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Bitter Gourd and Human Health

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ABSTRACT

Bitter gourd (*Momordica charantia* L.; Family: Cucurbitaceae) is a vegetable with tropical and subtropical distribution. Bitter gourd fruit is a rich source of nutrients and ranks first among cucurbits for its nutritive value, being a good source of carbohydrates, proteins, vitamins, and minerals. Natural antioxidants in bitter gourd are primarily plant phenolics and polyphenolic compounds derived from fruits and seeds, and thus are alternatives to replace synthetic antioxidants to enhance food quality. Fruit contains as many as 14 carotenoids (five at the immature stage, and six and 14 in the mature-green and ripe stages, respectively) and cryptoxanthin, which is the principal chloroplast- and chromoplast-based pigment in ripe fruit.

Keywords: antidiabetic, antioxidant, ethnomedical, human nutrition

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INTRODUCTION

Vegetables play a significant role in human nutrition, as vitamin sources (i.e., A, B_6, C, E, thiamine, and niacin), minerals, dietary fiber and other phytonutrients (Quebedeaux and Eisa 1990; Wargovich 2000). These compounds are associated with a reduced incidence of cancer, cardiovascular disease, and other chronic diseases (Quebedeaux and Eisa 1990; Wargovich 2000). A vegetable with several health promoting properties is bitter gourd (syn. bitter melon, balsam pear, *Momordica charantia* L.) which belongs to the family Cucurbitaceae. It is widely grown in Asia for its medicinal attributes, especially in China, India and Southeast Asia. There are also small acreages of this crop species grown in the United States, primarily in California and Florida.

Bitter gourd demonstrates wide diversity. The fruit morphology varies greatly in color, size, and exocarp characteristics (**Fig. 1**). For instance, Indian *M. charantia* var. *charantia* cultivars bear large fusiform fruit, while wild, free-living *M. charantia* var. *muricata* ecotypes develop small, round fruits (Chakravarty 1990). In contrast, three distinct types occur in China; ecotypes bearing small (10-20 cm) extremely bitter fruits; those which develop comparatively long (30-60 cm) slightly bitter fruits; and ecotypes which produce moderately to strongly bitter 9-12 cm long, triangular or cone-shaped fruit (Yang and Walters 1992). In Southeast Asian, small ecotypes enjoying worldwide cultivation are botanically designated as *M. charantia* var. *minima* Williams & Ng (fruit <5 cm in diameter), and large *M. charantia* var. *maxima* Williams & Ng (fruit >5 cm in diameter) (Reyes *et al*. 1994). However, Chinese bitter gourd ecotypes are morphologically different from Indian types, and have not yet received botanical variety designations.

ETHNOMEDICAL USES

Traditionally, plant extracts of bitter gourd have been used in the treatment of diabetes (e.g., India, China, and Central America; Grover *et al*. 2002; Yeh *et al*. 2003; Chen *et al*. 2003; Vikrant *et al*. 2003). The beneficial attributes of hypoglycaemic compounds (Ali *et al*. 1993; Srivastava *et al*. 1993; Jayasooriya *et al*. 2000), anti-carcinogenic and hypercholesterolemic (Ganguly *et al*. 2000; Ahmed *et al*. 2001) properties in bitter gourd fruit mesocarp, seed, and vegetative plant parts have been widely documented. It has been determined that bitter gourd contains the health-promoting substances charantin (hypoglycaemic; Yeh *et al*. 2003), momorcharin (inactivating ribosome; Feng *et al*. 1990; Leung *et al*. 1997), MAP30 (a *Momordica*-HIV protein that suppresses HIV activity; Lee-Huang *et al*. 1990, 1995), vicine (hypoglycaemic; Dutta *et al*. 1981), and momordicoside A and B (tumor growth inhibitors; Okabe *et al*. 1980)]. The antimicrobial (Omoregbe *et al*. 1996; Yesilada *et al*. 1999), antifertility (Basch *et al*. 2003), antiviral (Takemoto 1983; Lee Huang 1990; Nerurkar *et al*. 2006), and antiulcerogenic (Gurbuz *et al*. 2000) activities characterized in bitter gourd have been attributed to a broad array of biologically active phytochemicals, including triterpenes, and steroids (Grover and Yadav 2004).

The antioxidant properties of carotenoids which protect plant photosynthetic processes may also protect humans from carcinogens and heart disease (Simon 1997). Natural antioxidants in bitter gourd are primarily plant phenolics and polyphenolic compounds derived from fruits and seeds, and thus are alternatives to replace synthetic antioxidants to enhance food quality. Bitter gourd fruit contain as many as 14 carotenoids (five at the immature stage, and six and 14 in the mature-green and ripe stages, respectively) and cryp-

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Invited Research Note

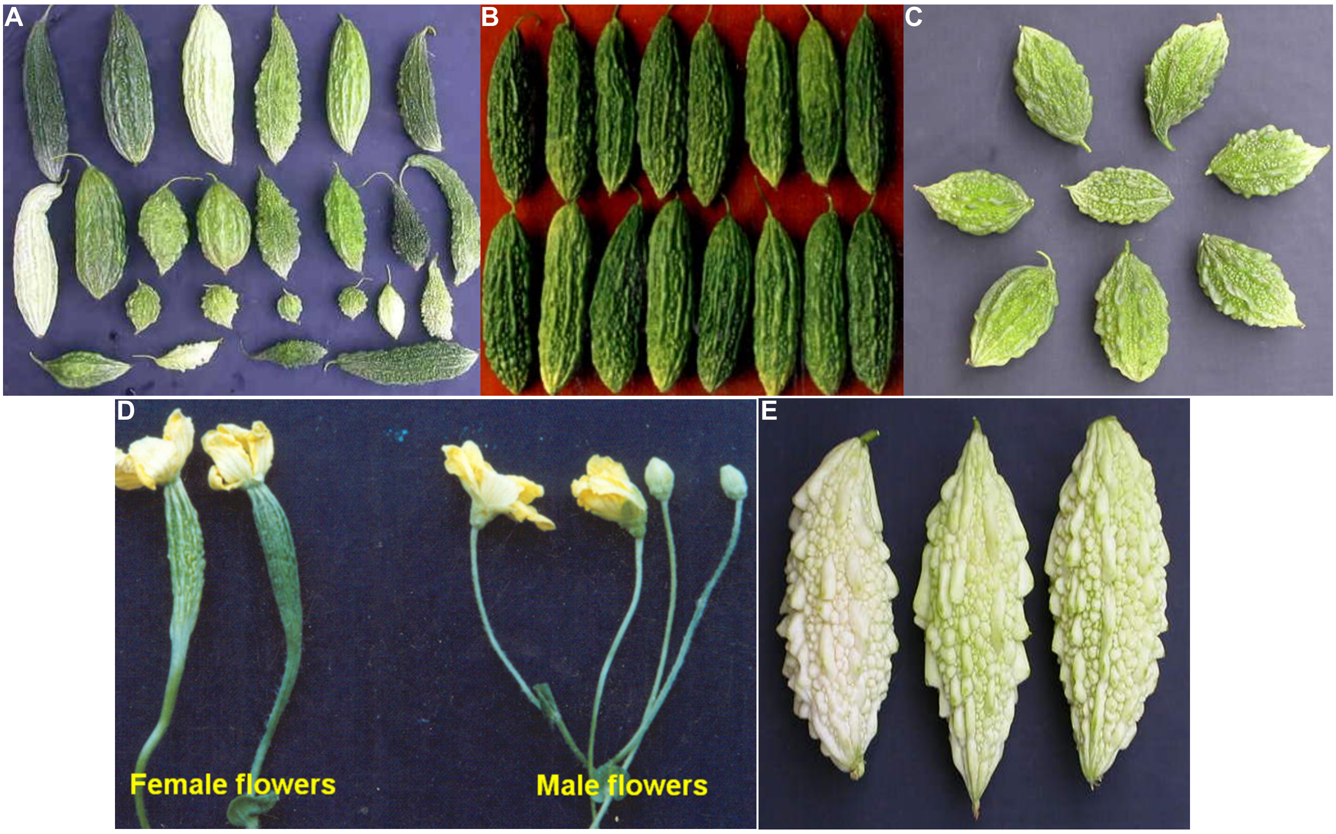

Fig. 1 (**A**) Diversity in fruit (size, shape, exocarp color, and surface texture of few bitter gourd (*Momordica charantia* L) accessions collected in India. (**B**) 'Pusa Vishesh'– A glossy-green, large-fruited (*M. charantia* var. *charantia*; 15-20 cm long) public-sector cultivar with higher ascorbic acid (818.7 mg·kg^{-1}) and chlorophyll (93.1 mg·kg^{-1}) contents (Pal *et al.* 2005), suitable for making dehydrated rings, is commercially grown in India. (**C**) Small-fruited (*M. charantia* var. *minima* Williams & Ng) types with higher proteins (29 g·kg^{-1}), carbohydrates (98 g·kg^{-1}), iron (94 mg·kg^{-1}), calcium (500 mg·kg^{-1}), (Desai and Musmade 1998) and Vitamin 'C' (900-1200 mg·kg^{-1}) (Behera *et al.* 2006). (**D**) Monoecious, small (10-12 cm corolla diameter), yellow, male and female flowers of *M. charantia* L. (**E**) Indian white-fruited varieties are high in total phenols, phenolic acids and other antioxidants (Horax *et al.* 2005).

Table 1 Comparative nutritive value of bitter gourd (*M. charantia*) and cucumber (*C. sativus*) fruit.

Fruit nutrient[1]	***C. sativus***	***M. charantia* var. *charantia* (Large fruited type)**	***M. Charantia* var. *muricata* (Small-fruited type)**
Moisture	96.3 g	92.4 g	83.2 g
Carbohydrates	2.5 g	4.2 g	9.8 g
Proteins	0.4 g	1.6 g	2.9 g
Fat	0.1 g	0.2 g	1.0 g
Fiber	0.4 g	0.8 g	1.7 g
Calcium	10.0 mg	20.0 mg	50.0 mg
Phosphorus	25.0 mg	70.0 mg	140.0 mg
Iron	1.5 mg	2.2 mg	9.4 mg
Vitamin A (as carotenes)	-	210 IU	220 IU
Vitamin C	7.0 mg	70-85 mg	90-120 mg

[1]Composition per 100 g fresh edible portion
Source: Desai and Musmade 1998

toxanthin which is the principal chloroplast- and chromoplast-based pigment in ripe fruit (Rodriguez *et al.* 1976). Additional carotenoids such as β-carotene, zeaxanthin and lycopene (primarily at ripe stage), and lutein and α-carotene (primarily at immature fruit) are also prevalent in the fruits, and thus bitter gourd could serve as an instructive model for studying carotenogenesis during ripening (Rodriguez *et al.* 1976; Tran and Roymundo 1999). The total carotenoid dry weight concentration of the seeds of bitter gourd at the immature (~2.8 μg·g^{-1}) stage is relatively low compared to the ripe (~271 μg·g^{-1}) stage. Carotene in the ripe seed coat is exclusively lycopene (~261 μg·g^{-1}) which accounts for 96% of the total carotenoids found in ripe seeds (Rodriguez *et al.* 1975).

Antioxidants in plants also include vitamin C, vitamin E, phenolic acids, and organosulfur compounds (Simon 1997). Bitter gourd fruits are, in fact, a rich source of the phenolic compounds like gallic acid, gentisic acid, catechin, chlorogenic acid, and epicatechin that vary from 80 to over 800 mg·kg^{-1}, each on dry weight basis among cultivars and tissues (Horax *et al.* 2005). These natural plant phenolics are an excellent source of antioxidants for reducing blood pressure, cancer, and cardiovascular diseases (Tanaka *et al.* 1993; Balentine *et al.* 1997; Bravo 1998; Surh 1999; Gorinstein *et al.* 2002; Wang and Mazza 2002; Hannum 2004).

NUTRITIONAL ATTRIBUTES

Bitter gourd fruit is a rich source of nutrients (Xiang *et al.* 2000) and ranks first among cucurbits for its nutritive value (Miniraj *et al.* 1993), being a good source of carbohydrates, proteins, vitamins, and minerals (Yawalkar 1980). For instance, Chinese bitter gourd is a rich source of vitamin C (44.0-78.0 mg·g^{-1} fresh edible portion), 16 essential amino acids and crude protein (11.4-20.9 g·kg^{-1}), levels higher than that found in tomato and cucumber (Xiang *et al.* 2000; **Table 1**).

Considerable variation in nutrient concentration exists in Indian bitter gourd accessions depending on geographic origin. The highest fresh concentrations of protein (2.1%), iron (30 mg·kg^{-1}), carbohydrates (7.2%), phosphorous (740 mg·kg^{-1}), and ascorbic acid, (740 mg·kg^{-1}) have been observed in local collections originating near Delhi, India (Kale *et al*. 1991). The small-fruited var. *muricata* types contain higher amounts of proteins, fats, carbohydrates, and minerals (i.e., iron, calcium and vitamin C contents) than large-fruited var. *charantia* types (Desai and Musmade 1998; Behera *et al*. 2006; **Table 1**).

SUMMARY

Bitter gourd is a rich source of many important health promoting substances that make it an economically important crop species for plant improvement. Efforts directed towards improving nutritional quality and consumer appeal (i.e., color, texture, shape, and size) in this species will provide a sustainable, inexpensive complement to medical and social programs aimed at alleviating certain human diseases. Well-designed interdisciplinary research involving nutritionists and physicians to elucidate mechanisms of action, long term medical studies to define optimum dosage and assess efficacy and safety in a clinical setting, vegetable breeders who improve fruit quality by identifying non-bitter or less bitter genotypes, and agronomists who explore genotype × environment interactions in various *M. charantia* types in pharmaceutical properties, need to be initiated to ensure broad consumer acceptance of this important crop species.

REFERENCES

Ahmed I, Lakhani MS, Gillett M, John A, Raza H (2001) Hypotriglyceridemic and hypocholesterolemic effects of anti-diabetic *Momordica charantia* (karela) fruit extract in streptozotocin-induced diabetic rats. *Diabetes Research and Clinical Practice* **51**, 155-161

Ali L, Khan AK, Mamun MI (1993) Studies on hypoglycemic effects of fruit pulp, seed, and whole plant of *M. charantia* on normal and diabetic model rats. *Planta Medica* **59**, 408-412

Balentine DA, Wiseman SA, Bouwens LCM (1997) The chemistry of tea flavonoids. *Critical Reviews in Food Science and Nutrition* **37**, 693-704

Basch E, Gabardi S, Ulbricht C (2003) Bitter melon (*Momordica charantia*): A review of efficacy and safety. *American Journal of Health-System Pharmacy* **60**, 356-359

Behera TK, Dey SS, Sirohi PS (2006) Variation in ascorbic acid and carotenoid content in bitter gourd (*Momordica charantia* L.) genotypes. International Conference on biotechnology approaches for alleviating malnutrition and human health held at Bangalore, India, 62 pp

Bravo L (1998) Polyphenols: chemistry, dietary sources, metabolism, and nutritional significance. *Nutrition Reviews* **56**, 317-333

Chakravarty HL (1990) Cucurbits of India and their role in the development of vegetable crops, In: Bates DM, Robinson RW, Jeffrey C (Eds) *Biology and Utilization of Cucurbitaceae*, Cornell University Press, Ithaca, New York, pp 325-334

Chen Q, Laureen L, Chan L, Li Edmund T (2003) Bitter melon (*Momordica charantia*) reduces adiposity, lowers serum insulin and normalizes glucose tolerance in rats fed a high fat diet. *The Journal of Nutrition* **133**, 1088-1093

Desai UT, Musmade AM (1998) Pumpkin, squashes and gourds, In: Salunkhe DK, Kadam SS (Eds) *Handbook of Vegetable Sciences and Technology*, Marcel Dekker Inc., New York, USA, pp 282-286

Dutta PK, Chakravarty AK, Chowdhury US (1981) Vicine, a favism-inducing toxin from *Momordica charantia* Linn. seeds. *Indian Journal of Chemistry* **20**, 669-671

Feng Z, Li WW, Yeung HW, Chen SZ, Wang YP, Lin XY, Dong YC, Wang JH (1990) Crystals of α-momorcharin: a new ribosome-inactivating protein. *Journal of Molecular Biology* **214**, 625-626

Ganguly C, De S, Das S (2000) Prevention of carcinogen induced mouse skin papilloma by whole fruit aqueous extract of *Momordica charantia*. *European Journal of Cancer Prevention* **9**, 283-288

Gorinstein S, Martin-Belloso O, Lojek A, Ciz M, Soliva-Fortuny R, Park YS, Caspi A, Libman I, Trakhtenberg S (2002) Comparative content of some phytochemicals in Spanish apples, peaches and pears. *Journal of the Science of Food and Agriculture* **82**, 1166-1170

Grover JK, Yadav SP (2004) Pharmacological actions and potential uses of *Momordica charantia*: A review. *Journal of Ethnopharmacology* **93**, 123-132

Grover JK, Rathi SS, Vats V (2002) Amelioration of experimental diabetic neuropathy and gastropathy in rats following oral administration of plant (*Momordica charantia*, *Eugenia jambolana*, *Mucuna pruriens* and *Tinospora cordifolia*) extracts. *Indian Journal of Experimental Biology* **40**, 273-276

Gurbuz I, Akyuz C, Yesilada E, Sener B (2000) Anti-ulcerogenic effect of *Momordica charantia* L. fruits on various ulcer models in rats. *Journal of Ethnopharmacology* **71**, 77-82

Hannum SM (2004) Potential impact of strawberries on human health: A review of the science. *Critical Reviews in Food Science and Nutrition* **44**, 1-17

Horax R, Hettiarachchy N, Islam S (2005) Total phenolic contents and phenolic acid constituents in 4 varieties of bitter melons (*Momordica charantia*) and antioxidant activities of their extracts. *Journal of Food Science* **70**, 275-280

Jayasooriya AP, Sakono M, Yukizaki C, Kawano M, Yamamoto K, Fukuda N (2000) Effects of *Momordica charantia* powder on serum glucose levels and various lipid parameters in rats fed with cholesterol-free and cholesterol-enriched diets. *Journal of Ethnopharmacology* **72**, 331-336

Kale AA, Gadakh SR, Adsule RN (1991) Physico-chemical characteristics of improved varieties of bitter gourd (*Momordica charantia* L.). *Maharashtra Journal of Horticulture* **5**, 56-59

Lee-Huang S (1990) MAP 30: A new inhibitor of HIV-1 infection and replication. *FEBS Letters* **272**, 12-18

Lee-Huang S, Huang, PL, Bourinbaiar AS, Chen HC, Kung HF (1995) Inhibition of the integrase of human immuno- deficiency virus (HIV) type 1 by anti-HIV plant proteins MAP30 and GAP31. *Proceedings of the National Academy of Sciences USA* **92**, 8818-8822

Leung KC, Meng ZQ, Ho WKK (1997) Antigenic determination fragments of α-momorcharin. *BiochImica et Biophysica Acta* **1336**, 419-424

Miniraj NM, Prasanna KP, Peter KV (1993) Bitter gourd (*Momordica* spp). In: Kalloo G, Bergh BO (Eds) *Genetic Improvement of Vegetable Plants*, Pergamon Press, Oxford, pp 239-246

Nerurkar PV, Lee YK, Linden EH, Lim S, Pearson L, Frank J, Nerurkar VR (2006) Lipid lowering effects of *Momordica charantia* (Bitter Melon) in HIV-1-protease inhibitor-treated human hepatoma cells, HepG2. *British Journal of Pharmacology* **148**, 1156-1164

Okabe H, Miyahara Y, Yamauchi T, Mirahara K, Kawasaki T (1980) Studies on the constituents of *Momordica charantia* L. I. Isolation and characterization of momordicosides A and B, glycosides of a pentahydroxy-cucurbitane triterpene. *Chemistry and Pharmacology Bulletin* **28**, 2753-2762

Omoregbe RE, Ikuebe OM, Ihimire IG (1996) Antimicrobial activity of some medicinal plants extracts on *Escherichia coli*, *Salmonella paratyphi* and *Shigella dysenteriae. African Journal of Medical Sciences* **25**, 373-375

Pal RK, Behera TK, Sen N, Singh M (2005) Influence of harvest maturity on respiration, ethylene evolution, texture and nutritional properties of bitter gourd. *Journal of Food Science and Technology* **42**, 197-199

Quebedeaux B, Eisa HM (1990) Horticulture and human health. Contributions of fruits and vegetables. *HortScience* **25**, 1473-1532

Reyes MEC, Gildemacher BH, Jansen GJ (1994) *Momordica* L. In: Siemonsma JS, Piluek K (Eds) *Plant Resources of South-East Asia: Vegetables*, Pudoc Scientific Publishers, Wageningen, The Netherlands, pp 206-210

Rodriguez DB, Raymundo LC, Tung-Ching Lee, Simpson KL, Chichester CO (1976) Carotenoid pigment changes in ripening *Momordica charantia* fruits. *Annals of Botany* **40**, 615-624

Simon PW (1997) Plant pigments for colour and nutrition. *HortScience* **32**, 12-13

Srivastava Y, Venkatakrishna-Bhatt H, Verma Y (1993) Antidiabetic and adaptogenic properties of *Momordica charantia* extract – An experimental and clinical evaluation. *Phytotherapia Research* **7**, 285-289

Surh Y (1999) Molecular mechanisms of chemopreventive effects of selected dietary and medicinal phenolic substances. *Mutation Research* **428**, 305-327

Takemoto DJ (1983) Purification and characterization of a cytostatic factor with antiviral activity from the bitter melon. *Preparative Biochemistry* **13**, 371-393

Tanaka T, Kojima T, Kawamori T, Wang A, Suzui M, Okamoto K, Mori H (1993) Inhibition of 4-nitroquinoline-1-oxide-induced rat tongue carcinogenesis by the naturally occurring plant phenolics caffeic, ellagic, chlorogenic and ferulic acids. *Carcinogenesis* **14**, 1321-1325

Tran TLH, Raymundo LC (1999) Biosynthesis of carotenoids in bittermelon at high temperature. *Phytochemistry* **52**, 275-280

Vikrant V, Grover JK, Tandon N, Rathi SS, Gupta N (2001) Treatment with extracts of *Momordica charantia* and *Eugenia jambolana* prevents hyperglycemia and hyperinsulinemia in fructose fed rats. *Journal of Ethnopharmacology* **76**, 139-143

Wang J, Mazza G (2002) Inhibitory effects of anthocyanins and other phenolic compounds on nitric oxide production in LPS/IFN-gamma-activated RAW 264.7 macrophages. *Journal of Agriculture and Food Chemistry* **50**, 850-857

Wargovich MJ (2000) Anticancer properties of fruits and vegetables. *HortScience* **35**, 573-575

Xiang C-P, Yin W-C, Li P-W (2000) Analysis and utilization of nutrient composition in bitter gourd (*Momordica charantia*). *Journal of Huazhong Agricultural University* **19**, 388-390

Yang S-L, Walters TW (1992) Ethnobotany and the economic role of the Cucurbitaceae of China. *Economic Botany* **46**, 349-367

Yawalkar KS (1980) *Vegetable Crops of India* (2nd Edn), Agricultural Publishing House, Nagpur, India, 370 pp

Yeh GY, Eisenber DM, Kaptchuk TJ, Phillips RS (2003) Systematic review of herbs and dietary supplements for glycemic control in diabetes. *Diabetes Care* **26**, 1277-1294

Yesilada E, Gurbuz I, Shibata H (1999) Screening of Turkish anti-ulcerogenic folk remedies for anti-*Helicobacter pylori* activity. *Journal of Ethnopharmacology* **66**, 289-293