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Nutraceuticals and bioactive components of bitter gourd (*Momordica charantia*)

Lalaine G. Gamolo[*1,3], Angelo Mark P. Walag[1], Romeo M. Del Rosario[2]

[1]*College of Science and Technology Education, University of Science and Technology of Southern Philippines, Cagayan de Oro City, Philippines*

[2]*College of Science and Mathematics, University of Science and Technology of Southern Philippines, Cagayan de Oro City, Philippines*

[3]*College of Arts and Sciences, University of Science and Technology of Southern Philippines-Claveria Campus, Poblacion Claveria, Misamis Oriental, Philippines*

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Abstract

As plants are considered as the main source of foods for living organisms, the consumption of plant-derived bioactive components among human beings is an increasing trend nowadays. The bitter gourd has been used as food and medicine across the world but mostly grows in tropical countries like Asia and Africa. This review compiles the various nutraceuticals such as the proximate biochemical, vitamin and mineral compositions, and bioactive components derived from bitter gourd and describe its potential to benefit human health. This review also provides valuable information for researchers to maximize the use of natural resources especially on controlling and preventing diseases. This article uses the systematic method for reviewing where the evidences collected from different scientific studies on bitter gourd were analysed and synthesized quantitatively. The fruits, leaves, seeds and roots of bitter gourd are found to contain abundant amounts of protein, lipid, carbohydrates, vitamins, minerals, and other bioactive components with healing potentials as well. Although plant-derived bioactive components are considered to cause less harm, the use of these compounds to cure and prevent diseases must undergo comprehensive scientific studies to confirm its potential since not all bioactive compounds coming from plants are beneficial to human health.

* **Corresponding Author:** Lalaine G. Gamolo ✉ lalaine.gamolo@ustp.edu.ph

Introduction

The use of plants as herbal medicine has been a tradition since the ancient times until now. The presence of diverse chemical compounds in plants makes it ideal source of medicinal drugs and healing compounds. In this article, the bitter gourd (*Momordica charantia*) is the subject for review. In the Philippines, bitter gourd is known as amargozo for Chavacanos, paria for Ilocanos, and ampalaya for Tagalogs (Bionity, n.d.; Herrera, 2019; Padre, 2009). The existence of bitter gourd worldwide bears the common names, which are reflected in Table 1, as ku gua in China, balsam pear in England, assorossie in France, karela or karalla for Hindis in India, pavakka for Tamils in India, komboze in Iran, nigauri in Japan, vo ju or yeo ju in Korea, peria or parai in Malaysia, kyethinkhathee in Myanmar, hanzal in Saudi Arabia, carela in Spain, ko guai in Taiwan, maraja in Thailand, and kho qua in Vietnam (Bionity, n.d.; Reetesh *et al.*, 2015; Rekha, 2015; Natureloc, 2022; General, 2015).

Table 1. Various names of *M. charantia*

Location	Common name	Reference
Philippines (Chavacano)	amargozo	Bionity (n.d.); Herrera (2019)
Philippines (Ilocano)	paria	Bionity (n.d.); Padre (2009)
Philippines (Tagalog)	ampalaya	Bionity (n.d.); Sanchez (2020); Reetesh *et al.* (2015); Rekha (2015)
China (Mandarin)	ku gua	Bionity (n.d.); Reetesh *et al.* (2015); Rekha (2015)
England (English)	balsam pear	Reetesh *et al.* (2015); Rekha (2015)
France (French)	assorossie	Reetesh *et al.* (2015); Rekha (2015)
India (Hindi)	karela or karalla	Bionity (n.d.); Reetesh *et al.* (2015); Rekha (2015)
India (Tamil)	pavakka	Bionity (n.d.); Natureloc. (2022)
Iran (Persian)	komboze	Bionity (n.d.)
Japan (Japanese)	nigauri	Bionity (n.d.); Reetesh *et al.* (2015); Rekha (2015)
Korea (Korean)	yo ju or yeo ju	Bionity (n.d.); General (2015)
Malaysia and Indonesia	peria, pare, or parai	Bionity (n.d.)
Myanmar (Burmese)	kyethinkhathee	Bionity (n.d.)
Saudi Arabia (Arabic)	hanzal	Bionity (n.d.)
Spain (Spanish)	carela	Bionity (n.d.)
Taiwan (Taiwanese)	ko guai	Bionity (n.d.); Reetesh *et al.*(2015); Rekha (2015)
Thailand (Thai)	marajin	Bionity (n.d.)
Vietnam (Vietnamese)	kho qua	Bionity (n.d.); Reetesh *et al.* (2015); Rekha (2015)

In folk medicines, bitter gourd is not only used for lowering of blood sugar levels but also to cure other diseases. The fruits of bitter gourd are used to treat skin ailments, ulcers, wounds, cough, diabetes, asthma, liver disease and fever. The leaves are usually prepared as tea or juice to treat menstrual disorders, to relieve intestinal gas and to use as antiviral for measles and hepatitis. The seeds of bitter gourd are used to treat intestinal parasites, lowering blood cholesterol, treat stomach aches and wounds. The roots are used to treat rheumatism, boils, and syphilis. Bitter gourds are found cultivated or non-cultivated (wild variety). In 2017, the World Vegetable Center has reported bitter gourd cultivation on approximately 340,000 hectares in Asian countries in which India and China are the major producers. In this review, the proximate biochemical compositions as well as the vitamin and mineral compositions of bitter gourd from various published scientific studies will be considered, compared and discussed. In addition, the biological activities of the different bioactive components found in bitter gourd will also be discussed.

Chemical components - Nutraceuticals

There are various chemical components found in bitter gourd. In this review, the nutraceutical and bioactive components will be considered.

The term nutraceutical comes from the words nutrition and pharmaceutical. Nutrition refers to the intake of foods and makes use of the nutrients it contains for good health while pharmaceutical

refers to the production of drugs for human medication. According to Nasri *et al.* (2014), nutraceutical is different from pharmaceutical such that the previous is not patented although both have the same uses – to cure diseases and prevent illnesses. Therefore, nutraceutical is also known as nutritional supplements. Scientific researchers have found that bitter gourd contains biochemical components, vitamins, and minerals that are known to supplement nutrition for human health.

Table 2. Proximate biochemical composition of *M. charantia*

Source	Accession	Plant parts	Biochemical compounds				References
			Protein	Lipid	Carbohydrate	Fiber	
Kebbi State, Nigeria	Not specified	Leaves (%)	10.25	3.03	28.52	25.31	Sulaiman and Yakubu (2018)
Bangladesh	Cultivated variety JIA	Fruits (%)	0.92	0.81	-	1.25	Barua *et al.* (2020)
	Cultivated variety GOJNEE	Fruits (%)	1.02	0.60	-	2.19	
Gia Lai, Vitenam	Wild	Stem and leaves (g/100g)	5.81	0.98	-	4.75	Dung and Tri (2021)
Not specified	Not specified	Fruits (g/100g)	2.10	1.0	10.60	1.7	Upadhyay *et al.* (2015)
Lagos State, Nigeria	Cultivated	Fruits (%)	27.88	-	34.31	13.60	Bakare *et al.* (2010)
		Leaves (%)	27.46	-	32.34	3.31	
		Seeds (%)	19.50	-	9.18	29.60	
Chittagong, Bangladesh	Cultivated	Fruits (%)	1.58	0.5	-	-	Ullah *et al.* (2016)
	Wild	Fruits (%)	2.40%	0.8	-	-	
	Cultivated	Fruits (%)	1.30	0.4	-	-	
	Cultivated	Fruits (%)	1.17	0.3	-	-	
Ekiti State, Nigeria	Cultivated	Leaves (%)	2.46	5.83	57.92	6.01	Ayeni *et al.* (2015)
India	Cultivated	Fruits (%)	1.60	0.20	4.20	1.7	Tiwari *et al.* (2021)
Ado Ekiti, Nigeria	Cultivated	Leaves (%)	9.89	5.37	-	20.86	Oloruntola *et al.* (2021)

In the nine studies conducted on the fruits, leaves, and seeds of bitter gourd collected from Bangladesh, India, Nigeria, and Vietnam, as shown in Table 2, it was determined that the protein content of bitter gourd collected from these areas ranges from 0.92% for fruits of cultivated accession taken from Bangladesh to 27.88% for fruits of cultivated accessions taken from Nigeria. Protein is an important biochemical component as it helps in the production of energy, in regulating the cellular processes, and functions in the structural and mechanical process in the human body (Morris and Mohiuddin, 2022). For the lipid content, it ranges from 0.30% for fruits of cultivated accessions taken from Bangladesh to 5.83% for the leaves of cultivated accession taken from Nigeria. Lipid, the same with protein, contributes to the cellular structure and functions of the human body and acts also as the main source of stored energy, regulates human body temperature and can also protect internal body organs (Morris and Mohiuddin, 2022). For its carbohydrate and fiber contents, the values obtained range from 4.20% for fruits of cultivated accession taken from India to 57.92% for the leaves of cultivated accession taken from Nigeria, and from 1.25% for fruits of cultivated accession taken from Bangladesh to 29.60% for seeds of cultivated accessions taken from Nigeria, respectively. Carbohydrate is an important macronutrient since it does not only supply energy for humans but it also plays an important role in the human gut health and immune system functions (Morris and Mohiuddin, 2022). While fiber is a kind of carbohydrate, it cannot be easily digested by the human body as it regulates the usage of sugar in the body. From the reviewed studies, the biochemical compositions of bitter gourd in terms of protein, lipid, carbohydrate, and fiber are not determined for each of the studies conducted. The

plant parts of bitter gourd in the reviewed studies which are the fruits, leaves, and seeds are not considered for each of the studies as well.

While most of the bitter gourd samples were sourced from Southeast Asian and West African countries, some of these studies did not also indicate the sources and accessions of bitter gourd sampled. From the studies conducted, most of the bitter gourd plant parts that were sampled for analysis were the fruits and leaves and most of these are cultivated accessions. The stem and seed parts of bitter gourd and its wild accession were rarely considered as samples for research studies. From the studies conducted, it can be inferred that bitter gourd can provide nutrients as it contains an appreciable amount of carbohydrates, fiber, protein, and lipid.

The scientific studies on the vitamin content of bitter gourd have also been conducted mostly in the West African and Southeast Asian countries. From the studies considered for review, it was found that most of the plant accession and parts of bitter gourd used are cultivated leaves. Fruit parts and wild accessions of bitter gourd are rarely used for research studies on vitamin compositions.

Table 3. Vitamin composition of *M. charantia*

Source	Accession	Plant parts	Vitamins				References
			A	B12	C	E	
Kebbi State, Nigeria	Not specified	Leaves (mg/100g)	0.186	-	1.351	0.186	Sulaiman and Yakbubu (2018)
Gia Laia, Vietnam	Wild	Stem and leaves (mg/100g)	-	-	83.04	-	Dung and Tri (2021)
Lagos State, Nigeria	Cultivated	Leaves (ppm)	0.03	5355	66000	800	Bakare *et al.* (2010)
Ado Ekiti, Nigeria	Cultivated	Leaves (mg/kg)	-	-	4.00	-	Oloruntola *et al.* (2021)
India and Indonesia	Cultivated	Leaves (mg/100g)	-	-	205.388	-	Goo *et al.* (2016)
		Fruits (mg/100g)	-	-	2022.563	-	
India	Cultivated	Fruits (mg/100g)	-	-	77.56	-	Tiwari *et al.* (2021)

As reflected in Table 3, the vitamins A and E compositions of bitter gourd shows a higher amount contained on bitter gourd leaves taken from Kebi State of Nigeria as compared to the leaves of cultivated bitter gourd taken from Lagos State of Nigeria. The vitamin A is also known as beta-carotene or retinol which is beneficial for eye's health by improving its vision and for treatment of under eye dark circles (Narayana Health, 2022). This vitamin can be acquired mostly from fruits and vegetables (Morris and Mohiuddin, 2022). The Vitamin E, also known as tocopherol, is considered as an antioxidant, and also plays an important role in cellular signals, aggregation of platelets and vasodilation (Morris and Mohiuddin, 2022). This vitamin also helps in the repair and reduction of damaged cells caused by free radicals as it reduces the aging process of body cells (Dubai Health Authority, n.d.). Further, it was found from the reviewed studies that the vitamin C compositions of bitter gourd vary among plant parts of bitter gourd – leaves, stem, and fruits, between cultivated and wild accessions, and among the sources of bitter gourd. The ascorbic acid is another name for vitamin C. It has many benefits which include wound and tissue healing, promoting hair growth, fighting many diseases, reducing risk of strokes, infection, cardiovascular diseases, and cancer, and it is also considered as a soluble antioxidant (Dubai Health Authority, n.d.; Morris and Mohiuddin, 2022; Narayana Health, 2022). Although the vitamin B12 composition of the cultivated leaves of bitter gourd have been determined to contain in an appreciable amount, other B vitamin such as B3 and B6, and compositions for vitamins D and K were not determined on bitter gourd samples. The vitamin B12 is also known as cyanocobalamin. According to Dubai

Health Authority (n.d.), it plays an important role for healthy brain function, in the formation and regulation of DNA, in the absorption of folic acid, and it also helps in the production of red blood cells. This vitamin can only be acquired from animal products according to Morris and Mohiuddin (2022) as it is a product of bacterial synthesis that takes place in the body of animals. Among the vitamin compositions considered, the result of the studies has shown that the bitter gourd is a good source for vitamins as it contains higher amount of vitamin C followed by vitamins B12, and vitamins A and E.

The mineral composition of bitter gourd varies depending on the location, accessions, and plant parts. In the eleven studies conducted in West African and Southeast Asian countries, it revealed that bitter gourd is rich in minerals. The minerals considered in the studies are calcium, sodium, potassium, iron, phosphorus, manganese, zinc, magnesium, copper, cobalt, and chromium. According to Dubai Health Authority (n.d.), calcium plays a role in regulating the nervous system and muscle functions on the human body and in the formation and strengthening of bones and teeth. Aside from maintaining the teeth and bone health, calcium also helps in reducing the presence of bad cholesterol or low-density lipoprotein cholesterol and in lowering the risk of developing colon cancer (Harshman and Aldoori, 2005; Morris and Mohiuddin, 2022; Narayana Health, 2022). A low-calcium diet may promote fat accumulation and weight gain. Sodium element, together with chlorine, also plays an important role in maintaining the human body's water balance, blood pressure regulation, cellular membrane transport, muscle contractions, and nerve innervations (Dubai Health Authority, n.d.; Morris and Mohiuddin, 2022).

The potassium element also plays an important role in maintaining the body's water and blood pH balance, muscle contraction, normal blood pressure, reduces bad cholesterol, and promotes normal function of the nervous system (Dubai Health Authority, n.d.; Morris and Mohiuddin, 2022; Narayana Health, 2022). Together with zinc and potassium, iron element is essential for the neural development of the fetus, growth and building of body tissues, formation of skin and bones and in promoting healthy skin and hair according to Narayana Health (2022) and Dubai Health Authority (n.d.). Phosphorus is usually stored in bones and is essential for bone growth, normal function of cells, and plays an important component in the structures of bones and teeth, DNA and RNA (Dubai Health Authority, n.d.; Morris and Mohiuddin, 2022). Zinc element is an important component of many enzymes and helps improve the immune function among elderly people (Harshman and Aldoori, 2005; Morris and Mohiuddin, 2022). Magnesium element is responsible for many metabolic processes in the human body such as the glucose and lipid metabolisms, and it also helps in preventing hypertension, cardiovascular diseases and diabetes (Harshman and Aldoori, 2005; Morris and Mohiuddin, 2022). Copper element is an important mineral as it helps in the energy metabolism and haemoglobin formation (Kohlmeier, 2015; Myint *et al.*, 2018).

Chromium mineral is responsible for many enzymatic processes and can affect the muscle activity and lipid profile of the human body (Vincent, 2003). Manganese and cobalt minerals play an important role in many biological processes, growth and development, and in the proper function of coenzyme vitamin B12, respectively (Jomova *et al.*, 2022). The daily intake of these minerals together with vitamins indeed plays a crucial role in the many metabolic processes of the human body and is therefore needed to maintain proper health and nutrition.

The mineral composition of bitter gourd in the reviewed studies follows the trend Ca> Na> P> Fe> K> Mn> Zn> Mg> Cu> Co> Cr as shown in Table 4. Among the four locations, the fruits of bitter gourd collected in Guyana were found to contain the highest amount of mineral copper while the leaves of bitter gourd collected from Kebbi State of Nigeria has the lowest amount in copper composition. For minerals zinc, iron, manganese,

and calcium, the leaves of bitter gourd sourced from Guyana are found to contain the highest amount of these minerals among the locations. The leaves of the bitter gourd collected from Kebbi State of Nigeria are found to contain the highest amount of phosphorus mineral while the leaves of cultivated bitter gourd sourced from Ado Ekiti State of Nigeria contain the least. Further, the fruits of cultivated bitter gourd collected in Pakistan are found to contain the highest amount of minerals magnesium and potassium among the locations and the leaves of cultivated bitter gourd in Lagos State of Nigeria contain the highest amount of sodium mineral.

Table 4. Mineral composition of *M. charantia*

Source	Accession	Plant parts	Minerals											References
			Cu	Zn	Fe	Mn	Co	P	Ca	Mg	Na	K	Cr	
Kebbi State, Nigeria	Not specified	Leaves (mg/kg)	7.57	13.8	7.69	12.5	13.46	5512.66	316.80	30.00	216.66	695.37	-	Sulaiman and Yakbubu (2018)
Bangladesh	Cultivated variety JIA	Fruits (ppm)	-	-	0.87	-	-	-	2.24	0.64	-	0.78	0.003	Barua *et al.* (2020)
	Cultivated variety GOJNEE	Fruits (ppm)	-	-										
Gia Lai, Vietnam	Wild	Stem and leaves (mg/100g)	-	0.86	1.89	-	-	36.52	9.24	16.34	-	-	-	Dung and Tri (2021)
Guyana	Not specified	Leaves (mg/g)	0.085	1.25	3.11	1.5	-	-	290.87	0.2	13.89	0.4	-	Ansari *et al.* (2019)
	Not specified	Fruits (mg/g)	0.30	1.0	1.99	0.5	-	-	28.96	0.044	7.76	0.6	-	
Lagos State, Nigeria	Cultivated	Leaves (ppm)	32	120	98	156	-	-	20510	255	22000	413	-	Bakare *et al.* (2010)
India	Cultivated variety NOOR	Fruits (mg/100g)	-	1.35	3.38	-	-	59.58	25.82	37.22	51.05	162.17	-	Mahwish *et al.* (2018)
	Cultivated variety BG20	Fruits (mg/100g)	-	1.47	3.34	-	-	74.74	30.42	40.02	57.61	217.50	-	
Pakistan	Cultivated variety Black king	Fruits (mg/100g)	-	1.78	3.90	-	-	92.92	48.42	46.74	58.24	258.83	-	
	Cultivated variety FSD long	Fruits (mg/100g)	-	1.50	3.28	-	-	84.50	41.44	40.53	54.22	235.42	-	
China	Cultivated variety KHBG1	Fruits (mg/100g)	-	1.41	3.50	-	-	68.50	32.08	33.61	61.81	176.83	-	
	Cultivated variety GHBG1	Fruits (mg/100g)	-	1.35	4.00	-	-	52.08	39.69	35.23	58.97	158.83	-	
Ekiti State, Nigeria	Cultivated	Leaves (mg/100g)	-	-	-	-	-	24.36	22.36	5.88	6.58	32.84	-	Ayeni *et al.* (2015)
Edo Ekiti, Nigeria	Cultivated	Leaves (mg/kg)	-	0.5	9.00	-	-	1.5	13.5	-	-	-	-	Oloruntola *et al.* (2021)
India	Cultivated	Fruits (mg/100g)	-	0.80	0.43	-	-	-	-	-	-	-	-	Tiwari *et al.* (2021)

Chemical components - bioactive components

Plants are found to contain various bioactive compounds which are considered as secondary metabolites. These compounds may have the potential to control and prevent many diseases and may also have the potential to cause harm on living organisms. In bitter gourd plants, various bioactive compounds that have the potential to benefit human health have been discovered.

Table 5. Bioactive components of *M. charantia*

Bioactive compound	Plant parts	Plant source	Biological activity	References
Charantin	Fruits, Leaves	India and Indonesia	Antidiabetic	Goo *et al.* (2016)
Momordicin; Momorcharin	Not specified	Not specified		Raoof and Mohamed (2018)
Phenolic acids (gallic acid, gentisic acid, catechin, chlorogenic acid, and epicatechin)	Fruit flesh, inner tissues and seeds	India and China	Antioxidant	Horax *et al.* (2006)
Momordin I	Not specified	Not specified	Tumor protective	McCreight *et al.* (2013)
Momordicines I and II	Not specified	Not specified	Antimicrobial	McCreight *et al.* (2013)
Acylglucosylsterols	Not specified	Not specified	Antimutagenic; Chinitase bacteriostatic effects	McCreight *et al.* (2013)

As shown in Table 5, this includes charantin, momordicin and momorcharin which are known to have an antidiabetic property, phenolic acids which are considered as antioxidants, momordin I which has the potential to prevent formation of tumors, momordicines I and II which possess an antimicrobial property and acylglucosylsterols which has an antimutagenic property.

In the studies considered, most of the plant parts where the bioactive compounds are taken are not specified as well as its sources. With the potential of the discovered bioactive components in bitter gourd, it implies that there could be more compounds contained in this valuable plant that are yet to be discovered.

Conclusion

M. charantia is an ordinary plant, usually grown in the tropical countries, with many extraordinary benefits. It was once used as a food source in the ancient times but later has been discovered to contain active biochemical components considered to be as its health-promoting and healing properties for various illnesses. With the results gathered from various studies reviewed in this article, bitter gourd is truly rich in protein, lipids, carbohydrates, fiber, vitamins C, B, A and E, and minerals such as calcium, sodium, phosphorus and iron.

The presence of nutraceuticals and bioactive components of bitter gourd are being supported by several scientific researches done globally. However, most of the studies considered in this review focused mainly on the plant parts of cultivated *M. charantia*. In the Philippines alone, scientifically published studies on the biochemical and nutraceutical components of various bitter gourd accessions are scarce. Additionally, rare studies have been conducted on the wild accessions of bitter gourd. In order to greatly utilize this valuable plant, more scientific researchers must be done further, especially on the different plant parts of both cultivated and wild accessions of *M. charantia*, to establish not only its nutritional and medicinal properties but also its efficacy and safety for human consumption.

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