramalhete et al. 2022). According to Manoramya et al. 2021, study was conducted to examine the effects of partly pure proteinase inhibitors from *Momordica balsamina* (MbPI) and *Erythrina variegata* (EvPI) from Indian coral trees on the growth and development of *Spodoptera frugiperda*, or fall armyworms. In the MbPI 6% combined therapy, there was 12.5% reduction in adult emergence and 12.5% reduction in pupal mortality.

Cardioprotective Activity

By reducing hyperglycemia and oxidative stress in the kidney and heart tissues of STZ-induced diabetic rats, *Momordica balsamina* reduces the risk of cardiac myopathology complications in diabetes mellitus. This protective effect against hyperglycemia-induced cardiovascular and haematological changes is possible (Ludidi 2018). The severity of doxorubicin-induced cardiac injury, particularly in the heart, was lessened by *T. cucumerina* (1000 mg/kg). It is determined that pretreatment with methanol extract of *T. cucumerina* fruit reduces doxorubicin-induced cardiotoxicity (Shah et al. 2012).

Gastroprotective Activity

According to the ethanol extract of *T. cucumerina* L. EETC's antiulcer activity on indomethacine-induced experimental ulcer models, the anti-ulcer effect of EETC at 150 mg/kg was assessed in Albino rats against Ranitidine as the reference in terms of neutralisation activity, hydrochloric acid inhibition, and inhibition of gastric juice release. 150 mg/kg of EETC was found to have the highest anti-ulcer activity, almost exactly matching the effectiveness of the prescription medication ranitidine (Palanisamy et al. 2015). Strong gastroprotective properties of *Trichosanthes cucumerina* include the capacity to greatly minimise the size and duration of stomach lesions induced by 100% ethanol and indomethacin. Hot water extract (HWE) at 750 mg/kg exhibited gastroprotective effects similar to those of sucralfate and cimetidine (Bobade et al. 2022). Rat's stomach acidity can be decreased and gastric mucus secretion significantly increased when *T. cucumerina* hot water extract (HWE) is used. The protective qualities of the mucus barrier are determined by the quantity or thickness of the layer that covers the mucosal surface.Endogenous prostaglandins mediate the cytoprotective effect of the antiulcer drug when ulcer lesions are induced by 100% ethanol or indomethacin. Thus, it is possible that HWE either stimulates prostaglandin-like chemicals or induces the release of prostaglandins (Bobade et al. 2022).

Antiaging activity

Using ultrasound assistance, the polysaccharides from the *Trichosanthes* peel (TPP) were extracted. Through the use of Sephadex G-100 column chromatography, TPP-1 and TPP were separated. TPP-1 was phosphorylated, and the resultant phosphorylated form of TPP-1 was given the designation PTTP-1. The findings showed that PTTP-1 and TPP-1 both had strong antiaging action. Additionally, PTTP-1 had greater antiaging effects in aged mice, suggesting that antiaging action was enhanced by phosphorylation (Zhang et al. 2017). The antiaging properties of *Momordica charantia L.* fruit methanol extracts have been the subject of much research (Cao et al. 2018) but not *M. balsamina.*

CONCLUSION AND FURTHER RESEARCH RECOMMENDATIONS

Both the *M. balsamina* and *T. cucumerina* subsp. *cucumerina* species can be regarded as nutrient dense vegetables, and they both have a variety of beneficial physiological properties. The associated wild plants offer additional potential food sources and phytoconstituents for giving nutrients and enhancing human health when compared to the known common green vegetables. On the other hand, the phytonutrients have to be employed as antioxidants in the nutraceutical, food, and cosmetic industries, were abundant in the green edible fruits, leaves, and stems. For a cost-effective and environmentally friendly treatment for rural areas, regular consumption of these wild vegetables along with other food ingredients in our diet decreases the risk of various chronic and nutrient-borne diseases, particularly diabetes and obesity. In addition, it may also be used as a green vegetable to alleviate the symptoms of Alzheimer disease due to rich source of carotenoids such as alpha carotene, beta carotene, lycopene and essential fatty acid, oleic acid. Nonetheless, due to the

enrichment of nutraceuticals including dietary fibre could also increase the gut micro biota composition through which increase in the short chain fatty acids (SCFA) and this subsequently maintain the intestinal health particularly through preventing the initiation of cancer primordial.

Apart from the green fruits considered as a valuable resource, future studies with the post harvested left out plant residues which are abundantly available in the rural vicinity and not consumed by animals can also be used as bio compost or organic fertilizer and may also be exploited as a potential bio pesticides/ bio insecticides/ bio weedicides as a nature based solution for crop protection and production has to meet zero waste generation and thereby achieving the sustainable development goals with inclusiveness of traditional knowledge.

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