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Momordica species: Harnessing medicinal potential for a healthier futureG. R. Uvaprakash, A. Sankari [◆], G. Ashok Kumar^{**}, K. Iyanar^{***} and V. Rajanbabu^{****}

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Momordica species, Cucurbitaceae are widely distributed in tropical and subtropical regions, mainly in Asia and Africa. These species include *Momordica dioica* Roxb. (spine gourd), *Momordica charantia* L. (bitter melon), *Momordica balsamina* L. (balsam apple), and *Momordica foetida* Schumach. (sweet snake fruit), which are rich in bioactive compounds with significant medicinal and nutritional benefits. This review explores the biochemical, pharmacological, and nutritional properties of these plants, emphasizing their potential applications in disease management and human health. The presence of phytochemicals, including flavonoids, alkaloids, triterpenoids, and phenolic compounds, contributes to their antidiabetic, anticancer, antioxidant, antimicrobial, and anti-inflammatory properties. Additionally, these species offer substantial nutritional benefits, being rich in vitamins, minerals, and proteins. Despite advances in modern medicine, the increasing global interest in natural therapeutics highlights the importance of further research on *Momordica* species for pharmaceutical applications. Future studies should focus on elucidating the molecular mechanisms underlying their pharmacological properties, enhancing bioavailability, and conducting clinical trials to validate their therapeutic effects.

1. Introduction

Momordica species belonging to the Cucurbitaceae family. These plants are medium in size and grow abundantly in warmer regions. *Momordica* species are perennial crops that can be considered to have consistent performance throughout the growing season. This is typically distributed across India, Pakistan, and Bangladesh, and it also stretches from the Himalayas to Sri Lanka. These plants are noted for their bitter taste caused by phytochemicals (alkaloids) and have numerous medicinal benefits. Experts believe that bitter melon domestication occurred in Eastern Asia, most likely in Eastern India or Southern China, but the particular origin remains uncertain (Walters and Decker-Walters, 1988). Some African countries eat the fruits, leafy shoots, and ripe seeds of these *Momordica* species as vegetables, spices, and beverages. South African indigenous people used *Momordica* species to increase the bitterness of meat and vegetables (Cantwell *et al.*, 1996). The *Momordica* species are open-pollinated types, having separate male and female blooms on the same plant. *Momordica* species begin flowering a month after planting and continue till dormancy. When ripe, the fruits are orange and velvety, and contain black seeds (Bakare *et al.*, 2010). Studies on rural food

consumption in developing countries have been centered on economic factors which might include pricing, income, and market development (Jia *et al.*, 2017), with little attention given to social and psychological aspects. Because of the increasing interest in medicinal plants worldwide, the global market is increasing at a rate of 7-15% annually, and the study of innovative drugs derived from natural materials continues to be regarded as essential despite the tremendous advances in contemporary medicine. Medicinal plants are currently the subject of scientific investigation as a possible therapeutic intervention.

2. Momordica species description

Four *Momordica* species, viz., *Momordica dioica* Roxb., *Momordica charantia* L., *Momordica balsamina* L. and *Momordica foetida* Schumach. are examined in this review for their nutritional, biochemical, and pharmacological characteristics as possible sources of naturally occurring bioactive compounds for use in pharmaceutical applications in the future. Therefore, providing baseline data for the evaluation of the nutritional, nutraceutical, and phytomedicinal bioactivities of *Momordica* species on human health is the main objective of this work.

M. dioica commonly known as spine gourd, is a small, spiny fruit bearing vine belonging to the Cucurbitaceae family. It is widely consumed as a vegetable due to its palatable taste and manageable size. Nutritionally, the plant is rich in vitamins A and C, iron, calcium, and dietary fibre, offering substantial health benefits. *M. dioica* flowers between June and July and fruits from September to November. The fruit is traditionally used in Indian System of Medicine across Asia and Africa, various parts of *M. dioica* including

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roots, leaves, and fruits are utilized to treat ailments such as fever, jaundice, asthma, and gastrointestinal disorders. Its dioecious nature requires both male and female plants for successful fruit production, which is important in cultivation practices (Jatale *et al.*, 2024). *M. dioica* also shows promising antimicrobial activity and is considered a sustainable, underutilized food source that contributes to food security, especially in tribal and rural communities. As modern science continues to explore plant-based medicines, *M. dioica* holds considerable pharmacological potential in managing lifestyle-related diseases and developing nutraceuticals.

M. charantia is known as bitter melon, is the most widely grown vegetable in the *Momordica* genus. It is recognized for its characteristic bitter flavor, which is caused by cucurbitane-type triterpenoids (Chen *et al.*, 2005). Bitter melon fruits have high levels of vitamin C, iron and antioxidants (Behera *et al.*, 2010; Krawinkel *et al.*, 2018; Tan *et al.*, 2008). Both ripe and unripe melons are commonly used in traditional medicine, it is used to cure stomach aches, anaemia, malaria, cough, and fever. In addition, it is a popular source of antidiabetic properties in the pharmaceutical business. Bitter melon's antioxidant profile makes it effective for treating cancer, hair, and skin concerns. Improves blood circulation and promotes overall wellness. This supplement is great for respiratory health due to its antihistamine, anti-inflammatory, expectorant, suppressant, and antiviral properties. It enhances liver enzymes and benefits bladder and intestinal function (Chitra *et al.*, 2024). The restricted genetic variety in natural bitter melon populations has inhibited crop improvement and varietal development, despite its biological and economic relevance (Dhillon *et al.*, 2016). Bitter melon, a tropical and subtropical crop, is susceptible to several biotic and abiotic stressors. To overcome obstacles, numerous genetic resources are vital for producing high-yielding and resilient bitter melon variations (Cui *et al.*, 2020). Grafting is an alternate tool to tackle soil and foliar diseases adopted in several crops. Cucumbers grafted on four cucurbit rootstocks (ridge melon, bitter melon, pumpkin, and bottle melon) began flowering on the 33rd day for bottle melon, luffa, and bitter melon, and on the 34th day for pumpkin using the splice grafting technique. The hole insertion grafting method required the greatest number of days for flowering. Kalaam F1, a non-grafted cucumber variety, produced blooms 60 days after seeding. According to Tamil Selvi and Pugalendi (2017), grafted bitter melons produce more female blooms and less male flowers than non-grafted plants (Pranitha *et al.*, 2024). These phytochemicals can be included in food products or supplements and used as nutraceuticals. *Momordica* species green fruits and leaves provide significant nutritional and nutraceutical benefits for human health. The study highlights *Momordica* species as a valuable source of nutritional and bioactive substances. Furthermore, this study supports the inclusion of these wild species in the primary food stream of the local population, which improves their nutritional status.

M. balsamina is known as balsam apple and it is a wild plant from the *Momordica* genus is referred to as African pumpkin, Southern balsam pear, or balsam apple (Bharathi and John, 2013). It grows best as a trailing plant in hot and humid situations and loves acidic soil (pH 5.0-6.5). Its life cycle ranges from annual to perennial. *M. balsamina* is a healthy vegetable, particularly the immature fruits, that are widely consumed in Sub-Saharan Africa. Furthermore, it has been utilized in traditional medicine, particularly in African nations (Thakur *et al.*, 2009). Medicinal plants are the primary source of life-saving medications for the majority of the global population.

Biotechnological methods are essential for selecting, multiplying, and conserving critical genotypes of medicinal plants. *M. balsamina* is a beneficial herb for nutraceutical use. The leaves are a valuable source of nutrition, containing 17 amino acids (Hassan and Umar, 2006). Adequate mineral composition, including potassium, magnesium, phosphorus, calcium, zinc, manganese, and iron, helps address micronutrient deficits in humans. It also has high levels of protein and fat with minimal fibre content. Momordins found in the plant can suppress the growth of HIV and other viruses. These fruit and leaf extracts of plants have antiparasitic properties and are used in traditional African medicine to treat malaria. Antiviral, anti-inflammatory, shigellocidal, antidiarrheal, antiseptic, antibacterial, and antimicrobial properties are all exhibited by the plant extract. Extracts from *M. balsamina* have been demonstrated to exhibit hypoglycemic and antibacterial qualities in addition to antidiarrheal effects in rats (Van de Venter *et al.*, 2008).

M. foetida is known as sweet snake fruit. A climbing perennial herb that was originated in tropical Africa and is now found globally, particularly in Southern Africa. In these areas, it is often used as medicine however, due to its unpleasant taste, it is frequently taken as a vegetable during famines (Olaniyi, 1975). The plant grows naturally, and it is rarely farmed for medicinal purposes. However, it has been used ethnobotanically to fatten rabbits and to identify suitable cocoa fields (Bosch, 2004). The plant has been cited in ethnobotanical surveys, triggering several investigations on phytochemical screening, and plasmodial, and antidiabetic activity. This study attempts to analyze known scientific literature and identify knowledge gaps to drive future research on the pharmacology, toxicity, and validity of unproven ethnobotanical claims. *M. foetida* is noteworthy in ethnobotany, however, this is the first scientific review of the species. Previous studies concentrated on the medicinal qualities of the Cucurbitaceae family.

3. Characteristics of *Momordica* species

Crop wild relatives are an essential resource made up of wild plant species that are closely related to farmed crops, producing a rich reservoir of genetic characteristics and variation. These relatives have enormous potential for improving cultivated varieties resilience, output, and adaptation, specifically in the face of environmental challenges like climate change, pests, and diseases. Among these, wild *Momordica* species stand out for their exceptional medicinal benefits. *Momordica* species include *Momordica dioica* Roxb., *Momordica charantia* L., *Momordica balsamina* L. and *Momordica foetida* Schumach. These plants, which live in a variety of ecological situations, have diverse phytochemical profiles and bioactive compounds, making them promising candidates for agronomic enhancement and medical applications.

4. Nutritional values

Momordica species are known for their nutritional benefits. These plants are rich in vitamins, particularly vitamin C, and contain essential minerals like potassium and magnesium. They also provide dietary fibre, antioxidants, and compounds with anti-inflammatory and antidiabetic properties. These fruits and vegetables are often used for their medicinal qualities in traditional medicine. The most commonly taken part of the plant is the ripe green fruit of the *Momordica* species, their delicate leaves, on the other hand, can be

cooked as a leafy vegetable and serve as a significant nutritional source. These verdant fruits and leaves are high in carbohydrates,

protein, minerals, and vitamins. The crop is commercially grown for both nutritional and therapeutic uses.

Table 1: Botanical description of *Momordica* species

Botanical name	Botanical description	References
<i>Momordica dioica</i> Roxb.	It is known as a spine gourd. Climbing plants have tuberous roots and simple tendrils. Flowers are dioecious, solitary, and located on the axilla. Leaves are broadly oval, strongly lobed, cordate base, denticulate edge, sharp, membranous apex, and petiole up to 2.5 cm long.	Bawara <i>et al.</i> , 2010
<i>Momordica charantia</i> L.	It is known as bitter melon, the plant is a monoecious, slender, tendril-climbing annual vine that reaches a height. Leaves have serrate borders that give the appearance of bites.	Matsumura and Urasaki, 2020
<i>Momordica balsamina</i> L.	It is known as the balsam apple, an annual herbaceous, monoecious climbing plant with glabrous or moderately hairy stems up to 4 to 5 meters long and tendrils for attachment to adjacent vegetation. It grows at altitudes of 0 to 1293 meters. These cucurbit-family plants are native to tropical and subtropical areas of Asia, Australia, and Africa.	Thiaw <i>et al.</i> , 2023
<i>Momordica foetida</i> Schumach.	It is otherwise called as sweet snake fruit: The plant is a perennial climbing herb with beautiful blossoms. The petals centers are usually orange or crimson, with creamy areas surrounding them. The fruits have soft spines around 900 mm long and 40 mm wide, often bright orange in color and spherical.	Aguoru and Okoli, 2008

Table 2: Mineral content of *Momordica* fruit

Composition	<i>Momordica dioica</i> Roxb.	<i>Momordica charantia</i> L.	<i>Momordica balsamina</i> L.	<i>Momordica foetida</i> Schumach.
Moisture %	84.1	93.20	71.00	94.05
Ash %	6.7	7.36	18.00	0.79
Lipids %	4.7	6.11	2.66	0.81
Fiber %	21.3	13.60	29.00	2.19
Protein %	19.38	27.88	11.29	1.20
Carbohydrate %	47.92	34.31	39.05	-
Energy kcal/100 g	311.5	241.66	189.22	19
Calcium mg/100 g	33	20	941	2.35
Magnesium mg/100 g	-	-	220	0.64
Sodium mg/100 g	1.51	2.40	122.49	-
Potassium mg/100 g	8.25	171.00	1320.00	0.84
Iron mg/100 g	4.6	1.8	60.3	1.04
Zinc mg/100 g	-	-	3.18	-
Manganese mg/100 g	-	0.08	11.6	-
Copper mg/100 g	-	0.19	5.44	-
Phosphorus mg/100 g	42	70	130.46	-
Vitamin-C mg/100 g	-	96	-	-

(Behera *et al.*, 2010).

5. Bioactive compounds of *Momordica* species

Momordica species have exceptional therapeutic potential due to their various pharmacological actions, including antidiabetic, antioxidant, anti-inflammatory, antibacterial, and anticancer characteristics, all linked to their extensive phytochemical and bioactive component profile. Natural bioactive chemicals are chemical substances that interact with live organisms, tissues, or cells. They can be found in many different animals, including mammals, plants,

and microorganisms. These molecules are not essential vitamins or minerals, but they are necessary for good health and the prevention of chronic diseases. Flavonoids, also alkaloids, and triterpenoids are all bioactive substances found in plants, particularly medicinal species like *Momordica*. Their biological actions include antioxidant, antidiabetic, antibacterial, and anti-inflammatory properties. Understanding these chemicals is critical to maximizing the medicinal benefits of traditional herbs.

5.1 *Momordica dioica* Roxb.

M. dioica a dioeciously climbing plant is classified within the Cucurbitaceae family. It contains a variety of phytochemicals, including steroids, triphenoids, urisolic acid, thiamine, riboflavin, and niacin. Momordicin is a phytochemical alkaloid found in the seed, whilst *M. foetida* can be found in the roots. The factory contains phytochemicals including lectins, triterpenes, proteins, and vitamins. *M. dioica* fruit has a high vitamin C content. They also have alkaloids, flavonoids, glycosides, and amino acids. The fruit contains 84 humidity, 7.7 g carbohydrates, 3.1 g protein, 3.1 g fat, 3.0 g fibre, and 1.1 g minerals. It contains many vitamins such as ascorbic acid, carotene, thiamine, riboflavin, and niacin (Singh, 2004). The study found that ethanolic extract had the highest inhibition (84.2%) in DPPH-free revolutionary scavenging, followed by waterless (74.8), ethyl acetate (69.4), and chloroform (59.7) extracts. The presence of phenolics, flavonoids, and amino acids in ethanol extract results in 80.1 inhibition of total antioxidant activity, followed by waterless (71.9), ethyl acetate (67.2), and chloroform (53.2) extracts. Blood urea and serum creatinine levels were evaluated to identify nephrotoxicity markers. Apkins detected reduced glutathione and the result of lipid peroxidation as well (Jain and Singhai, 2010). Cisplatin treatment led to considerable weight loss and raised urea and creatinine levels. Prize administration has significantly improved biochemical recovery in both restorative and defensive groups. Ilango *et al.* (2012) investigated the antibacterial activity of a methanolic extract from *M. dioica* fruit pulp *in vitro*. The study found secondary metabolites such as steroids, adipose acids, proteins, saponin, glycosides, and triterpenes in hexane extracts and ethyl acetate. Methanolic extracts were highly effective against *Salmonella typhi* and *Shigella dysenteriae* at concentrations ranging from 100 to 500 µg/ml. Mishra *et al.* (2006) used *M. dioica* seed oil as a germicide and found it effective against insects, resulting in up to 100 mortalities at 4 exposures in 24 h. The lower attention threshold of 2 was beneficial, but for 100 mortalities, a longer time was required. The presence of the alkaloid momordicin in oil painting was thought to be the cause. Fruits contain residues of alkaloids and ascorbic acid, as well as lectins, β-sitosterol, saponin, glycosides, triterpenes of ursolic acids, hederagenin, oleanolic acids, α-spiranosterol, stearic acid, and gypsogenin, two unique aliphatic components.

5.2 *Momordica charantia* L.

M. charantia contains numerous primary metabolites, including carbohydrates, fiber, proteins, minerals, and vitamins. *M. charantia* contains a variety of chemical constituents, including heteropolysaccharides (*e.g.*, arabinose, galactose, glucose, mannose, and rhamnose) proteins, and peptides (*e.g.*, momordins, momorcharins) terpenoids and saponins (*e.g.*, cucurbitane and cucurbitacin's), flavonoids, and phenolic compounds (Yoshime *et al.*, 2016). *M. charantia* contains triterpenes, protein, steroids, alkaloid compounds, lipids (the lauric, mydriatic, palmitic, stearic, linoleic, and eleostearic acid), phenolic compounds, and minerals (Cu, Fe, Mg, Zn, and Ca). *M. charantia* leaves and flowers include triterpenoids (momordicin and charantin), carotenoids (antheraxanthin, lutein, violaxanthin, α-carotene, and β-carotene), and phenylpropanoids caffeic acid, chlorogenic acid, epicatechin, gallic acid, p-coumaric acid, rutin, and trans-cinnamic acid (Sathasivam *et al.*, 2021). *M. charantia* fruits contain around 93.2% water, with protein and fat content ranging from 18.02 to 0.76%. The fruit pulp of *M. charantia* contains soluble pectin and

galacturonic acid. The fruits contain glycosides, saponins, alkaloids, reducing sugars, resins, phenolic compounds, fixed oil, and free acids (Bakare *et al.*, 2010). *M. charantia* green fruits include vitamins A, C, and P and minerals like thiamine, riboflavin, and niacin. The essential oil extracted from water-stressed seeds contains sesquiterpenes, phenylpropanoids, and monoterpenes, whereas seed oil contains tocopherols and polyphenols. Phenolic chemicals distributed throughout the crop defend against oxidative damage (Yoshime *et al.*, 2016; Wardani *et al.*, 2021). *M. charantia* contains several phenolic acids, including gallic, chlorogenic, catechin, caffeic, p-coumaric, and ferulic acids. The fruit of *M. charantia* contains several compounds, including capsanthin, lutein, also zeaxanthin, β-cryptoxanthin, vitamin C, α-carotene, and β-carotene (Lee *et al.*, 2017). *M. charantia* fruits antioxidant properties are strongly correlated with its phenolic acid and carotenoid content at different stages of maturity. The crop contains non-essential amino acids, including arginine, alanine, aspartic acid, glycine, glutamic acid, proline, histidine, and serine. Non-essential amino acids have larger concentrations compared to essential amino acids like leucine, also cysteine, a substance called isoleucine, methionine as lysine, threonine, tyrosine, and valine. *M. charantia* leaves contain primarily leucine and aromatic amino acids (tyrosine and phenylalanine), with aspartic acid and glutamic acid being the main non-essential amino acids (Khanna, 2004).

5.3 *Momordica balsamina* L.

M. balsamina leaves, fruits, seeds, and bark include secondary metabolites such as alkaloids, flavonoids, glycosides, steroids, terpenes, cardiac glycosides, saponins, tannins, and lectins. The principal metabolites are crude lipids (2.66%), common sugars, and protein. It contains 11.29% crude fiber, 29% calories, amino acids, carbohydrates, and 39% chlorophyll (Abegunde *et al.*, 2018). The leaves are a rich source of nutrition, including 17 amino acids and appropriate mineral content. *M. balsamina* is high in potassium, calcium, magnesium, sodium, phosphorus, manganese, zinc, and iron, which help prevent micronutrient deficits in humans (Nitu and Patidar, 2017). The vegetable of *M. balsamina* includes significant amounts of saponins, steroid rings, and carbohydrates. Alkaloids, tannins, flavonoids, glycosides, steroids, and terpenes are also found, albeit in lesser amounts. The plant's distinctive components, including pseudoalkaloid, contain a variety of phenolic acids, including quinic and chlorogenic acids. For the first time, *M. balsamina* has been found to contain isocitric feruloyl acids. Common flavonoids including kaempferol, quercetin, and isorhamnetin have different glycoside forms. *In vitro* and *in vivo*, flavonoids exhibit several biological activities, including anti-inflammatory, antioxidant, antidiabetic, and antimalarial properties (Mashiane *et al.*, 2022).

5.4 *Momordica foetida* Schumach.

M. foetida has been used in ethnomedicine to treat various diseases. The plant's chemical properties have been linked to its ability to cure diseases, leading to various phytochemical studies. Early attempts to determine the chemical contents of *M. foetida* revealed the presence of alkaloids and glycosides. Research on *M. foetida* found a variety of phytochemicals, including steroids, saponins, reducing sugar, cardiac glycosides, phenolics, terpenes, and flavonoids (Olaniyi, 1975). Another analysis found the following substances: alkaloid compounds, carbohydrates (starches and cellulose), cardio glycoside, flavonoids, terpenoids that the saponins tannins, steroids,

and sterols. *M. foetida* ethnomedicinal use could be confirmed by its phytochemicals, which have been connected to sickness treatment, including saponins having antidiabetic activity (Madala *et al.*, 2016). (Froelich *et al.*, 2007) Three substances were recovered from the methanolic extract of the whole plant: stigmasterol-1- β -D-glucoside, sitosterol glycoside, 5,25-stigmastadien-3 β -glucoside, and 1- β -hydroxyfriedel-6(7)-en-3-one. Cucurbitane triterpenoids were extracted from the chloroform extract of the leaf. The methanolic leaf extract was chromatographed and revealed the presence of six compounds: 5,7,4-trihydroxy flavanone-7-O-D-glucopyranoside, 5,7,3,4-tetrahydroxy-flavanone-7-O- β -D-glucopyranoside, and 5,7-dihydroxychromone-7-O- β -D-glucopyrano.

6. Phytomedicinal and pharmacological activities of *Momordica* species

Phytosterol, cucurbitane, triterpenoids, carotenoids, flavonoids, and phenolic acids are the major bioactive compounds found in *Momordica* plants. The health advantages of phytochemicals found in *Momordica* species, especially those with potent antidiabetic, antitumor, and antioxidant potential, have been emphasized by recent studies. *Momordica in vitro* research revealed evidence for the biological efficacy of particular components, such as the presence of phenolic compounds, carotenoids, and triterpenoids in *Momordica* species. The main components of the family Cucurbitaceae are triterpenoids.

6.1 *Momordica dioica* Roxb.

M. dioica as commonly known as spine gourd, is a rich source of vitamin C and iodine. The human body to cure disease in traditional medicine. The plant has medicinal properties for treating eye disorders, fever, snake bites, and lizard irritation, as well as diabetes (Khare, 2004; Kirtikar and Basu, 1935). Pharmacological studies have highlighted a source of various therapeutic compounds such as neuroprotective activity, antiallergic, antiedemic, antifertility, antimicrobial, and antimalarial effects. While studying the spermatogenic effects of an ethanolic extract of the fruit of *M. dioica* on animals, behavioural observations revealed sedative action. There is limited research on the plant's pharmacological and other effects. *M. dioica* root juice has immune-stimulant and antimicrobial properties. Its fruits are utilized as vegetables (Sadyojatha and Vaidya, 1996). The nephroprotective efficacy of *M. dioica* fruit extract (200 mg/kg) was examined by Jain and Singhai (2010) who reported that it contains 74.8% of aqueous, 69.4% ethyl acetate, and 59.7% of

chloroform extracts and were shown to inhibit DPPH free radicals less than the ethanolic extract (84.2%). Ethanol extract reduced total antioxidant activity by 80.1% due to the presence of amino acids, flavonoids, and phenolics. Then came aqueous (71.9%), ethyl acetate (67.2%), and chloroform (53.2%) extracts. Blood urea and serum creatinine levels were investigated as biochemical indicators of nephrotoxicity. Kidney tissues have lower quantities of glutathione and lipid peroxidation products. Cisplatin dramatically decreased body weight with a single dose while raising creatinine and urea levels. The *in vitro* antibacterial activity of a methanolic extract of *M. dioica* fruit pulp was examined by (Ilango *et al.*, 2012). They found that the primary effective secondary metabolites against *Shigella dysenteriae* and *Salmonella typhi* were steroids, fatty acids in proteins and hexane extract, saponin glycosides, and triterpenes in the ethyl acetate soluble portion of methanolic extract, at concentrations of 100 to 500 μ g/ml. For many ailments, *M. dioica* roots are quite helpful. Abortifacane and spermicidal are among the several drugs it contains. Additionally, bleeding piles and urinary tract infections are commonly treated with it (Satyavati *et al.*, 1987). When compared to standard medication, the soluble fraction and extract of the methanolic extract of *M. dioica* fruit pulp demonstrated analgesic effectiveness, according to (Ilango *et al.*, 2012). When compared to the vehicle-treated control group, petroleum ether, ethyl acetate, and methanol extracts demonstrated notable analgesic effects in acetic acid-induced writhing syndrome. However, methanol and ether extracts demonstrated stronger analgesic effects than ethyl acetate extract (Rakh and Chaudhari, 2010). Its hepatoprotective activity may be due to the phytoconstituents of *M. dioica*, which include traces of alkaloids, lectin, β -sitosterol, saponin, glycosides, triterpenoid, long chain aliphatic hydrocarbons, tannins, and fixed oil. Lipid peroxide formation is inhibited and AST, ALT, lipid peroxide, and total serum bilirubin levels are significantly reduced when total antioxidant levels rise. Oxidative stress has an important role in the pathogenesis of many clinical conditions, such as cardiovascular dysfunction, atherosclerosis, inflammation, carcinogenesis, drug toxicity, reperfusion injury, and neurodegenerative diseases. The bioactive compound found in *M. dioica* is furnished in Table 3. The human body enzymatic and nonenzymatic antioxidant systems are two of its many defenses against the harm that reactive oxygen species can cause. Flavonoids and phenolic substances were detected in the methanolic extract of *M. dioica*. Additionally, the radical produces the compound to cure the disease of the blood urea, glutathione, lipid peroxidation, and serum creatinine were analyzed as biochemical markers of the nephrotoxicity activity of the plants.

Table 3: Phytomedicinal properties present in *Momordica dioica* Roxb.

Pharmacological properties	Compounds	References
Anticancer and antimicrobial	α -spinasterol octadecenoate	Luo <i>et al.</i> , 1998
	α -spinasterol-3-O- β -D-glucopyranoside	Luo <i>et al.</i> , 1998
Analgesic	Oleanolic acid	Luo <i>et al.</i> , 1997
	Gypsogenin	Luo <i>et al.</i> , 1997
	Hederagenin	Luo <i>et al.</i> , 1997
Antiallergic	3 β -O-benzoyl-6-oxo-ursolic acid	Luo <i>et al.</i> , 1997
	3 β -O-benzoyl-11-oxo-ursolic acid	Luo <i>et al.</i> , 1997
	3-O- β -D-glucopyranosylhederagenin	Luo <i>et al.</i> , 1998
	3-O- β -D-glucopyranosylgypsogenin	Luo <i>et al.</i> , 1998
	3-O- β -D-glucuronopyranosylgypsogenin	Luo <i>et al.</i> , 1998

6.2 *Momordica charantia* L.

M. charantia has therapeutic properties and is also consumed as a vegetable. The primary chemical ingredients include sterols, triterpenes, and bioactive protein, as well as a lectin with insulin like activity. It contains substances with antidiabetic, anticancer, antitumor, antimicrobial, antiviral, antihelminthic, antimalarial, antiulcerative, and immunomodulatory characteristics (Gupta *et al.*, 2011; Kulkarni *et al.*, 2021; Malik *et al.*, 2021). The bioactive compound found in *M. charantia* is furnished in Table 5. According to a phytochemical with hypoglycemic properties, may help treat diabetes and jaundice (Prabhakar, 2022). The fruit juice and leaf tea have been used as an emmenagogue and to cure fevers, worms and parasites, wounds, infections, diabetes, colic, and malaria. Fruit extracts from *M. charantia* reduce the risk of cancer by having chemoprotective qualities and antioxidants (Dzotam *et al.*, 2016; Khalid *et al.*, 2021). *M. charantia* leaves are used to prevent parasites and worms and to treat wounds. China, India, Africa, and the Southeast United States have all used *M. charantia* for traditional medical uses (Grover and Yadav, 2004). *M. charantia* seeds were analyzed as a possible method of birth control in China in the 1980s (Kumar *et al.*, 2010). Antidiabetic, anthelmintic, abortifacient, antibacterial, antiviral, hypoglycemia, and chemopreventive qualities have all been demonstrated for *M. charantia*. *M. charantia* fruits and

leaves have biological properties such as antidiabetic, antirheumatic, antiulcer, anti-inflammatory, and antitumor (Dzotam *et al.*, 2016). *M. charantia* includes compounds with hypoglycemic properties that reduce blood sugar levels, promote hunger, and aid digestion. *M. charantia* is used to treat digestive issues (Ludidi *et al.*, 2019). *M. charantia* is a popular herbal remedy for lowering blood glucose and treating diabetes (Birla, 2016; Leung *et al.*, 2009). *M. charantia* has shown hypoglycemic properties in type 2 diabetes patients. Research indicates that *M. charantia* can reduce serum cholesterol, hepatic total cholesterol, triglycerides, and elevated cholesterol levels (Chen *et al.*, 2003; Tan *et al.*, 2008). The studies revealed that the juice of *M. charantia* reduces lipid accumulation and increases lipolysis in human adipocytes (Ingle *et al.*, 2017; Tan *et al.*, 2015). *M. charantia* juice has been shown in animal tests to reduce body weight by blocking lipogenic genes and raising plasma catecholamine levels (Nerurkar *et al.*, 2010). Asthma, skin infections, malignancies, and hypertension have all been treated using the ripe fruit of *M. charantia* (Semenya and Potgieter, 2015). The seeds are surrounded by a sweet red fleshy pulp that tastes similar to watermelon (Poyraz and Gumus, 2016). In certain regions of West Africa, postpartum women are given *M. charantia* leaves as part of a green vegetable soup to help purify breast milk and stop blood loss during childbirth. Nonetheless, *M. charantia* may be suggested as a protein supplement for animal feed (Kuetze *et al.*, 2010).

Table 4: Phytochemical properties present in *Momordica charantia* L. leaf extract

Pharmacological properties	Compounds	References
Anti-inflammatory and anticancer	Momordicoside F2	Cao <i>et al.</i> , 2018; Ju <i>et al.</i> , 2004
Anticancer	Goyaglycoside B	Cao <i>et al.</i> , 2018; Raina <i>et al.</i> , 2016
Antiageing	Karaviloside III	Cao <i>et al.</i> , 2018
Antiageing	Charantoside VI	Cao <i>et al.</i> , 2018
Antiageing	Charantagenin E	Cao <i>et al.</i> , 2018
Antiageing	Charantoside II	Cao <i>et al.</i> , 2018
	Momordicoside F2	Cao <i>et al.</i> , 2018
	Goyaglycoside D	Cao <i>et al.</i> , 2018; Wang <i>et al.</i> , 2012
	Stigmasterol glucoside	Desai and Tatke, 2015; Kangsamaksin <i>et al.</i> , 2017
	(19R)-7 β ,19-epoxy-19-methoxycucurbita-5,24-dien-3 β ,23-diol	Cao <i>et al.</i> , 2018; Jiang <i>et al.</i> , 2016
	Kuguacin J	Limtrakul <i>et al.</i> , 2013

6.3 *Momordica balsamina* L.

M. balsamina is one of the most significant medicinal plants since it is widely utilized to make life-saving medications. *M. balsamina* often called balsam apple, Southern balsam pear, or African pumpkin, is a wild plant of the *Momordica* genus (Bharathi and John, 2013). It is a healthy vegetable, particularly the immature fruits, that are widely consumed in Sub-Saharan Africa. Furthermore, it has been utilized in traditional medicine, particularly in African nations (Thakur *et al.*, 2009). Exploration of *M. balsamina* pharmacological compounds present in anticancer, antidiabetic, antioxidant, and antimicrobial potential can reveal various bioactive compounds. Although, the crop's high potassium content is known to promote hypertension and other cardiovascular illnesses, in rural areas, it can be eaten as a vegetable to supplement meals with protein and potassium (Souida *et al.*, 2018). Due to its potent scent, *M. balsamina* fruit is used as a lotion and mixed with almond and olive oils to cure hemorrhoids, bandages, and chapped hands (Mada *et al.*, 2013). Fruit pulp from

M. balsamina is mixed with oil and used as an antiphlogistic treatment in West Africa. *M. balsamina* mashed fruit is used as a bitter tonic and poultice (Semenya and Potgieter, 2015). The herb *M. balsamina* is used as medicine to cure yaws and fevers. Nonetheless, leaves have been utilized as tea by Tsonga and Zulus to treat intestinal, stomach, and blood-liver disorders (Kumar *et al.*, 2010). The leaves are used for herbal medicine and as a culinary herb, the Portuguese suggested *M. balsamina* leaves for liver, stomach, and blood deficiencies (Madala *et al.*, 2014). The leaves of *M. balsamina* are used to treat mild forms of malaria, fevers, ulcers, diabetes, and digestive disorders. Furthermore, *M. balsamina* is used as medicine in West Africa; namely, for fever, yaws, and purgatives in both humans and animals (Mostafa *et al.*, 2018; Oloyede and Aluko, 2012). The roots of *M. balsamina* are used to treat urethral discharge in both humans and animals, as well as an ingredient in an aphrodisiac concoction. It is recommended to utilize all plant parts of

M. balsamina when treating skin conditions like scabies (Ozusaglam and Karakoca, 2013; Pauliuc and Botau, 2013; Waako *et al.*, 2005; Wikaningtyas and Sukandar, 2016). The bioactive compound found in *M. balsamina* is furnished in Table 4 because African pumpkin seed protein extract contains sugars like lactose and D-galactose, it has a hemagglutinating effect (Bulbul, 2016). Prior studies in both

humans and animals have demonstrated that the O blood type has greater hemagglutinating activity than other blood cell types in rats, the leaves and the fruits are both haemolytic and hepatotoxic, but in large amounts, they are toxic to various organs and tissues (Semenya and Potgieter, 2015). Determining the ideal dosage is essential to maximizing its potential as a medicinal herb.

Table 5: Phytomedicinal properties present in *Momordica balsamina* L. leaf extract

Pharmacological properties	Compounds	References
Antidiabetic	Cucurbitane glycoside	Farooq <i>et al.</i> , 2019
Anticancer	Kuguacin J	Spengler <i>et al.</i> , 2009
Anticancer	Karavilagenin C	Ma <i>et al.</i> , 2012
Anticancer	Balsaminagenin A	Ramalhete <i>et al.</i> , 2009
Anticancer	Balsaminoside B	Ma <i>et al.</i> , 2012
	Balsaminol F	Ramalhete <i>et al.</i> , 2016; Ramalhete <i>et al.</i> , 2011
Antiviral	Momordin I	Thakur <i>et al.</i> , 2009
	Momordin II	Thakur <i>et al.</i> , 2009
Antimalarial	Balsaminapentaol	Ma <i>et al.</i> , 2012; Ramalhete <i>et al.</i> , 2009
Antiparasitic	Cucurbalsaminol	Ma <i>et al.</i> , 2012; Shoaib <i>et al.</i> , 2014

6.4 *Momordica foetida* Schumach.

Many of the traditional therapeutic uses are similar to those of other *Momordica* species. In East and Central Africa, *M. foetida* preparations are used to treat diabetes, peptic ulcers, and hypertension. In albino rats that are fasting, a fetid that was isolated from *M. foetida* can lower blood glucose levels (Marquis *et al.*, 1977). Similarly, because of its hypoglycemic action, which lowers blood sugar levels while also promoting appetite and aiding in the full digestive process, *M. foetida* is used to treat digestive issues (Daniel *et al.*, 2014). The bioactive compound found in *M. foetida* is furnished in Table 6. The high concentration of phenolic and flavonoid components in *M. foetida* aqueous extract possesses antioxidant properties (Acquaviva *et al.*, 2013). Numerous illnesses, including diabetes, rheumatoid arthritis, Alzheimer's and Parkinson's disease, and others, are strongly linked to oxidative stress. Antioxidants have

been used pharmacologically to treat neurodegenerative disorders and stroke, cough, digestive issues, headaches, earaches, toothaches, and snake bites can all be treated with *M. foetida* juice, dried leaves, and crushed leaves (Jabeen and Khanum, 2017). The dried or cooked leaves can be used to cure malaria, cobra poisoning, and skin issues. *M. foetida*'s roots are toxic, and East Africans use the crushed seeds to treat constipation. *M. foetida* promotes weight loss in obese individuals. In Tanzania, the fruit pulp of *M. foetida* is used as a possible insect repellent because it is believed to be toxic to common pests like ants, moths, and weevils. According to Pinar *et al.* (1983) and Pirillo *et al.* (1995), momordocin which was isolated from *M. foetida*, exhibits insecticidal properties. In Uganda, the whole *M. foetida* plant is applied to animals to ward against ox peckers. In Gabon, cushions are stuffed with soaked and dried *M. foetida* leaves for commercial usage. Because *M. foetida* is a good source of protein, cattle prefer to graze it (Talukdar and Hossain, 2014).

Table 6: Phytomedicinal properties present in *Momordica foetida* Schumach. leaf extract

Pharmacological properties	Compounds	References
Lowers blood pressure and inflammation	Quercetin alone-glycoside	Dabeek and Marra, 2019; Khoza <i>et al.</i> , 2016
	Quercetinacetyl-glycoside	Khoza <i>et al.</i> , 2016
Antitumor, antioxidant and anti-inflammatory	Quercetin glycoside	Khoza <i>et al.</i> , 2016
	Quercetin diglycoside	Khoza <i>et al.</i> , 2016
	Kaempferol malonyl-glycoside	Khoza <i>et al.</i> , 2016
	Kaempferol acetyl-glycoside	Abegunde <i>et al.</i> , 2018
	Isorhamnetin acetyl-glycoside	Kandakumar and Manju, 2017
	Isorhamnetin glycoside	Kandakumar and Manju, 2017
	Kaempferol glycoside	Khoza <i>et al.</i> , 2016
	Kaempferol diglycoside	Abegunde <i>et al.</i> , 2018

7. Conclusion

The *Momordica* genus comprises species such as *Momordica dioica* Roxb., *Momordica charantia* L., *Momordica balsamina* L., and *Momordica foetida* Schumach. Represents a valuable group of plants with significant nutritional, medicinal, and therapeutic potential. Bioactive substances such as alkaloids, flavonoids, saponins, terpenes, and minerals are abundant in this *Momordica* species. Their wide range of biochemical characteristics results in several health advantages. They exhibit promising anti-inflammatory, anticancer, antimicrobial, antidiabetic, and antioxidant properties. Many naturally occurring bioactive compounds, resins, alkaloids, flavonoids, glycosides, steroids, terpenes, cardiac glycosides, saponins, pectin, carbohydrates, fatty acids, amino acids, fiber, chlorophyll, phosphorus, calcium, potassium, magnesium, salt, zinc, manganese, and iron are present in these species. With their antimicrobial, antiparasitic, and antiulcer properties, *Momordica* spp. can also cure gastrointestinal disorders. They also contain biochemicals that have anticancer properties. They have traditionally been used to treat a variety of illnesses, ranging from digestive problems and skin disorders to more serious conditions including diabetes, cancer, and high blood pressure. Clinical research provides evidence that these herbs can be used to cure a variety of ailments. Conventional applications in polyherbal medicine indicate synergistic effects, particularly in the treatment of malaria with *M. foetida*. The presence of ribosome inactivating proteins (RIPs) in *Mordica balsamina* may make it useful for HIV/AIDS treatment. The species are becoming more popular as natural and affordable substitutes for allopathic therapies, particularly in places with low resources or in rural areas. To validate and maximize medical usage, standardization, and more thorough biochemical analysis are required. Additional research on mechanisms of action, root systems, and human clinical trials is necessary. Compared to cultivated variety, wild species have a higher phytoconstituent diversity but receive less investigation. Complex chemical compounds often require high concentrations to exhibit biological activity. It is challenging to identify precise bioactive chemicals due to a lack of comprehensive compositional analysis. To ensure consistent therapeutic efficacy, extracts must be standardized. With the growing need for natural and affordable healthcare options worldwide.

Momordica species are particularly attractive prospects for the development of functional foods, medications, and nutraceuticals. By increasing the commercial potential of these underutilized crops, further study and investment in this genus will benefit rural and agricultural populations in addition to aiding in drug development and public health. Furthermore, antioxidants possess anti-aging and neuroprotective capabilities. *Momordica* species is also reported to have hypoglycemic, cardioprotective, and antihypertensive properties according to clinical research, these herbs may be used to treat several conditions, such as eczema, dysmenorrhea, gout, jaundice, kidney stones, leprosy, leucorrhea, pneumonia, psoriasis, rheumatism, scabies, piles, cancer, coronary heart disease, diabetes, digestive disorders, fevers, ulcers, malaria, tumors, asthma, skin infections, and hypertension. Four crops are identified in the review as having herbal and medicinal properties that can be used to treat a range of illnesses. To comprehend the medicinal properties of these plants better, improved biochemical characterization is required. This review helps comprehend the commercial qualities of the crop, which is currently being cultivated as a commercial vegetable. Understanding

the pharmacological actions of *Momordica* species will enhance their value and assist producers.

Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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