Ethnobotany and Nutritive Value

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Abstract

Momordica species have been used as both food and medicine in the regions in which it grows, for centuries in ancient traditional Indian, Chinese, and African pharmacopoeia as anthelmintic, laxative, digestive stimulant, and to enhance appetite. Usefulness of various *Momordica* species as anthelmintic, vermifuge, cathartic, hypoglycemic, aphrodisiac, antipyretic and in the treatment of burns, bilious disorders, diabetes, cataract, hypertension, leprosy, jaundice, snake bite, hemorrhoids, and piles has been mentioned. However, traditional knowledge related to the use of these species by indigenous tribes is not yet fully documented in the published literature. The leaves and young fruits are cooked and eaten as vegetable in India, Cameroon, Sudan, and Southern Africa. Leaf and fruit extracts of bitter gourd are used in the preparation of tea and is a popular health drink in Japan. Tender clippings of bitter gourd and teasel gourd are used extensively as leafy vegetable in parts of India and elsewhere in Southeast Asia. The fruits of the sweet gourd are esteemed as the fruit from Heaven for its ability to promote longevity, vitality, and health. Fruits of spine gourd contain aliphatic compounds which act as appetizer and astringent. Use of *M. sahyadrica* tuber paste as detergent and toilet soap holds promise in the cosmetic and health care industry. Bitter gourd has a relatively high nutritional value compared to other Cucurbits, due mainly to the iron and ascorbic acid content. *Momordica* is noted for acids with conjugated double bonds and high levels of antioxidant activity were noticed in balsam apple. *M. dioica* have medium protein value, fat, and phenolic compounds, and have maximum calorie value when compared to eight traditional wild vegetables of Indo-Persian region and could be a good supplement for nutrients such as fiber, potassium, zinc, lipid, protein, and carbohydrates. Sweet gourd contains β-carotene and lycopene at very high levels, with those of lycopene being up to 308 μg/g in the seed membrane, about 10-fold higher than in other lycopene-rich fruits and vegetables. Nutritional supplementation trials in Vietnam have shown that children fed with 'xoi gac' (rice cooked with fruit pulp of *M. cochinchinensis*, popularly called gac) have significantly higher plasma β-carotene, compared to those who received synthetic

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β-carotene powder or none. This chapter focuses on the nutritional composition as well as medicinal and therapeutic properties of Asiatic *Momordica* species.

Keywords
Ethnobotany · Proximate principles · Mineral content · Antioxidant · *Momordica* spp

Ethnobotany

The genus *Momordica*, primarily known as bitter gourd, comprises many species of medicinal importance in Asia and Africa. Barring bitter gourd (*M. charantia* var. *charantia*) other species (including *M. charantia* var. *muricata*) occur in wild state and are gathered by tribals as vegetables. Teasel gourd, sweet gourd, and spine gourds (*M. subangulata* subsp. *renigera*, *M. cochinchinensis*, *M. sahyadrica*, and *M. dioica*) are the other *Momordica* species of economic importance, mostly wild gathered but grown to a limited extent in the eastern and northeastern parts of India. Many species of *Momordica* are used as wild vegetable, fodder, and indigenous medicine for treatment of malaria and other diseases in Kenya (Aynesu 1978; Njoroge and Newton 2002). Although, there is a general belief that bitter gourd is good for diabetic cure and recent research (Aktar et al. 1981; Day et al. 1990) reveals its hypoglycemic properties, commercial formulations are scanty in the ayurvedic pharmaceutical industry.

Aboriginal people live in their traditional ranges and largely follow traditionally oriented lifestyles, depending more on bush food than store brought food. Usefulness of various *Momordica* species as anthelmintic, vermifuge, cathartic, hypoglycemic, aphrodisiac, antipyretic, and in the treatment of burns, bilious disorders, diabetes, cataract, hypertension, leprosy, jaundice, snake bite, haemorrhoids, and piles has been mentioned [van Rheede (1678–1693), Watt (1891), Kirtikar and Basu (1933), Uphof (1968), Walters and Decker Walters (1988), Rastogi and Mehrotra (1990), Yang and Walters (1992), Dwivedi (1999), Jeffrey (2001), Bhat et al. (2003), and Deshmukh and Rothe (2003)]. However, traditional knowledge related to the use of these species by indigenous tribes is not yet fully documented in the published literature. Joseph and Antony (2008) give a detailed account of the ethnobotany of the genus in the Western Ghats of India.

M. balsamina. The leaves and young fruits are cooked and eaten as vegetable in India, Cameroon, Sudan, and Southern Africa. The bitter young fruits are reported widely as edible, whereas the ripe fruits cause vomiting and diarrhea, and can be poisonous. However, the bright red pulp is eaten in Namibia. The unripe fruits are also used to prepare pickles, and as salted and sun dried vegetable for lean months in India. The leaves and fruits are sometimes used in sauces and soups.

The leaves and stems are used as fodder in Australia and Senegal. The leaves form a slightly soapy solution in water and are used to clean metal objects and to wash the body. Common and widespread medicinal uses are as anthelmintic (fruits, seeds, and leaves), against fever and extreme uterine bleeding (leaves), to treat syphilis, rheumatism, hepatitis, and skin disorders, stomach and intestinal complaints (Hutchings et al. 1996). Other uses include abortifacient, lactogenic including veterinary (Geidam et al. 2004) and hypoglycemic (Hutchings et al. 1996) and in treating diabetes (Njoroge and Luijk 2004). The whole plant together with *Strophanthus*, is used in the preparation of an arrow poison in parts of Nigeria. In Hausa land of Nigeria and the Republic of Niger, the leaves are cooked as part of green vegetable soup for lactating mothers, where it is believed to help the mother to

regenerate her lost blood during labor and to purify her breast milk (Hassan and Umar 2006).

M. charantia. The immature and ripe fruits are cooked and eaten as vegetable in Asia and Africa. Extremely bitter forms are cooked in water and drained before seasoning. Bitterness may be reduced by parboiling or soaking in salt water. The unripe fruits are also used to prepare pickles and chips in India. Mature fruits are sliced cross sectionally and salted or blanched in salt water and sun dried for off-season use. The young non-bitter fruits are also used as salad in Zimbabwe. Young shoots and leaves are also cooked and eaten as vegetable in India and used as flavoring in Java and Philippines (Anonymous 1952). The growing tips of the vine and the young leaves are parboiled to remove much of the bitterness and then cooked with other vegetables and meat or fish (Barley 1894; Miller et al. 1946). Leaf and fruit extracts are used in the preparation of tea and is a popular health drink in Japan (Tindall 1983; Reyes et al. 1994). The sweet red arils are sucked from the seeds by children and adults (Morton 1962).

It has been used for centuries in ancient traditional Indian, Chinese, and African pharmacopoeia as anthelmintic, laxative, digestive stimulant, and to enhance appetite. In ayurveda, *M. charantia* is grouped under vegetable class of medicine and claimed to possess several therapeutic properties like regulation of digestion and metabolism, softening and clearing the motion, and improving digestion of sweet substances. It also cures fever, harmonizes enzymatic and related metabolic vitiations, is beneficial in anemia and diabetes/polyurea, and also relieves worms (Tiwari 2007). Whole plant, leaves, and especially fruits are used in folk medicine to treat diabetes in Asia (Perry 1980; Khajuria and Thomas 1993; Platel and Srinivasan 1995; Fernandopulle and Ratnasooriya 1996; Decker-Walters 1999), West Africa (Burkhill 1935), and even in the New World (Coe and Anderson 1996; Marr et al. 2004).

Lira and Caballero (2002) have reported the use of the feral wild-type as an aphrodisiac in Mexico. The fruit juice/leaf tea is used for sores and wounds, infections, worms, and parasites and for measles, hepatitis, and fevers. The plant is generally used as a hypoglycemic and anti-diabetic agent (Chen et al. 2003; Vikrant et al. 2001). In Mauritius, apart from its anti-diabetic properties, the oiled leaves are applied on the entire body to attenuate fever. The root decoction has abortifacient properties while the leaf and stem decoction is used against dysentery, rheumatism, and gout (Gurib-Fakim 1996). The extracted juice from leaf, fruit, and even whole plant are routinely used for treatment of wounds, infections, parasites (e.g., worms), measles, hepatitis, and fevers (Behera et al. 2008). The juice of the leaves and fruit is given as an anti-helmintic and the pulverized part is applied externally against malignant ulcers (Oliver 1960). Traditionally, wild bitter gourd (*M. charantia* var. *abbreviata*) leaves are crushed to obtain the juice for applying on the skin for treating insect bites, bee stings, burns, contact rashes, and wounds. Decoction of its leaves and fruits is drunk as preventative or treatment for stomachache, toothache, liver diseases, diabetes, hypertension, and cancer (Chiu and Chang 1995).

M. dioica. Tender fruits and deseeded fruits (both immature as well as ripe) are cooked as vegetable and also roasted and made into chutney with condiments and coconut. Ripe fruits are eaten raw and aril of ripe seeds are consumed as refreshment. Tender leaves, flowers, and tuberous root of female plants are also eaten. It is reported to possess hypoglycemic, hepatoprotective, gastroprotective and ulcer healing activities, analgesic, expectorant, post coital antifertility, nematocidal, antiallergic, antimalarial, antifeedant, antibacterial, and antifungal activities (Fernandopulle and Ratnasooriya 1996). Fruits contain aliphatic compounds and act as appetizer and astringent (Ali and Srivastava 1998). The whole plant is used for treatment of eye diseases, poisoning, and fever (Satyavati et al. 1987). Tubers are extensively used in treatment of intestinal ulcer, piles, and snake bite by the tribes of Kerala (Joseph and Antony 2008) and root paste of male creeper is applied on scorpion sting, snake bite, and rat bite in Rajasthan (Seliya and Patel 2009). The root is

also used to stop bleeding from piles, as an expectorant and also in urinary and bowel complaints (Kirtikar and Basu 1981). The fruits, leaves, and tuberous roots are used in India as a folk remedy for diabetes (Sadyojatha and Vaidya 1996). Tuberous roots are used for curing diarrhea, fever, and rheumatism by the tribals of Odisha and the seeds are used against chest problems and also to stimulate urinary discharge (Bharathi et al. 2007). Decoction of leaves reduces fever; tuberous roots help in relieving headache, excess sweating, stone formation, migraine; while fruit is quite helpful in controlling diabetes and blood pressure (Ram et al. 2001). Across the whole of south, central, and eastern part of India, it is a high value, tender fruit vegetable.

M. sahyadrica. Tender fruits are consumed as health food for asthmatic and intestinal ulcer patients. Tender leaves and shoots of male plants are cooked as a leafy vegetable and are recommended for pregnant women and anemic patients in the "Paniya" community of Wyanad. Use of tuber paste as detergent and toilet soap holds promise in the cosmetic and health care industry. The medicinal uses of *M. sahyadrica* are restricted to Malayarayar, Gowli, and Jain Kurbas, all forest dwelling and grazier tribes. Tuber paste is also used as anti-inflammatory medicine in mastitis of milking cows and treatment of painful eruptions, swellings and breast inflammations in humans. Tuber juice along with *Calotropis* leaves are used as abortifacient in early stages of pregnancy. For the people of Malanadu and Konkan, its fruits are auspicious during "Anantha Padmanabha Pooja"; a 'prasadam-curry or rasam' made of *M. sahyadrica* is served in Shimoga area. In Hassan district, a vegetable dish made of potato, chickpea, and *M. sahyadrica* is a must for 'Ganesha Pooja' celebrations. However, in spite of its extensive edible use as a high value vegetable, its cultivation is not encouraged in the Karnataka part of Western Ghats. The local people believe that its cultivation will bring misfortune to the grower. The taboos discouraging *M. sahyadrica* husbandry has deep roots in conservation ethics.

M. subangulata subsp. *renigera*. Unlike other *Momordica* species, *M. subangulata* subsp. *renigera* do not appear to have multiple ethnobotanical importance. In Malaysia, the fruit and foliage is consumed as vegetable. Uphof (1968) gives a small account of economic importance of *M. subangulata* in Southeast Asia and mentions the use of tender shoots, leaves, and unripe fruits as vegetable under the name "Kambur" in Indonesia. Tender fruits are consumed extensively as fresh vegetable in whole of northeastern and eastern India.

M. cochinchinensis. Traditionally, it has been used as both food and medicine in the regions in which it grows. The fruits are esteemed as the fruit from Heaven (Voung 2001) for its ability to promote longevity, vitality, and health. The ripe fruit arils are cooked with red glutinous rice called '*xoi gac*' to impart its color and flavor in Vietnam and Thailand. Traditionally, '*xoi gac*' is served at weddings, the New Year (Tet), and for other important celebrations (Do 1991). During these occasions, it is essential to mask the white color of rice, since white is considered as the color of death. A document on Vietnamese traditional medicine lists the use of the gac seed membrane, which contains β-carotene and lycopene, to treat infantile rachitis, xerophthalmia, and night blindness. The report notes that the oil extract from the seed membrane can be given to small children to improve growth (Vu 1986).

The tender fruits of the plant are esteemed as vegetable. Young leafy shoots are cooked and eaten in Bali and the Philippines (Anonymous 1952). Tribal settlers like Mundas, Toppo, Tirkey, and Minj of Andamans also use it extensively as a leafy vegetable. It is traditionally used for wound healing, to improve eye health and to promote normal growth in children. The seeds are known in Traditional Chinese Medicine (TCM) as "Mubiezi". It is reported to have resolvent and cooling properties, are used for treating liver and spleen disorders, chest complaints, abdominal pains, dysentery, wounds, hemorrhoids, bruises, swelling, and pus (De Shan et al. 2001) while in India the seeds are

used for treating anemia and arthritis (Nayak 1993).

M. cymbalaria. The fruits are used as a vegetable by the rural people of south Tamil Nadu (Sundararaj and Balasubramanyam 1959; Parvathi and Kumar 2002) and preserved in the form of sun dried chips or after pickling (Anonymous 1952). Tender fruits are used to prepare Kaasara fry, Varugulu, and pickles in Andhra Pradesh, India. It has been used in various Asian traditional systems of medicine for a long time. The plant is traditionally used as abortifacient (Nadkarni and Nadkarni 1982) and for the treatment of diabetes mellitus, rheumatism, ulcer, skin disease, and diarrhea (Jeyadevi et al. 2012; Prashantkumar and Vidyasagar 2006; Rajasab and Isaq 2004). It was reported to possess hypoglycemic (Rao et al. 2003), anti-implantation and anti-ovulatory (Koneri et al. 2006), antidiarrhoeal (Swamy et al. 2008), anticancer (Jeevanantham et al. 2011), anti-microbial (Sangeetha et al. 2010), hepatoprotective (Kumar et al. 2008), nephroprotective (Kumar et al. 2011), anti-ulcer (Bharathidasan et al. 2010), and anticonvulsant activity (Murthy et al. 2007). No information is available on the ethnic uses of *M. clarkeana, M. rumphii*, and *M. denticulata* in Southeast Asia.

Folk Taxonomy

Interpretation of vernacular names given to a plant/species can provide evidence for evaluating the human interaction with the plant. The literature survey reveals innumerable vernacular names for *Momordica* spp, in various Indian languages. However, wild species with narrow distribution range and rarity often do not figure in the vernacular dictionary or may have the same name as the comparatively better known relative. Nevertheless, local dialects may have some names specific to the user community that needs to be recorded for collection and ethnobotanical study of the target taxon. One of the priorities to be evaluated when looking at the viability of a new crop is its acceptability to the consumers. In the case of *Momordica* species, fruits are esteemed and relied upon resource in several areas of its distribution range. A perusal of the available literature reveals many vernacular names in various Indian languages (Table 5.1).

Nutritive Value

Diversified and highly nutritive vegetables are of great importance in alleviating hunger and malnutrition. A balanced diet should contain adequate energy, protein, carbohydrate, fats, minerals, essential amino acids, and vitamins. To understand the place of the genus *Momordica* in the human diet, it is necessary to know about their composition from the nutritional point of view. Based on the available literature, the nutrient composition of *Momordica* species is compiled and presented in Tables 5.2 and 5.3. From these tables can be seen a lot of variations in the chemical composition reported, which may be due to the fact that the composition is influenced by farming practices, prevailing environmental condition, and age of plants. In comparison with other crops like cereals, pulses, and animal products, vegetables especially cucurbitaceous vegetables are not good sources of energy in the human diet. The use of cucurbits as food plants is not primarily for calorie, mineral, or vitamin values as they are poor or only modest sources of these nutrients. They are all relatively low in food value especially in protein. However, there are few exceptions like bitter gourds richer in vitamin C, spine gourd (*M. dioica*) high in protein, and sweet gourd (*M. cochinchinensis*) containing high carotenoid and lycopene pigments.

Bitter gourd has a relatively high nutritional value compared to other Cucurbits, due mainly to the iron, phosphorus, and ascorbic acid content (Oliver 1960; Morton 1967) but poor source of vitamin A and calcium (Morton 1967). The ascorbic acid is retained by the green fruit during storage; if stored after ripening, considerable loss of ascorbic acid occurs. It retains its ascorbic acid for four weeks when refrigerated at 32–35 °C and 85–90 % relative humidity

Table 5.1 Vernacular names of wild *Momordica* spp. in India and SE Asia

SN	Accepted taxon name	Vernacular name	Language/area
1	*M. charantia* var. *muricata*	Mithipaval, Chinna paval	Tamil
		Chundappaval, Karandkappaval, Kattuppaval, Naippaval, Kundupavai, Nadanpaval, Kuttahippaval, Undappaval, Kaduhagalikkai, Jungle karela, Uchchhe, Oochya, Oochi	Malayalam
		Jangli karela	Bengali
		Gidda hagala	Hindi, Marathi
		Kadu hagali	Kannada
		Tulsi karela	Tulu
			Oriya
2	*M. charantia* var. *charantia*	Pavakkai, Pagel	Tamil
		Karela, Kash	Bengali
		Karela, Kareli	Hindi
		Halal	Kannada
		Kaippa, Kaippakka, Kaippavalli, Pavel, Pullayini, Rajavalli	Malayalam
		Karle	Marathi
		Karkotakee, Karavalli, Karavella, Karavellaka, Katika, Sushavi, Vishakantaki	Sanskrit
		Kakara kayi	
		Hagala kayi	Telugu
		Karathay	Kannada
			Konkan
3	*M. balsamina*	Mokha	Hindi
		Mokha	
		Garafuni	Arab
			Nigeria
4	*M. dioica*	Pazhupagel, Thulapava, Kuruvithalaipavai, Palupakkai	Tamil
		Akkarakka	Telugu
		Desi kankad	Oriya
		Kattupaval, Naipaval, Venpaval, Erumappaval, Kattu kappakka	Malayalam
		Karlikai	
		Kartoli	Kannada
		Vahisi	Marathi
		Kakrol	Sanskrit
		Karonda	Hindi
		Thumba-Karavila	Rajasthan
			Sinhala (Sri Lanka)
5	*M. sahyadrica*	Vaikka, Mada Hagalikka, Kadukovakka, Kattupaval, Pothupaval	Malayalam
		Madavala hagalikkai, Katteli, Madahagala, Mattahagala, Karayachakka, Akkachikka	Kannada
			Tulu

(continued)

Table 5.1 (continued)

SN	Accepted taxon name	Vernacular name	Language/area
6	*M. cochinchinensis*	Golkakra	Bengali
		Hathia kankad	Oriya
		Hathi karela	Assam
		Adavi kakrol, Crow cucumber	Telugu
		Jangli Kakrol	Andaman Islands
		Rajkangra	Tripura
		Gac	Vietnam
		Mu bie zi	China
		Terua	Malaya
		Makkao	Indochina
		Makubet sushi	Japan
7	*M. subangulata* subsp. *renigera*	Assam kankad/hybrid kankad	Oriya
		Bhat karela	Assam
		Lamkarote	Manipur
		Kangra	Tripura
		Maitamtok	Mizoram
		Meeta chottele	Nepal-Sikkim
		Kaksa	Bihar
		Kakrol, Kangra	Bengal, Tripura
		Karkul	Mizoram
		Gantola	Bangalore
		Yunnan mu	China
8	*M. subangulata* subsp *subangulata*	Phak mae, Phak Hai	Thailand
9	*M. cymbalaria*	Athalkkai	Tamil Nadu
		Karchikai	Karnataka
		Vasarakayee	Andhra Pradesh
10	*M. denudata*	Batu-Karavila	Sri Lanka

(Anonymous 1952). Drying in sun (green fruit slice) also leads to 80 % loss of ascorbic acid (Anonymous 1952) and cooking destroys 40–50 % (Miller et al. 1946; Anonymous 1952). The proximate analysis shows that the leaf and fruit of *M. charantia* are good sources of carbohydrate and protein; these may serve as sources of energy and nutrients for the body metabolic activities in addition to its medicinal properties (Bakare et al. 2010). The nutritional value of small bitter gourds (*M. charantia* var. *muricata*) is higher or at par in most of the components except phosphorus than that of large bitter gourds (*M. charantia* var. *charantia*). *M. charantia* is a good source of calcium and abundant calcium carbonate crystals in the form of cystoliths and pure crystals as calcium oxalate are found in every part of the plant (Chakravarty 1937). The leaves are a good source of calcium, carotene, riboflavin, and ascorbic acid (Anonymous 1952).

M. charantia var. *abbreviata* (synonymous to var. *muricata*) is reported to have potent antioxidant and free radical scavenging activities and its therapeutic benefits and bioactive compounds warrant further investigation (Semiz and Sen 2007; Wu and Ng 2008; Islam et al. 2011). Jittawan and Siriamornpun (2008) reported that

Table 5.2 Proximate composition of *Momordica* spp. (value per 100 g)

	Moisture (g)	Ash (g)	Fat (g)	Fiber (g)	Protein (g)	Carbohydrate (g)	Energy (K. Cal.)	Reference
M. charantia var. *muricata* (fruit)	83.20	–	1.00	1.70	2.10	10.60	60.00	Gopalan et al. (1982)
M. charantia var. *charantia* (fruit)	92.40	–	0.20	0.80	1.60	4.20	25.00	Gopalan et al. (1982)
M. charantia (boiled, drained, no salt)	93.95	–	0.18	2.0	0.84	4.32	19.00	USDA Nutrient database
M. balsamina (fruit)	89.40	–	0.10	1.80	2.00	5.10	–	Arnold et al. (1985)
M. balsamina (leaf)	89.40	–	0.10	0.90	3.00	3.60	–	Arnold et al. (1985)
M. balsamina (leaf)	85.00	–	0.50	2.75	5.00	6.82	–	Odhav et al. (2007)
M. dioica (fruit)	84.10	–	1.00	3.00	3.10	7.70	52.00	Gopalan et al. (1982)
M. s. subsp. *renigera* (fruit)	90.40		0.10	1.60	0.60	6.40	29.00	Gopalan et al. (1982)
M. cochinchinensis (fruit)	88.60	–	0.10	1.10	1.50	7.60	37.00	Gopalan et al. (1982)
M. cochinchinensis (fruit)	93.00	–	–	1.03	0.94	–	–	AVRDC (2002)
M. cymbalaria (fruit)	84.30	–	–	6.42	2.15	12.60	73.00	Parvathi and Kumar (2002)

leaf extract of bitter gourd showed the higher value of antioxidant activity based on 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical-scavenging activity and ferric reducing antioxidant power (FRAP), while the green fruit extract showed the highest value of antioxidant activity based on hydroxyl radical-scavenging activity, β-carotene–linoleate bleaching assay, and total antioxidant capacity. Seeds of bitter gourd also possess potent antioxidant activity, which may be directly or indirectly responsible for its hypoglycemic property (Sathishsekar and Subramanian 2005).

Bitter gourd flesh contains high lysine and relatively lower glutamic acid and arginine compared to soy protein isolate. In addition, essential amino acids, including threonine, valine, methionine, isoleucine, leucine, and phenylalanine are comparable in amount to soy proteins and other legume proteins (Islam et al. 2011). Hassan and Umar (2006) detected 17 amino acids with glutamic acid, leucine, and aspartic acid being the

Table 5.3 Mineral composition and vitamin content of *Momordica* spp. (value per 100 g)

	Calcium (mg)	Magnesium (mg)	Phosphorus (mg)	Iron (mg)	Zinc	Carotene (mg)	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	Vitamin C (mg)	Reference
M. charantia var. *muricata* (fruit)	23.00	–	38.00	2.00	–	0.13	0.07	0.60	0.40	96.00	Gopalan et al. (1982)
M. charantia var. *charantia* (fruit)	20.00	–	70.00	1.80	–	0.13	0.07	0.90	0.50	88.00	Gopalan et al. (1982)
M. charantia (boiled, drained, no salt)	9.00	16.00	36.00	0.38	–	6 (μg vitamin A equiv.)	0.05	0.05	0.28	33.00	USDA Nutrient database
M. balsamina (fruit)	35.90	41.20	35.80	2.60	1.00	–	0.04	0.06	–	0.50	Arnold et al. (1985)
M. balsamina (leaf)	340.00	87.10	27.70	12.70	0.90	–	0.01	0.09	0.70	0.40	Arnold et al. (1985)
M. balsamina (leaf)	2688.00	613.00	356.00	23.00	12.00	–	–	–	–	–	Odhav et al. (2007)
M. dioica (fruit)	33.00	–	42.00	4.60	–	1620 (IU)	0.05	0.10	0.60	–	Gopalan et al. (1982)
M. s. subsp. *renigera* (fruit)	27.00	–	38.00	–	–	–	–	–	–	–	Gopalan et al. (1982)
M. cochinchinensis (fruit)	64.00	–	89.00	–	–	–	–	–	–	–	Gopalan et al. (1982)
M. cochinchinensis (fruit)	23.00	–	–	0.34	–	91	–	–	–	–	AVRDC (2002)
M. cymbalaria (fruit)	72.00	–	0.46	1.70	2.82	0.01	–	–	–	290.00	Parvathi and Kumar (2002)

Fig. 5.1 Ripe fruits of *M. cochinchinensis*

predominant amino acids. Isoleucine, leucine, valine, and aromatic acids were found to be higher than the WHO/FAO/UNU (1985) requirement pattern for children, while sulfur containing amino acids are the only limiting amino acids for adults. Bitter melon contained 17 amino acids at satisfactory levels, except cysteine and methionine and this crop could be a very good source in the production of arginine, alanine, gamma amino butyric acid (GABA), and other amino acids found in high concentrations, on a commercial basis (Kim et al. 2011).

Crude fiber decreases the absorption of cholesterol from the gut and also delays conversion of starch into sugars and such attributes would be desirable for the diabetic and the higher crude fiber content of *M. cymbalaria* which is a desirable attribute (Parvathi and Kumar 2002). Calcium is required for growth of bones and teeth as well as for maintaining normal heart rhythm, blood coagulation, muscle contraction, and nerve responses and ascorbic acid is important in immune response, wound healing, and allergic reactions. The higher content of calcium, potassium, and ascorbic acid in *M. cymbalaria* may be exploited and used for health benefits (Parvathi and Kumar 2002).

M. dioica has medium protein value (19.38 mg/g), fat (4.7 mg/g) and phenolic compounds (3.69 mg/g) and have maximum calorie value (4125/83 kcal/Kg) when compared to eight traditional wild vegetables of Indo-Persian region (Ali and Deokule 2009) and could be a good supplement for nutrients such as fiber, potassium, zinc, lipid, protein, and carbohydrates (Ali 2010, 2011a). Plant foods that provide more than 12 % of their calorific value from protein are a good source of protein (Pearson 1976) and in this context, *M. dioica* fruits are good sources of protein (Ali 2011b). *M. dioica* is also suitable for high temperature food processes, because it has very low free sugar concentrations, thereby reducing the possibility of Maillard reaction and subsequent acrylamide formation (Ali and Deokule 2010). Teasel gourd is rich in carotene, protein, carbohydrate (Rashid 1993), and vitamin C (154.7 mg/100 g of edible portion) (Bhuiya et al. 1977). *M. sahyadrica* being a recently established taxonomic entity, reliable estimate of its nutritional contents are not available. However, being closely related to *M. dioica*, it can be reasonably inferred to be similar to it.

Vegetables do not contain vitamin A but have carotenoids with active ingredient carotene, mostly β-carotene, a precursor of vitamin A, also known as pro-vitamin A. Vitamin A deficiency (VAD) causes loss of vision, night blindness, and damages eye cornea leading to total blindness. The ripe fruit of *M. cochinchinensis* (Fig. 5.1) is becoming known as a premier source of carotenoids and its aril was extensively studied for β-carotene and lycopene. The aril contains β-carotene and lycopene at very high levels, with those of lycopene being up to 308 μg/g in the seed membrane, about 10-fold higher than in other

lycopene-rich fruits and vegetables (Vuong 2001; Aoki et al. 2002; Vuong et al. 2003, 2006). Aril tissues contained 2,227 μg total lycopene and 825 μg total carotenoids (718 μg of total β-carotene and 107 μg α-carotene/g FW). The aril also contains 102 mg oil/g of fruit weight (Voung 2001) and of the total fatty acids in sweet gourd aril, 69 % are unsaturated and 35 % of these are polyunsaturated (Voung and King 2003). Oil extracted from the fruit aril showed a total carotenoid concentration of 5,700 μg/ml, with 2,710 μg of that being β-carotene. This oil also included high levels of vitamin E (Vuong and King 2003; Kuhnlein 2004). The fatty acids in the aril are important for the absorption of fat-soluble nutrients including carotenoids in a diet typically low in fat (Kuhnlein 2004; Vuong 2001). Thus, *M. cochinchinensis* provides an acceptable source of high levels of valuable antioxidants that have good bioavailability. However, these studies have been conducted in ripe fruits of *M. cochinchinensis* and the nutrient content of tender fruit is least studied. Apart from *M. cochinchinensis* arils of other *Momordica* species (except *M. cymbalaria*) are also bright red in color and may contain high levels of lycopene and β-carotene. For example, bitter gourd contains bright red seeds due to high lycopene, a pigment that can be used as an artificial food colorant (Yen and Hwang 1985). However, the yield of arils/fruit is much higher in *M. cochinchinensis* and extraction may be economically feasible.

Pre-school children up to 4 years of age and pregnant mothers are the most affected by VAD. Nutritional supplementation trials in Vietnam have shown that children fed with '*xoi gac*' (rice cooked with fruit pulp of *M. cochinchinensis*, popularly called *gac*) have significantly higher plasma β-carotene, compared to those who received synthetic β-carotene powder or none (control). Increases in plasma retinol, α-carotene, zeaxanthin, and lycopene levels were also significantly greater in children fed with gac (Vuong et al. 2003). It is likely that the fatty acids in gac are what make its β-carotene more bioavailable than that of the synthetic form (Vuong et al. 2003).

The leaves of *M. balsamina* are a popular vegetable, consumed regularly in the eastern parts of South Africa (Fox and Young 1982; Van Wyk and Gericke 2000; Hart and Vorster 2006; Jansen van Rensburg et al. 2007; Odhav et al. 2007). The ash content, which is an index of mineral contents in biota, is high (18.00 ± 0.56 % DW) in leaves which indicates *M. balsamina* leaves could be good sources of mineral elements and could be a good supplement for some mineral elements particularly K, Ca, Mg, Fe, Cu, and Mn when compared with RDA values (Hassan and Umar 2006). Odhav et al. (2007) also recommended the commercial cultivation of *M. balsamina* as the mineral content is much higher than typical mineral concentrations in conventional edible leafy vegetables. *M. balsamina* leaves can provide 20–33 %, 59–87 %, 16 %, 16 % of protein, 31 %, 31 %, 23 %, 19 % of carbohydrate to daily requirement of adults, children, pregnant, and lactating mothers respectively (Hassan and Umar 2006). These results show that *M. balsamina* leaves could be important green leafy vegetables as a source of nutrients to supplement other major sources. However, chemical analysis alone should not be the sole criteria for judging the nutritional importance of a plant's parts. It is imperative to consider other aspects such as presence of anti-nutritional/toxicological factors and biological evaluation of nutrients' form, content, availability, and utilization. However, research efforts in these areas are rather meager. Wild vegetables like *M. balsamina* leaves could be promoted as a protein supplement for cereal-based diets in poor rural communities, while its high potassium content can be utilized for the management of hypertension and other cardiovascular conditions. The relatively high concentrations of zinc, iron, and manganese could contribute toward combating the problem of micronutrient deficiencies (Flyman and Afolayan 2007). In addition to its nutritive value, *M. balsamina* has efficient free radical scavengers (94 % inhibited) and could potentially be exploited as sources of antioxidants (Odhav et al. 2007).

Other Phytochemicals

A number of phytochemicals of potential medical components have been isolated from *M. charantia*, like the ribosome inactivating protein (RIP), MAP30 (*Momordica* anti-HIV protein), which suppresses HIV (human immunodeficiency virus) activity, *M. charantia* lectin (MCL), *M. charantia* inhibitor (MCI), and momordicoside A and B, both of which can inhibit tumor (Lee-Huang et al. 1990; Bourinbaiar and Lee-Huang 1996; Beloin et al. 2005). Lee-Huang et al. (1995) cloned *Map30* gene and used to express biologically active re-MAP 30 which exhibited anti-HIV and anti-tumor activities from bitter gourd. *Momordica* fruit contains steroids, charantin, momordicosides (G, F1, F2, I, K, L), acyl glucosyl sterols, linolenoyl glucopyranosyl elenosterol, amino acids, fatty acids, and phenolic compounds. The phytochemicals isolated from the whole plant, vines, or leaves include saponins, sterols, steroidal glycosides, alkaloids, amino acids, and proteins (Raman and Lau 1996). Phytochemicals of pharmaceutical importance like momordicin II (ribosome inactivating protein) and rosmaric acid (caffeic acid ester) have been isolated from *M. balsamina* (Bosch 2004) and phytochemical screening of its leaves revealed the presence of tannins, saponins, and lectins (Akinniyi et al. 1983). Lectins, β-sitosterol, saponin glycosides, triterpenes of ursolic acid, hederagenin, oleanolic acid, α-spiranosterol, stearic acid, gypsogenin, momodicaursenol, and some aliphatic constituents were isolated from different parts of *M. dioica* (Ghosh et al. 1981; Sadyojatha and Vaidya 1996; Ali and Srivastava 1998 and Luo et al. 1998).

Charantin, a typical cucurbitane-type triterpenoid obtained from *M. charantia* is a potential substance with antidiabetic properties (Krawinkel and Keding 2006) and demonstrated to treat diabetes and can potentially replace treatment (Pitiphanpong et al. 2007). It was identified by Lolitkar and Rao (1960) who showed that when charantin is taken orally or intravenously in rabbits, it produces hypoglycemic effects (Lolitkar and Rao 1966). This compound is a mixture of two compounds (1:1), namely, β-sitosteryl glucoside ($C_{35}H_{60}O_6$) and 5,25-stigmasteryl glucoside ($C_{35}H_{58}O_6$). A number of patents have been submitted on activities and processes of *Momordica* spp. for insulin-type properties. Cochinin B, a novel ribosome-inactivating protein (RIP) is purified from the seeds of *M. cochinchinensis* (Chuethong et al. 2007) manifested strong anti-tumor activities. Wong et al. (2004) isolated five trypsin inhibitors, exhibiting a molecular weight of 5100, 4800, 4400, 4100, and 3900, respectively, from seeds of *Momordica cochinchinensis* differing in specific trypsin-inhibitory activity.

Postharvest research leading to product utilization as nutraceuticals and nutritional supplements needs attention. While *M. cochinchinensis* is reported to be the richest source of β-carotene and is shown to play a big role in alleviating vitamin A deficiency in tropical countries, there is no concerted effort on its development. Other species of Asian *Momordica* including bitter gourd offer high potential for developing vitamin A supplements from seed aril and fruit pulp. Use of wild species as leafy vegetables is reported from Asia and Africa. *M. balsamina* is one of the most nutritious leafy vegetables in Africa. Similary, *M. subangulata* and *M. cochinchinensis* are used extensively in Asia as a leafy vegetable. They need to be studied for popularization and use as leafy vegetable crops. There is an export market demand for *M. cochinchinensis* and other Asian *Momordica* from ethnic communities living outside Asia. Postharvest processing and export open up avenues for more income generation in India, Vietnam, Sri Lanka, and other SE Asian countries.

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