

Momordica balsamina L.: An unexploited vegetable crop rich in medicinal and nutritional properties



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Summary

African pumpkin (*Momordica balsamina* L.) is a tendrilled, wild-type vine plant with a wide range of therapeutic and nutritional properties that has been used as a conventional medicament in many countries. Alkaloids, resins, glycosides, flavonoids, saponins, cardiac glycoside, steroids and terpenes are found in the plant's fruits, seeds, leaves and bark, and they have varied medicinal properties viz., anti-bacterial, anti-diarrheal, anti-plasmodial, anti-septic, anti-inflammatory, anti-microbial, antioxidant, hypoglycemic, analgesic, and hepatoprotective activities. 'Momordin,' a therapeutic agent, can stop HIV and other viruses from multiplying. The leaves are also a good source of nutrients because they contain 17 amino acids and minerals like potassium, magnesium, phosphorus, calcium, sodium, zinc, manganese, and iron. It also aids in the fight against soil micronutrient deficiencies and high protein and fat content with low fibre content. High potassium content is an excellent source for controlling hypertension and other cardiovascular disorders. This plant may be a protein supplement for poor rural people's cereal-based diets. The medicinal and nutritional value of this wild herb for health care management is discussed in this review.

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INTRODUCTION

The genus *Momordica* is a member of the Joliffieae (Schrad.) tribe of the Cucurbitaceae family and is a native to the Palaeotropical region⁵⁶, with about 40 species⁷³ found in the warm tropical belt of both hemispheres, mainly in the African continent and with about ten species in South-East Asia.¹⁸ Except in the north-east, *Momordica dioica* and *M. charantia* are found throughout India, whereas *M. subangulata* ssp. *renigera* is found only in the north-east and adjacent to the north Bengal hills. *M. cochinchinensis* is localised to the Andaman Islands and a few places in the eastern and north eastern states. *M. balsamina* is mainly found in Rajasthan and Gujarat's dry zone, but *M. cymbalaria* is found in Andhra Pradesh, Karnataka, Madhya Pradesh, and Maharashtra. *M. sahyadrica* is a newly described species of the Western Ghats.³⁰

Among other species of *Momordica*, *M. balsamina* L. is an important vegetable crop while it is neglected and lesser

known. *Momordica balsamina* L. commonly known as Balsam apple (English), *Junglee karela* or *Jhaar karela* (Hindi) is an annual vine native to the tropical regions of Africa and was introduced in Asia, Australia and Central America. Leaves and fruits are used as a vegetable. It belongs to the family Cucurbitaceae with chromosome number 2n=22. It is a tendril-bearing vine native to the tropical regions of Africa and introduced in Asia, Australia and Central America. It is also called *Jhaar karela* or *Junglee karela* (Hindi), Balsam apple (English). It is found as a monoecious climber on bushes in sandy or rainfed areas of Rajasthan, Punjab western U.P. and Saurashtra up to an altitude of 300 m.⁶⁶ Leaves orbicular, glabrous, palmately 3-5 lobed; flowers yellow, solitary; fruits tuberculate, 2.0 – 7.0 cm long, broadly ovoid, narrowed at both ends; seeds grey, ellipsoid, compressed, slightly verrucose. Tender fruits of the plant are eaten as vegetables or pickled; they are used for flavouring food dishes; leaves and stems are used as camel fodder.⁶⁶ It is propagated through seeds. At maturity, fruits turn green to orange to scarlet red and split from the base to expose the seeds. The fruits are harvested from untouched places from July to November in the arid zone and sold at high prices. Fruit length, diameter and weight varied from 2.5-3.5 cm, 1.7-2.6 cm and 4.5-5.0 g, respectively. A

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single vine bears 162-212 marketable fruits during the entire season and produces 0.7-1.0 kg of fruits.¹⁵

This bioactive compounds-based review of *Momordica balsamina* fruits discusses that it possesses activities like antimicrobial, antispasmodic, anti-inflammatory, analgesic, anti-HIV, hypoglycemic, anti-diahorral, hepatoprotective, anti-malarial, anti-oxidant, anti-cancer, wound healing, etc.^{31, 11, 4, 9, 41} The fruit is reported to contain momordicin, vitamin C, resin acids, fixed oil, carotene, volatile aromatic oil, alkaloids, cucurbitacins and saponins.⁴²

Phytochemical composition and activity

Secondary metabolites such as glycosides, steroids, flavonoids, alkaloids, saponins, terpenes, cardiac glycoside, lectins and tannins are found in the leaves, fruits, seeds, and bark of *M. balsamina*.⁶³ Plant lectins are primarily found in mature seeds.¹ Crude lipids (2.66 %), common sugars, proteins (11.29 %), natural fibre (29 %), energy, amino acid, carbs (39 %), and chlorophyll are the significant metabolites.^{25, 65, 45, 26, 10, 1} The leaves are a good source of nutrients, including 17 amino acids and a good mineral balance.^{25, 63, 70, 69, 43} Potassium, calcium, magnesium, sodium, phosphorus, manganese, zinc, and iron are abundant in *M. balsamina*, which helps to prevent micronutrient deficits in humans.

The non-targeted phytochemical profiling of marketable-sized fruits of *M. balsamina* was carried out at ICAR-CIAH, Bikaner, India. The methanolic extract of marketable-size

fruits of *M. balsamina* was subjected to Gas Chromatography Mass spectroscopy (GC-MS/MS) analysis and detected >100 compounds. The detected phytochemicals were identified based on retention time and matching their mass spectra to spectra in NIST 14 library. The results revealed the presence of fatty acids, phenolics, terpenoids, flavanoids, alkaloids, tannins, esters and amino acid derivatives, comprising 100 compounds. Of the detected compounds, the major part was fatty acid (about 60%), which contains MUFA's and PUFA's along with some unusual fatty acids with an odd number of carbon compounds. Most detected compounds have been proven to have essential bio-activities like anti-microbial, anti-inflammatory, anti-cancer, analgesic, antipyretic, anti-diabetic, hepatoprotective, cardiovascular, antioxidant, anti-mutagenic, etc. Some important phytochemicals like 3',5'-Dimethoxyacetophenone, Ar-tumerone, Ascorbic acid, Heptadecanoic acid, Cyclopropanedecanoic acid 2-hexyl, Cyclononasiloxane, octadecamethyl-, 4,7,10-Hexadecatrienoic acid, 8,11,14-Eicosatrienoic acid, (Z,Z,Z)-, 2-(Dimethylamino) ethyl adamantanecarboxylate, Dotriacontane, 2,6,10,14,18,22-Tetracosahexaene, 6,9,12,15-Docosatetraenoic acid, Bisabolen-12-OL, etc. were detected in *M. balsamina* fruits which proved the pharmaceutical applications against major diseases like cancer, diabetics, cardiovascular and some other chronic diseases.¹⁵ Some of the bioactive compounds detected from *M. balsamina* are listed in Table 1.

Table 1: Some important Bioactive compounds detected in *M. balsamina* during GC-MS/MS analysis

Compounds	Group
Phenol	antioxidant
Phenol, 2-methoxy-	antioxidant
1,4:3,6-Dianhydro- α -D-glucopyranose	derived bioactive carbohydrate
1-Dimethyl(octyl)silyloxypropane	plant metabolite but bioactivity not known
Benzoic acid, 4-methoxy-, methyl ester	preservative used in ointments that prevent or treat fungal skin diseases
3',5'-Dimethoxyacetophenone	Antioxidant, analgesic, antipyretic and antiinflammatory
Ar-tumerone	Non-Curcuminoids anticancer agent from turmaric
Tridecanal	volatile compound
9-Hexadecenoic acid, methyl ester, (Z)-	C16:1 fatty acid
L-(+)-Ascorbic acid 2,6-dihexadecanoate	Vit C
Heptadecanoic acid, methyl ester	C17 fatty acid
9,12-Octadecadienoic acid (Z,Z)-, methyl ester	Fatty acid C18:2
9-Octadecenoic acid, methyl ester, (E)-	C18:1
9,12-Octadecadienoic acid (Z,Z)-	C18:2
Octadec-9-enoic acid	Fatty acid

9,12,15-Octadecatrienoic acid, ethyl ester, (Z,Z,Z)-	Fatty acid
Octadecanoic acid	C18
Hexadecanamide	Fatty acid derivatives
Cyclopropanedecanoic acid, 2-hexyl-, methyl ester	increased human cyclooxygenase activity
9-Hexadecenoic acid, methyl ester, (Z)-	Fatty acid
Cyclononasiloxane, octadecamethyl-	Part of essential oil Antioxidant and insecticidal activity
9-Octadecenoic acid (Z)-, methyl ester	Fatty acid
9,12,15-Octadecatrienoic acid, methyl ester	C18:3 omega 3 fatty acid
4,7,10-Hexadecatrienoic acid, methyl ester	Unusual fatty acid C17:3 cardioprotective
8,11,14-Eicosatrienoic acid, (Z,Z,Z)-	It has a role as a nutraceutical, a human metabolite and a fungal metabolite. It is a fatty acid 20:3 and a long-chain fatty acid.
9,12,15-Octadecatrienoic acid, methyl ester	C18:3 omega 3 fatty acid
11-Eicosenoic acid, methyl ester	gondoic acid, is a monounsaturated omega-9 fatty acid found in a variety of plant oils and nuts
Eicosanoic acid, methyl ester	C20
9,12-Tetradecadien-1-ol, acetate, (Z,E)-	alcoholic compound
Heneicosanoic acid, methyl ester	antioxidant
1,9,12,15-Octadecatetraene, 1-methoxy-	Fatty acid
1H-Benzocyclohepten-7-ol, 2,3,4,4a,5,6,7,8-octahydro-1,1,4a,7-tetramethyl-, cis-	Diterpenoids, Antioxidant activity
Carbamic acid, 2-(dimethylamino)ethyl ester	esters
Cyclopentadecanone, 2-hydroxy-	Cyclopentadecanolide and cyclopentadecanone are two important macrocyclic musk[1], and widely used 22 in perfumes, cosmetics, food, and medical.
Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester	fatty acid
Docosanoic acid, methyl ester	C22 fatty acid Therapeutic, Diagnostic activities. behenic acid is often used to give hair conditioners and moisturizers their smoothing properties.
2-(Dimethylamino)ethyl adamantanecarboxylate	bioactive small molecule; Supplied in oil form; sedative-hypnotic drug
Cyclononasiloxane, octadecamethyl-	same as 75 Part of essential oil Antioxidant and insecticidal activity
Tricosanoic acid, methyl ester	Fatty acid C23
9,12-Octadecadienoic acid (Z,Z)-, 2,3-dihydroxypropyl ester	fatty acid C18:2
Oleic anhydride	fatty acid
Octadecanoic acid, 2,3-dihydroxypropyl ester	fatty acid
Tetracosanoic acid, methyl ester	Lignoceric acid C24 straight-chain saturated fatty acid
Dotriacontane	Antimicrobial, antioxidant, antispasmodic
2,6,10,14,18,22-Tetracosahexaene, 2,6,10,15,19,23-hexamethyl-, (all-E)-	Drug for dermatological disorders, used to treat wounds, ulcer
6,9,12,15-Docosatetraenoic acid, methyl ester	adrenic acid cardio protective, Hypocholesterolemic
BISABOLEN-12-OL <BETA-> DB5-2242	Sesquiterpene Exhibits Cytotoxicity in Breast Cancer Cell Lines



Fig. 1: Profuse flowering and fruiting in *M. balsamina* on trellis system

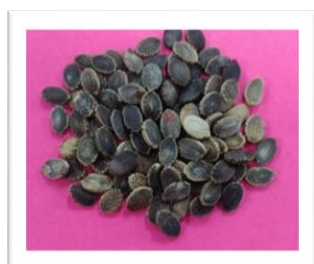


Fig. 2: Seeds, Flowering pattern, Tender fruits (ready for sale) and Mature fruits (for seed extraction) of *M. balsamina*



Fig. 3: Whole plant of *Momordica balsamina*

Nutritional value

M. balsamina is useful in the production of dietary supplements because of its high protein and fat content and low fibre level.^{7, 17, 55, 24, 38, 63, 1} *M. balsamina*'s leaves are a good source of nutrients, including 17 amino acids.^{16, 25, 17, 58} As a meat sauce, *M. balsamina* leaves are combined with peanuts and honey.^{19, 46, 59, 23, 12, 49, 40}

The edible seed is surrounded by the crimson, squishy flesh of the *M. balsamina* fruit.^{10, 20, 61} *M. balsamina*'s soft fruits and shoots are commonly boiled with meat, and both can be added to the soup. Young *M. balsamina* fruits are cooked and consumed; after peeling, soak in salt water to reduce bitterness before cooking; additionally, South Africans and Nigerians value the fruit for its superior flavour.^{3, 24, 61} *M. balsamina* fruits are common

ingredients in Indo-Pakistani pickles and are frequently used in curries and meat meals.

M. balsamina tender shoots are commonly served with okra soup by the Kanuris of Borno State, where the plant is known as a vegetable.²⁸ *M. balsamina* is commonly used in aphrodisiac preparations, but the fruits are also used as purgatives, poultices, and vermifuges in Senegal.^{33, 61}

Medicinal value

Table 2. Compounds extracted from *M. balsamina* L. and their health benefits

S. No.	Compound	Health benefits	References
1	Cucurbitane glycoside	Anti-diabetic	Spengler <i>et al.</i> (2009) ⁶² , Farooq <i>et al.</i> (2019) ²¹
2	Kuguacin J	Anti-cancer	Spengler <i>et al.</i> (2009) ⁶²
3	Karavilagenin C	Anti-cancer	Ramalhete <i>et al.</i> (2009) ⁵² , Ma <i>et al.</i> (2012) ³⁵
4	Balsaminagenin A	Anti-cancer	Ramalhete <i>et al.</i> (2009) ⁵² , Ma <i>et al.</i> (2012) ³⁵
5	Balsaminoside B	Anti-cancer	Ramalhete <i>et al.</i> (2009) ⁵² , Ma <i>et al.</i> (2012) ³⁵
6	Balsaminol F	Schistosomicidal activity against <i>Schistosoma mansoni</i> adult worms	Ramalhete <i>et al.</i> (2011) ⁵⁴ , Ramalhete <i>et al.</i> (2016) ⁵³
7	Momordin I	Anti-viral	Thakur <i>et al.</i> (2009) ⁶⁵
8	Momordin II	Anti-viral	Thakur <i>et al.</i> (2009) ⁶⁵
9	Balsaminapentaol	Anti-malarial	Ramalhete <i>et al.</i> (2009) ⁵² , Ma <i>et al.</i> (2012) ³⁵
10	Cucurbalsaminol	Anti-parasitic	Ma <i>et al.</i> (2012) ³⁵ , Shah <i>et al.</i> (2014) ⁶⁰

Soaked leaves of *M. balsamina* are used to cure wounds in several parts of Africa and Europe. Furthermore, the fruits and leaves are utilised as hemostatic antiseptics in Nigeria and Syria to cure wounds.^{36, 58, 37} Because of its pungent odour, the fruit of *M. balsamina* is used as a liniment, blended with olive oil and almond oil to cure chapped hands, band, and haemorrhoids.³⁶ *M. balsamina* fruit pulp is blended with oil as an anti-phlogistic treatment in West Africa. *M. balsamina*'s mashed fruit is used as a poultice and bitter tonic.⁵⁸ The leaves of the *M. balsamina* plant are used to cure fevers and yaws. Tsonga and Zulus, on the other hand, have utilised leaves as a tea to treat blood-liver deficits, stomach and intestinal problems.³²

M. balsamina leaves were advised by the Portuguese for blood, stomach, and liver deficiencies, as well as for herbal medicine and culinary purposes.^{65, 38} The leaves of *M. balsamina* are used to treat diabetes, digestive problems, fevers, ulcers, and a mild form of malaria. *M. balsamina* is also used as a medication in West Africa for fever, yaws, and purgative in humans and animals.^{44, 27, 28,}

⁴⁰ The roots of *M. balsamina* are used as an aphrodisiac and in the treatment of urethral discharge in both humans and animals. Saponins, alkaloids, and phenolic

M. balsamina is widely regarded as one of the most important medicinal plants utilized as a source of life-saving medications for the world's population.^{25, 65, 32, 61} The crop can be eaten as a vegetable to supplement protein and potassium in poor rural communities' diets, but its high potassium content is linked to the treatment of hypertension and other cardiovascular diseases.^{51, 58, 28, 61} Some of the medicinal compounds extracted from *M. balsamina* are listed in Table 2.

substances in *M. balsamina* seeds may have anti-diabetic properties.⁹ When treating skin diseases like scabies, it's best to utilise the entire *M. balsamina* plant.^{68, 47, 48, 71} *M. balsamina* leaves and tendrils are widely used as a potherb and anti-emetic by the Pedi people in South Africa, while the Venda people used the leaves infusions as anti-emetic and Congo as colic. *M. balsamina* leaves and fruit are widely used for medical and spiritual purposes in the Okavango Delta, as well as as skin ailments in China.³⁹ Seed can be used as a poison in hunting arrows in various nations. Insecticidal activities are present throughout the entire plant extract.^{67, 70, 69}

M. balsamina aqueous leaf extract has also been used to reduce and treat period discomfort in young girls, as well as to boost milk production in postnatal women.⁶⁴ The leaves are prepared as part of a green vegetable soup for post-natal women in Hausa territory, Nigeria, and the Republic of Niger, where it is believed to assist the mother replace her lost blood during labour and cleanse her breast milk.³⁹

Antioxidants are acknowledged as a component and supplement of excellent human health since they help people and animals stay healthy and avoid diseases like

cancer, coronary heart disease, and even altitude sickness.^{64, 27, 50} Diabetes, malaria, colic, sores and wounds, infections, worms and parasites, as an emmenagogue, measles, and hepatitis, fevers, diarrhea, cancer, ulcer, HIV, bacterial infection, and constipation are all treated with *M. balsamina*.^{58, 1, 6} *M. balsamina* is also thought to help with mental disease.⁵ The fruit pulp of *M. balsamina* contains anti-HIV effects.² *M. balsamina* leaves and fruit extracts have antiplasmodial action against malaria.⁸ Including sugar D-galactose and lactose in the crude protein extract from African pumpkin seeds confers hemagglutinating action.¹² Furthermore, several earlier research tested the hemagglutinating activity on human and animal blood types and found that the hemagglutinating activity was higher in the 'O' blood type than in the other blood cell types.^{57, 61} Extract from *M. balsamina* has also shown anti-leukemic and anti-viral properties against leukaemia, liver cancer, solid sarcomas, and melanoma.

M. balsamina L. fruit juice has hypoglycemic properties, stimulates hunger, and aids in digestion.^{32, 14} *M. balsamina* has been shown to have hypoglycemic properties in both normal and diabetic rats, as well as individuals with type 2 diabetes.^{68, 57, 33, 32, 51, 29, 67, 34} P-Insulin, a polypeptide derived from the fruits and seeds of *M. balsamina*, decreases and normalizes blood sugar levels in rats quickly. The leaves were shown to be very hemolytic and hepatotoxic in rats, while the fruits were proven to be toxic to many organs and tissues of rats at extremely high doses.⁵⁸ To maximize its potential as a therapeutic herb, it's crucial to determine the right dose.

On the leaves of *M. balsamina* L., an underutilised wild vegetable in Botswana, proximate and mineral analyses were performed.²² Protein, fibre, fat, and ash were found to be 288, 37, 54, and 127 g/kg, respectively. Potassium was the most prevalent mineral, with 27.05 g/kg, followed by magnesium (3.82 g/kg), phosphorus (3.24 g/kg), calcium (2.22 g/kg), and sodium (0.06 g/kg). Zinc (0.39 g/kg), manganese (0.15 g/kg), and iron (0.14 g/kg) were the other minerals found. This wild vegetable had higher protein and fat content than cabbage, lettuce, and spinach, but lower fibre content. Except for salt, the minerals found in the leaves of *M. balsamina* were higher than those found in the exotic vegetables. In poor rural communities, the wild vegetable might be marketed as a protein supplement for cereal-based diets, and its high potassium content could be used to treat hypertension and other cardiovascular diseases.

Conclusion

M. balsamina has a high nutritional and therapeutic value due to its biochemical composition. Many of its components have unique biological features, and their combination could have fascinating pharmacological effects. Several research have shown that *M. balsamina* has the potential to be used as a medicine because of its anti-diabetic, anti-microbial, anthelmintic, abortifacient, anti-bacterial, anti-viral, and chemopreventive properties. Resins, alkaloids, flavonoids, glycosides, steroids, terpenes, cardiac glycoside, saponins, pectin, carbohydrates, amino acids, proteins, lipids, fibre, chlorophyll, phosphorus, calcium, potassium, magnesium, salt, zinc, manganese, and iron are among the natural bioactive substances it contains.

M. balsamina's antimicrobial, antiparasitic, and anti-ulcer properties are the mechanisms behind its inhibitory effects on gastrointestinal illness. Several biochemicals isolated from *M. balsamina* have also been shown to have anti-cancer properties. *M. balsamina*'s antioxidant properties also help to prevent cancer by reducing oxidative stress and oxidative damage such as lipid peroxidation. Antioxidants also have anti-aging and neuroprotective properties. Additionally, *M. balsamina*'s hypoglycemic activities help to prevent diabetes, while its hypocholesterolemic activities help to protect the heart, and their low Na⁺/K⁺ ratio helps to prevent hypertension. Clinical evidence suggests that they are effective in treating a variety of ailments, including dysmenorrhea, eczema, emmenagogue, galactagogue, gout, jaundice, kidney (stone), leprosy, leucorrhea, pneumonia, psoriasis, rheumatism, scabies, piles, cancer, coronary heart disease, diabetes, digestion disorder, fevers, ulcers, malaria, tumours, asthma.

According to the review, *M. balsamina* has medicinal and herbal qualities that can be utilised to treat a variety of diseases. To better understand the therapeutic characteristics of *M. balsamina*, more biochemical characterization is required. This review also aids in understanding the crop's commercial qualities in order to promote *M. balsamina* commercial farming. A greater understanding of *M. balsamina*'s pharmacological activity would increase its worth and help its growers.

Declaration of interests

The authors have no conflict of interest to declare.

Data sharing

All relevant data are within the manuscript.

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