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Review Article

# Phytochemical, medicinal properties and pharmacological studies on bitter gourd *(Momordica charantia)*: A Review

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ABSTRACT

Herbal remedies have attracted and served mankind from the time immemorial. *Momordica charantia* (MC) is the member of the cucurbitaceae family, is known as bitter melon, bitter gourd and karela. It is used traditionally as both food and medicine. Fruit juice of *Momordica charantia* has been used for the treatment of Diabetes for centuries. Charantin, a natural steroidal glycoside present in the fruits of this medicinal plant, has been reported to possess potential hypoglycemic activity. Medicinally, the plant has a long history of use by the indigenous people as a folk medicine and medical literature has consistently supported these therapeutic potentials. Several medicinal properties of the bitter gourd have been studied by various researchers, such as antidiabetic, antioxidant, anti-inflammatory, anti-cancer etc. This review addresses pharmacognostic, phytochemical, medicinal and pharmacological properties in detail.

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## INTRODUCTION

It is an annual plant with slender climbing or trailing habit (Bhattacharjee, 2004), stem more or less hairy (Dymock, 1890), belong to the *Cucurbitaceae* family (Ross, 2003; Lubhaya, 1984). It is cultivated in gardens everywhere in India, for its fruit. Two types are grown in N. India the hot season or Jethuya and the rainy season or Baramasiya, the latter bears fruits nearly throughout the year (Anonymous, 1998). The plant is of specific importance because of its hypoglycemic and antidiabetic activity (Bhattacharjee, 2004). *Momordica charantia* or Karela fruit, extracts of which are commonly used on the Indian subcontinent for the treatment of Diabetes (Evans, 2009). There are two varieties, one with a small roundish or ovoid fruit (uchche) and other longer and more cucumber-like. Its fruits, seeds, and leaves are used as medicine (Nadkarni, 1954). Root also has medicinal value (Kritikar and Basu, 1987). It is cultivated throughout India (Hooker, 1894). The seeds are sown in January to March or June to July in the plains, and in the hills, sowing time is April to July (Bhattacharjee, 2004).

It's stem long, much-branched, angled and grooved, more or less pubescent or hairy; young parts hairy or villous. Tendrils simple, slender, elongate, pubescent (Kritikar and Basu, 1987). Leaves palmately five-lobed, sinuate, toothed and villous on the under surface. (Khory, 1985). Cordate at the base, deeply divided into 5-7 lobes, the lobes are acute or subacute, petioles 2.5-5 cm long, channeled, pubescent. Flowers middle-sized, pale yellow (Dymock, 1890; Dey1973), but they are monoecious. Male flowers solitary, peduncles 5-10 cm. long, glabrous or pubescent. Calyx 8-10 mm. Long, lobes 5-6 mm. long. Corolla somewhat irregular, segments obtuse or emarginated, 1.6-2 cm long, veined. Female flowers: peduncles are slender, 5-10 cm long. Staminodes 3, glanduliform. Ovary fusiform and stigmas 3, bifid (Kritikar and Basu, 1987). Fruits differ in

size, color, surface characters (Bhattacharjee, 2004). They are oblong, 10 to 14 inches long, and 2 to 4 inches in diameter, edges curiously notched or ridged, tubercled and of the size of kakadi, taste extremely bitter. In young fruits the pulp over the seeds is whitish, becoming red after a time (Khory, 1985), seeds obovate or complanate, smooth corrugate or sculptured (Hooker, 1982).

Vernacular

This plant is known for different name in different region like Karela, Kareli, Karola (Hindi), Karala, Karale, Karli (Marathi), Pava-kai, Pavakkapchedi, Pagal, Pakal, Poda langkai (Tamil), Kakara-chettu, Mettakakara, Tellakakara, Urakakara, Kakara (Telgu), Karala, Uchchhe, Karala, Kerula, Baramasiya, Jethuya, Karala, Potikakar (Bengali), Hagala, Uchchhe, Hagala-kayi, Hagola, Kagalakayi, Kayi gida(Canarese) Karavella, Sushavi, Ambuvallika, Brihadvalli, Chiripatra, Kandakataka, Kandura, Kantaphalla, Karaka, Karavalli, Karawallilata, Karavella, Karavellaka, Karavelli, Kathilla, Kathillaka, Katilla, Katillaka, Sushavi (Sans), Bitter gourd, Carilla Fruit, Balsam apple, Hairy Mordica (English), Momordique charantia, Pandipane (French), Gurkenahnlicher Balsamapfel (German), Karelo (Sind), Karela, Karelo, Karelu, Korela, Karelan (Gujrati), Karla (Mah), Kurela-gro, Karla, Karela (Bombay), Paval, Kaipavalli, Kaippa, Kappakka, Pantipavel, Pavakkacheti (Mal), Karathay (Kon), Quisaul-barri, Ulhimar, Karavella, Kessaul-barri, Quisaul Himar (Arabic), Kakiral, Kakral (Assam), Kehingabin, Kyethenka (Burma), Ku Kua, Kukwa Laipu-tan (Chinese), Karela (Deccan), Karella (Urdu); Mreas (Cambodia), Nutipakal (Ceylon); Koo Kwa Kan, Ku Kua Kan, Lai Kua (Malaya); Pepino de Sao Gregorio (Portuguese), Karena (Uriya), Erva de Sao Caetano, Melao de Sao Caetano (Brazil), Karela (Duk), Simahang (Persian), *Momordica charantia* (Latin), Bitter guard (Trade name) (Dymock, 1890; Nadkarni, 1954; Kritikar and Basu, 1987; Chopra 1958; Khory, 1985; Daljeet, 1975; Chopra, 1958; Dayal, 1993; Sharma, 2003; Riyazuddin, 1888; Lubhaya, 1984; Dey,1973; Anonymous, 1998; Anonymous, 2005).

Figure 1. Leaves of *Momordica charantia.*

Scientific Classification

| |
|---|
| Kingdom: Plantae |
| Class: Dicotyledone |
| Order: Cucurbitales |
| Family: Cucurbitaceae |
| Genus: Momordica |
| Species: *Momordica charantia* |
| Scientific name: *Momordica charantia* Linn. |

Figure 2-3. Flowers & Fruits of *Momordica charantia.*

Mizaj (Temperament)

The Unani physicians described the temperament of Karela Hot and Dry in first degree (Kabeer Uddin, YNM), Hot and Dry in second degree (Nabi, 2007; Riyazuddin, 1888; Hasan, YNM; Ashraf, YNM; Fazal Ullah, 1918), Hot and Dry in third degree (Ghani,2011, Kabiruddin, 2000; Hakeem, 2002; Lubhaya, 1984; Hakeem, 2002; Ansari, 1930).

Afa'al (Action)

Dafe Ziabetus (Bhattacharjee, 2004; Anonymous, 1998; Sharma, 2003; Lubhaya, 1984; Anonymous, 2005); Hypoglycemic (Bhattacharjee, 2004); Muharrik (Khory, 1985; Nadkarni, 1954; Kritikar and Basu, 1987); Qatil-e-Kirm-e-Shikam (Khory, 1985; Nadkarni, 1954; Kritikar and Basu, 1987; Kritikar and Basu, 1987; Dymock, 1890; Lubhaya, 1984); Muqawwi (Khory, 1985; Nadkarni, 1954; Kritikar and Basu, 1987); Muqawwi-e-Meda (Nadkarni, 1954; Kritikar and Basu, 1987; Bhattacharjee, 2004); Moqie (Nadkarni, 1954; Kritikar and Basu, 1987), Muwallid-e-Seer (Nadkarni, 1954), Qabiz (Nadkarni, 1954; Kritikar and Basu, 1987); Musaffi-e-khoon (Nadkarni, 1954; Lubhaya, 1984), Mushil (Nadkarni, 1954; Kritikar and Basu, 1987; Dymock, 1890); Mudir-e-ha'iz (Nadkarni, 1954); Kasir-e-Riyah (Kritikar and Basu, 1987; Bhattacharjee, 2004, Bhattacharjee, 2005; Sharma, 2003); Muqawwi-e-Baah (Kritikar and Basu, 1987), Mulaiyan (Kritikar and Basu, 1987; Nadkarni, 1954); Dafe humma (Kritikar and Basu, 1987); Cooling (Kritikar and Basu, 1987); Mushtahi (Kritikar and Basu, 1987); Musqit-e-Janeen (Bhattacharjee, 2004); Jali (Lubhaya, 1984); Mufattit-e-hisaat (Hakeem, 1343H).

Istemal (uses)

Ziabetus (Bhattacharjee, 2004; Sharma, 2003; Dandiya, 1989), Da-us-Sadaf (Sharma,2003; Nadkarni, 1954), Scabies (Khory, 1985), Rheumatism (Khory, 1985; Nadkarni, 1954; Kritikar and Basu, 1987; Dymock, 1890; Bhattacharjee, 2004; Sharma, 2003), Gathiya (Khory, 1985; Nadkarni, 1954; Dymock, 1890; Bhattacharjee, 2004), Qurooh (Nadkarni, 1954; Kritikar and Basu, 1987), Mubassir (Nadkarni, 1954), Jarooh wa Qurooh (Nadkarni, 1954); Boils (Nadkarni, 1954); Ophthalmia (Kiritikar and Basu, 1987); Aatshak (Kritikar and Basu, 1987); Fakhruddam (Kritikar and Basu, 1987), Urinary discharge (Kritikar and Basu, 1987), Dama (Kritikar and Basu, 1987), Warm-e-Shobat-ur-Riya (Kritikar and Basu, 1987), Cholera (Kritikar and Basu, 1987), Bawaseer (Kritikar and Basu, 1987; Sharma, 2003), Juzaam (Kritikar and Basu, 1987; Dymock, 1890; Sharma, 2003), Yarqaan (Kritikar and Basu, 1987; Sharma, 2003; Riyazuddin, 1888; Hakeem, 1343H), Soozak (Kritikar and Basu, 1987), Niqras (Hakeem, 1343H), Amraz-e-meda wa jigar (Ansari, 1930; Khory, 1985; Nadkarni, 1954), Ratudhin (Nadkarni, 1954), Matli (Nadkarni, 1954), Humma (Kritikar and Basu, 1987), Ishaal (Kritikar and Basu, 1987), Zaheer (Kritikar and Basu, 1987).

Muzir (Adverse effects)

To individuals of hot temperament (Ghani, 2011; Hakeem, 2002; Riyazuddin, 1888). Cause dryness (Kabiruddin, 2000; Lubhaya, 1984); it causes dysentery (Riyazuddin, 1888).

Musleh (Corrective)

Sikanjibeen and cold items (Ghani, 2011; Hakeem, 2002; Hakeem1343H)

Mirch siya, Dar-e-fil fil (Kabiruddin, 2000); Roghan (Lubhaya, 1984)

Miqdar-e-khuraq

Joshanda of leaves- 1 to 2 tola (Kabiruddin, 2000; Lubhaya, 1984)

2 to 5 tola (Dayal, 1993)
Powder- 1 Masha (Lubhaya, 1984)
Juice-10-20 ml (Anonymous, 2005).

Therapeutic uses

The root is used in ophthalmic and in prolapses vaginae. Fruit cures biliousness, Kapha, blood diseases, anemia, asthma, ulcers, bronchitis; the juice is useful in cholera. It also used to syphilis, rheumatism, troubles of the spleen (Kiritikar and Basu, 1987). The juice is rubbed in burning of the soles of the feet (Kiritikar and Basu, 1987; Dymock, 1890). It is used internally as a laxative, and as an ointment for sores. The fruit and leaves are useful in piles, leprosy, jaundice, and as a vermifuge. It is applied externally to the scalp in pustular eruptions. Infusion of the leaves is taken for contusions. The pounded leaves mixed with some fatty material are made into an ointment useful in scabies and other skin diseases. The leaves are crushed and steeped in water which is then given internally as a remedy for diarrhea and dysentery (Kiritikar and Basu, 1987). Fruit is useful in gout, rheumatism and sub-acute cases of the spleen and liver. It is supposed to purify blood and dissipate melancholic and gross humor (Nadkarni, 1954). Leaf-juice 1/8 seer is given in bilious affections as emetic and purgative alone or combined with aromatics (Nadkarni, 1954, Kiritikar and Basu, 1987). Leaf-juice 0.5 tola with a little turmeric powder added is given for the nausea of children, as it acts as the emetic and thus cleanses the stomach (Nadkarni, 1954). The expressed juice of the plant with chalk is used in aphthae, and also an emmenagogue in dysmenorrhoea (Nadkarni, 1954, Kiritikar and Basu, 1987. The whole plant powdered is used for dusting over leprous and other intractable ulcers (Khory, 1985).

Phytochemistry

Water (90%), Protein (1.6 %), Fat (0.2%), Calcium (0.03%), Phosphorous (0.07%), Iron (12 mg in 100gm), Vitamin (6-8%) (Lubhaya, 1984).

Fruits contain protein, fat, carbohydrate, mineral matter and moisture. It is rich in vitamins like riboflavin, thiamine, ascorbic acid and as corbegenin, Green fruit contains luteolin. Seeds yield the essential oil. It also contains bitter glycosides, cucurbitacins (Bhattacharjee, 2004).

β- Sitosterol-β-D-glucoside and stearic acid isolated from seeds; octacosane, 1-triacontanol, 7-stigmasten-3β-ol, 7,25-stigmastadien-3β-ol, 5,25-stigmastadien-3β-ol glucoside and a phytospingosine isolated from leaves; two lectins (I,II) differing in amino acid composition and amino terminal sequences, two new triterpene glycosides-momordicosides A and B- isolated from seeds and characterised as 3-O-β-gentiobioside and 3-O-β-D-xylopyranosy (1-4)-[β-D-glucopyranosyl (1-6)]-β-D-glucopyranoside respectively of cucurbit-5-en-3β,22(S),23(R), 24( R), 25-pentaol; momordicoside C,D and E isolated from seeds and characterised as 3-O-β-gentiobiosides of cucurbit-5-en-3β, 23, 24,25-tetraol, cucurbit-5,24-dien-3β,22,23-triol and 3β-hydroxy-23,24,25,26,27-pentanor-20(ξ) cucurbit-5-en-22-al respectively; two cytokinins-zeatin and zeatin riboside-isolated from seeds; vicine isolated from seeds; four momordicosides G, F1, F2 and I isolated from immature fruits, of which G and F characterized as 3-O-β-D-allopyranoside and 3-O-β-D-glucopyranoside respectively of 5,19-epoxy-25-methoxy-5β-Cucurbita-

6,23-dien-3β-ol, and F2 and I as 3-O-β-D-allopyranoside and 3-O-β-D-glucopyranoside of 15, 19-epoxy-5β-Cucurbita-6, 23-diene-3β, 25-diol respectively; in addition, momordicosides K and L isolated from fruits and their structures established; momordicines I and II isolated from leaves and characterized as 3β, 7β, 23ξ-trihydroxy-Cucurbita-5,24-dien-19-al and its 23-O-β-glucopyrano-side respectively; momordicine III isolated as its acetate and characterised as 23-O-β-glucopyranoside of 3β, 7β,23ξ-trihydroxy-24-oxocucurbita-5,25-dien-19-al (Rastogi and Mehrotra, 2001). The main constituents of bitter melon (Karela) are triterpene, protein, steroid, alkaloid, inorganic, lipid, and phenolic compounds. *Momordica charantia* (Karela) consists the following chemical constituents those are alkaloids, momordicin and charantin, charine, momorchanins, momordenol, momordicilin, momordicius, momordicinin, momordin, momordolol, charantin, charine, cryptoxanthin, cucurbitns, cucuritacins, cucuritanes, cycloartenols, diosgenin, elaeostearic acids, erythrodiol, galacturonic acid, gentisic acid, goyaglycosides, goyasaponins, and multiflorenol cryptoxanthin, cucurbitins, cucurbitacins, cucurbitanes, cycloartenols, diosgenin elaeostearic acids, erythrodiol, galacturonic acids, gentisic acid, goyaglycosides, goyasaponins, guanylate cyclase inhibitors, gypsogenin, hydroxytryptamines, karounidiols, lanosterol, lauric acid, linoleic acid, linolenic acid, momordenol, momordicillin, momordicinin, momordicosides, momordin, momordolo (Das, 2015). Glycosides (Momordin and Charantin), Polypeptide-p (insulin-like peptides), Oils (Stearic and Oleic Acids) and Protein MAP30 have been found to possess hypoglycemic properties (Pandey et al., 2015).

## Pharmacological studies

Several medicinal properties of the bitter gourd have been studied by various researchers that include anti-diabetic, anti-ulcerogenic, anti-mutagenic, antioxidant, anti-tumor, immune-modulatory activities etc. Some important pharmacological effects are as follow:

### Anti-Inflammatory action

Ganesan et al. (2008) demonstrated that anti-inflammatory activity of dried leaves was comparable to 10 mg/kg of indomethacin. Further, Sharma et al. reported wound healing capacity of fruit powder were comparable to those of povidone iodine ointment in an excision, incision and dead space wound model in rats.

### Anticancer action

In vitro studies (Yasui et al., 2005) indicated that *Momordica charantia* fruit and seed extracts inhibited the growth of several cancer cell lines, including prostate adenocarcinoma, human colon cancer (Caco-2 cells)and the highly metastatic breast cancer cell line MDAMB.

In vitro studies have also demonstrated the anti-cancerous and anti-leukemic activity of bitter gourd against numerous cell lines, including liver cancer, human leukemia, melanoma and solid sarcomas (Fang et al., 2012).

### Antidiabetic effect

Administration of alcohol of an extract of bitter melon produced a dose dependent decrease in blood glucose levels in Alloxan induced rabbits. There was a significant fall in blood sugar level in High dose (1.5GM/kg) in comparison to low dose (0.5gm/kg) and median dose (1gm/kg) shown by LSD test. This is comparable to the effect of Metformin (Yakaiah Vangooti et al., 2013). Batran et al. (2006) further reported that bitter gourd extracts have anti-diabetic, hepato-renal protective and hypolipidemic effects in alloxan-induced diabetic rats.

### Antioxidant activity

Different parts of this plant have been used in the Indian medicinal system for a number of ailments besides diabetes. Antioxidant activity of extracted phenolic compound from bitter melon has been reported (Horax et al., 2005). Antioxidant properties of *Momordica charantia* (Karela) Seeds on Streptozotocin induced-diabetic rats has been studied and results clearly suggest that seeds of *Momordica charantia* (Karela) may effectively normalize the impaired antioxidant status in streptozotocin induced-diabetes (Sathishsekar et al., 2005).

### Anxiolytic action

Ganesan et al., (2008) proved anxiolytic activity of methanol extract of dried leaves of *Momordica charantia* in elevated plus maze test.

### Hypoglycaemic activity

Charantin isolated from fruits of *M. charantia* was tested for its hypoglycemic activity. In fasting rabbits, it gradually lowered blood sugar within one to four hours and recovered slowly to the initial level. Charantin was found to be more potent than tolbutamide, however, both compounds produced the similar pattern of blood sugar change. The hypoglycaemic activity of charantin in depancreatized cats was less, but abolished, indicating a pancreatic as well as extra-pancreatic action (Lolithak et al., 1966).

### Hypolipidemic properties

In an in vivo study (Ahmed et al., 1998) the elevated cholesterol and triglyceride levels in diabetic rats were

returned to normal value after 21 days of administration of bitter gourd fruit and/or seeds. Virdiet al. (2001) evaluated the effects of bitter gourd oil (BGO) on the blood and liver lipids of rats.

### Anti-viral properties

Various extracts of the leaves have demonstrated in vitro anti-bacterial activities (Mwambete et al., 2009) against *E. coli,* Staphylococcus, Pseudomonas, Salmonella, Streptobacillus and Streptococcus. An extract of the entire plant was shown to have antiprotozoal activity against *Entamoeba histolytica* (Gupta et al., 2010).

### Antifertility activity

Stepka et al., (1974) have demonstrated in vivo antifertility effect of fruit and leaf of bitter melon in female animals.

### Anti-ulcer activity

MC has been shown to have antiulcer activity observed against two different models of the ulcer. In one study, momordin Ic (10mg/kg, p.o.) potentially inhibited ethanol-induced gastric mucosal lesions (Matsuda et al., 1999). Interestingly, MC has been shown to have anti-*H. pylori* activity, which would also beneficially contribute to anti-ulcer activity (Yesilada et al., 1999). In another study, dried-powdered fruits in filtered honey showed significant and dose-dependent anti-ulcerogenic activity against ethanol-induced ulcerogenesis in rats. In addition, ethanol fruits extract also showed significant antiulcer activity against HCl-EtOH induced ulcerogenesis in indomethacin pre-treated rats and diethyldithiocarbamate induced ulcer models (Gurbuz et al., 2000).

### Cardiovascular effects

Effect of charantin on cardiovascular system was studied. At the dose of 800 mg/kg, 5-10% of blood pressure lowering of the anaesthetized cat was observed. The contraction of isolated heart of frog was increased at the dose of 5-10 mg and the same dose was effective to terminate the action of acetylcholine (Sonal et al, 2015). Effect of charantin (a pure chemical from *Momordica charantia*) was studied on the cardiovascular system. At the dose of 800 mg/kg, 5-10% of blood pressure lowering of the anaesthetized cat was observed (Olivier, et al., 2016).

### Immunomodulatory activity

However, its immune stimulant activity has been attributed to increasing in interferon production and natural killer cell activity (Cunnick et al., 1990). Intraperitoneal administration of alpha-momorcharin and beta-momorcharin (50g weekly for 5 weeks) to BALB/cAn or C57BL/6N mice resulted in high levels of IgE production (PCA titer), while no cross immunological reactivity among these proteins was found (Zheng et al., 1999).

### Hypocholesterolemic effect

Several experimental studies carried out in normal as well as diabetic animals have shown the hypo-cholesterolemic effect by MC (Platel et al., 1993; Singh et al., 1989; Ahmed et al., 2001). However, in another study total lipids as well as phospholipid concentrations in heart and brain were significantly higher when karela oil was given compared with linseed oil administered rats (Dhar and Bhattacharyya, 1998).

### Anti-malarial activity

Kohler et al., (2002) observed weak in vitro antiplasmodial activity of MC extract.

### Anti-bacterial and anti-protozoal action

Pandey et al., (2015) reported that the *Momordica charantia* extracts also inhibit the growth of numerous gram-negative and gram-positive bacteria, including E. coli, Salmonella, Shigella, Staphylococcus, Pseudomonas, Streptobacillus, Streptococcus, and H. pylori, and protozoal organisms such as *E. histolytica* and Plasmodium falciparum. The antibacterial and antifungal activities of *Momordica charantia*, (Olivier et al., 2015) was investigated against Staphylococcus aureus (gram+ve), Escherichia coli (gram-ve) and Candida albicans (fungi) using the Stokes disc diffusion, the pour plate, well diffusion and streak plate methods.

### Anti-diarrheal activity

The anti-diarrheal activity of aqueous extract of the leave of *Momordica charantia* was evaluated on castor oil induced diarrhea, gastro-intestinal transit, intestinal fluid accumulation and gastric emptying in rats. The aqueous extract of the plant showed inhibitory activity against castor oil-induced diarrhea (Olivier et al., 2016).

### Safety aspects

The LD50 of 50 per cent ethanolic extract of fruit is 681 mg/kg i.p. in mice (Anonymous, 2005).

## CONCLUSION

Bitter gourd (M.C.) has been in used since times immemorial to treat the wide range of indication. The plant contains various chemical constituents which are responsible for its pharmacological activities. Experimental studies have demonstrated its anti-diabetic, anti-cancer, anti-ulcerative, anti-oxidant and other activities. The efficacy of Bitter gourd is much more popular as antidiabetic. It is now obvious that M.C

can help as a natural source product in the treatment process of many diseases.

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