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, B6, C, E, thiamine, and niacin), minerals, dietary fiber and other phytoneutrients (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; Jayasooryya 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), morcharin (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 (Ómøregbe 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 cryptoxanthin, which is the principal chloroplast- and chromoplast-based pigment in ripe fruit.
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

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

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

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

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**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 Vishes’—A glossy-green, large-fruitd (*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).
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 larger-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 agricultural properties, need to be initiated to ensure broad consumer acceptance of this important crop species.

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