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Mini Review

Nutritional compositions, health promoting phytochemicals and value added products of bitter gourd: a review

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Abstract

In many Asian countries Bitter gourd (*Momordica charantia* L.) has been used as food and medicine from ancient times. Bitter gourd has huge positive health benefits due to present ample of phytochemicals and proteins. Bitter gourd leaf, stem and seed also contain various health promoting antioxidants such as gallic acid, caffeic acid and catechin. In the present review, physicochemical properties, nutritional values and health promoting phytochemicals as well as value added products of Bitter gourd are discussed. Subsequently, this review also would be helpful for food producers and consumers to get current knowledge about Bitter gourd for their application and industrialization.

Introduction

Consumption of vegetables has been increased owing to their high content of bioactive compounds like ascorbic acid, phenolic acids, carotenoids, flavonoids, proteins, minerals and dietary fibers while insufficient source of sugar (Cefalu *et al*., 2008; Cousense *et al*., 2008). Among various vegetables bitter gourd is one of most nutritionally rich and plentiful medicinal properties of vegetable around the world (Islam *et al*., 2011). Bitter gourd *(Memordica charantia)* is a member of the Cucurbitaceae family and widely grown in Asia, South America, India, Caribbean, East Africa, Middle East and America (Cefalu *et al*., 2008; Cousense *et al*., 2008). Bitter gourd is an annual fruity vegetable and referred to as bitter melon, Karela or balsam pear (Satkar *et al.,* 2013). The fruits, seeds, leaves, vines and roots of bitter gourd have been used as food and remedy from various types of diseases (Islam *et al*., 2011). It is an important source of essential amino acids, vitamin C, vitamin A, carotenoids, folic acid, thiamin, riboflavin, niacin, and minerals (Ali *et al*., 2008; Horax *et al.* 2010; Sandra *et al*., 2011) and has an important role in human diet for maintaining sound health. The seeds of bitter gourd are also rich source of protein and oil (Ali *et al*., 2008).

Bitter gourd consumption has tremendously increased day by day not only for their nutritional value but also their therapeutic value. Bitter gourd exhibited good sources of catechin, gallic acid, gentisic acid, chlorogenic acid (Budrat and Shotipruk, 2009) and saponin compounds (Tan *et al*., 2014). Horax *et al*. (2005) also revealed that bitter gourd also potential sources of antioxidant that would be used in food system. Pericarp and seeds of bitter gourd *(Momordica charantia)* could be used as sources of different antioxidant agents (Horax *et al*., 2010). Body weight gain and blood glucose levels could be reduced as well as the levels of energy metabolism might be increased in high-fat diet fed mice after consumption of bitter gourd *(Momordica charantia)* powder (Bian *et al*., 2016). These authors also demonstrated that glucose metabolism-associated pathways could be affected by consumption of bitter gourd powder in high-fat diet fed mice. Lyophilized of bitter gourds superfine powder could influence the gut microbiota in diabetic rats but bacterial taxa were same to the normal rat. *Momordica charantia* (bitter gourd) oil could regenerate the tissue without side effect in wound healing of rabbit skin (Piskin *et al.,* 2014). DMC (3β,7β-dihydroxy-25-methoxycucurbita-5,23-diene-19-al) isolated from wild bitter gourd which is positively interfere with peroxisome proliferator-activated receptor (PPARγ) in lipid metabolism, insulin sensitivity apoptosis, and cell differentiation thus contribute to account for the hypoglycemic and antitumor activities (Weng *et al*., 2013). Bitter gourds (*Momordica charantia* L.) enhance the GLP-1 secretion thus control the glucose homeostasis through an incretin effect (Huang *et al*., 2013). *Momordica charantia* seed extracts also could

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be used for leukemia therapy (Soundararajan *et al*., 2012).

There are some reviews on bitter gourd such as health promoting phytochemicals of bitter gourd (Tan *et al*., 2016); potential uses of bitter gourd as pharmacological (Grover and Yadav 2004); impact of bitter gourd on anti-diabetic and hypoglycaemic (Leung *et al*., 2009); antidiabetic and medicinal potency of bitter gourds (Joseph and Jini, 2013) and role of bitter gourd on obesity and related complications (Alam *et al*., 2015). However, there are some inadequate information's about bitter gourd regarding the physiological characteristics, nutritional value, and impact of nutritional values on health. Therefore, these reviews will focus on nutritional, medicinal and functional properties of bitter gourd.

Characterization and nutritional compositions of bitter gourd vegetable Physiological characteristics

Generally, bitter gourd fruits are 1.0-9.8 inch long and 1.0-5.9 inch wide with oval, round, oblong and club in shape and dark green to white in color. The size and shape of the fruit vary with the different varieties (Islam *et al*., 2011; Kumar *et al*., 2016). The length of China cultivar bitter gourd vegetable 20-30 cm (7.9-11.8 in) and oblong with bluntly tapering ends and light green in color whereas Indian cultivar only 6-10 cm (2.4-3.9 in) (Islam *et al*., 2011; Kumar *et al*., 2016). The fruit of bitter gourd takes 45 to 80 days to get mature and the harvesting starts from 60 days of planting and it is continued up to 150 days (Islam *et al*., 2011; Kumar *et al*., 2016).

Types of bitter gourd

Various types of bitter gourds are available in around the world. India long green, India long white and Hybrid India baby are available in India (Figure 1a) whereas Japan Green Spindle, Green Lover, Hong Kong Green are famous in Japan, China and Hong Kong, respectively (Figure 1b). In Bangladesh, mainly two varieties are found small size is locally called Ucche and large size is called Korolla (Figure 1c) (Alam *et al*., 2015).

Shelf-life of bitter gourd

The fruit of bitter gourd is perishable and shelf life of only 4 days at ambient conditions and can be preserved for more than 3-4 weeks in cold storage at 0-7^{0}C. Fresh cut bitter gourds have only 4 days shelf life when stored at 2^{0}C (Wang *et al*., 2007).

Uses of bitter gourd

Bitter gourd fruits and leaves are generally consumed as stir frying or cooking as curries, boiling, steaming, juice, extracts, and tea (Abdullah and Kamarudin, 2013). However, various parts of bitter gourd are using in many purposes reported by Kandangath *et al.* (2015). Bitter gourd leaf paste or hot water extract could be used to reduce or control of many diseases such as treatment of leprosy, piles and jaundice; treatment of ringworm, bowel movement, cough, congestion and chest pain (Kandangath *et al*., 2015). Bitter gourd fruit juice has many positive health properties such as anti diabetes, treatment of malarial fevers and anti-helminthic (Abdullah and Kamarudin, 2013). Moreover, bitter gourd seed could produce spontaneously vomiting and also used to reduce fat (Abdullah and Kamarudin, 2013; Kandangath *et al*., 2015).

India Long Green India Long White Hybrid India Baby

Figure 1(a). Different variety of bitter gourd in India

Japan Green Spindle Green Lover Hong Kong Green

Figure 1(b). Different variety of bitter gourd in Japan and Hong Kong

Korolla Ucche

Figure 1(c). Different variety of bitter gourd in Bangladesh

Nutritional Profiles

Nutritional compositions of bitter gourd vegetable are shown in Table 1. Ali *et al.* (2008) reported that bitter gourd is an important source of carbohydrate, proteins, vitamins, minerals and other nutrients for maintaining proper health. It is a highly nutritious vegetable due to the presence of higher amount of protein, ascorbic acid, calcium, iron, and phosphorus (Assubaie and El-Garawany, 2004). Total fat content of whole fruit ranged from 2.9%-6.4% of dry matter (Chuang *et al.* 2006; Habicht *et al*., 2011). Bitter gourd also contains high amount

Table 1. Physico-chemical and nutritional composition of bitter gourd vegetable

Parameters	Amount
Moisture (%)	93.8
Ash (%)	0.8
Protein (g)	0.90
Fat (g)	0.10
Carbohydrate (g)	0.20
Dietary fiber (g)	3.30
SDF (% dry basis)	14.4
IDF (% dry basis)	30.2
Organic acids (g)	0.11
TSS (°Brix)	3.2
Acidity (%)	0.03
Reducing sugars (%)	2.5
Total sugars (%)	2.8
Chlorophyll (mg/L)	10.9
Vitamin C (mg)	50.0
Vitamin A (mg)	0.04
Thiamin (mg)	0.05
Riboflavin (mg)	0.03
Niacin (mg)	0.40
Phosphorus (mg/100g)	69.0
Calcium	22.0
Potassium	26.0
Magnesium	16.0
Iron	0.9
Sodium	3.0
Zinc	0.1

(adapted from Raman and Manimegalai, 1998; Horax *et al*., 2010; Islam *et al*., 2011; Satkar *et al*., 2013)

of Vitamin A, vitamins B_1, B_2, B_3 and B_9 (Joseph and Jini, 2013). It is also good source of inorganic minerals such as Phosphorus, potassium, calcium, magnesium, sodium, Iron and zinc (Islam *et al*., 2011). Bitter gourd vegetables also contain different types of amino acids such as glutmine, asparagines, glycine, lysine, alanine, leucine, valine, arginine, proline, serine, isoleucine, phenylalanine, tryptophan, histidine, threonine, methionine (Islam *et al.,* 2011). Table 2 and Table 3 shows the amino acid profiles and the mineral contents of pericarp and seeds from bitter gourd at various maturity stages.

Bioactive compounds of bitter gourd

Bitter gourd vegetables are considered significant sources of different bioactive compounds. Many researchers have already identified different bioactive compounds in bitter gourd vegetables (Table 4a-c). The quality and quantity of bioactive compound present in bitter gourd could be depends on many factors such as harvest time, temperature, state of maturity, and post harvest storage as well as size, shape, colour of bitter gourd (Horax *et al*., 2005; Tan *et al*., 2014; Sing *et al*., 2016). In addition, bioactive compounds extraction from bitter gourd depends on temperature, length of extraction, particle size and number of extractions of a sample, water to powder ratio, powder particle size, the ratio of water and plant material and the type of solvents used (Sorifa *et al*., 2010; Cerda *et al*., 2013; Tan *et al*., 2016). In this section we have described different types of bioactive compounds of bitter gourd vegetables.

Impact of processing effects on total polyphenols in bitter gourd

Bitter gourd vegetables are a good source of total phenolics which have high antioxidant ativity (Tan *et al*., 2016). The total phenolic content in immature, mature and ripe bitter gourd ranged from 6.9 to 15.7, 6.4 to 14.8, and 4.3 to 14.9 mg GAE/g ethanol extract, respectively where as mature and ripe seed ranged from 6.4 to 18.0 and 6.1 to 20.9 mg GAE/g ethanol extract, respectively (Horax *et al*., 2010). Budrat and Shotipruk (2009) reported that total phenolic contents in subcritical, soxhlet and solvent extraction were 52.63, 6.68, 6.00 mg GAE /g DW respectively. Zhu *et al.* (2012) showed that total polyphenols and total flavonoids of lyophilized superfine grinding bitter gourd powder had 10.03 and 5.27 mg/g, respectively where as hot air drying bitter gourd powder had 6.43 and 2.09 mg/g. Islam *et al.* (2011) observed that total phenolic content of oven dried and freeze dried tissues from four varieties ranged from 5.39-8.94 mg CAE/g dry matter and 4.64-8.90 mg CAE/g dry matter. Tan *et al.* (2014) mentioned that total phenolic contents of green house grown bitter gourd ranged from 5.1-7.9 mg GAE/g dry basis. Horax *et al.* (2005) revealed that total phenolic contents of the flesh, inner tissue and seed from four varieties of bitter gourd ranged from 5.36-8.90 mg CAE /g dry material, 4.64-8.94 mg CAE /g dry material and 4.67-8.02 mg CAE /g dry material, respectively. Tan *et al.* (2014) found that total phenolic contents of aqueous and 80% ethanol extract were 10.06mg GAE/g dry basis and 10.07 GAE/g dry basis. Kubola *et al.* (2008) reported that the total phenolic content in leaf, green fruit, stem and ripe fruit from bitter gourd were 4.74,3.24 and 2.59 and 2.24 mg GAE/g dry sample, respectively. Total phenolic contents in seed, seed coat tissue and flesh of bitter gourd ranged from 4.67-8.02, 4.64-8.94, and 5.36-8.90 mg/CAE dry matter, respectively and the flesh provided significantly higher phenolic contents than other part using four varieties (Islam *et al*., 2011).

Impact of processing effects on individual polyphenols compounds in bitter gourd

Polyphenol groups are flavonoids, phenolic acids, tannins (hydrolysable and condensed) stilbenes and lignans (D`Archivio *et al*., 2007). Phenolic compounds are observed abundant in plants (Li *et al*., 2006). Lin and Tang (2007) and also reported that deep coloured fruits and vegetables have polyphenol compounds specially flavonoids. Individual polyphenols in bitter mellon are quantified using HPLC. A wide variety of individual polyphenols or phenolic profile of bitter gourd fleshes, seeds and inner tissues are shown in Table 4a, Table 4b and Table 4c, respectively. The two types of flavonoids such as catechin and epicatechin are abundant in

Table 2. Amino acid composition (mg/g protein) in immature, mature and ripe stage of pericarp and seeds from bitter melons

Amino acids	Pericarp		Seed	Pericarp	Seed
	Immature	Mature	Mature	Ripe	Ripe
Cys	21.3 ± 5.3	22.3 ± 2.9	16.5 ± 0.7	18.3 ± 0.3	19.0 ± 0.4
Asx	91.3 ± 2.5ab	93.8 ± 2.6a	78.0 ± 3.6cd	84.5 ± 1.6bc	73.4 ± 2.6d
Thr	24.9 ± 0.7a	25.2 ± 1.1a	17.4 ± 0.8c	21.1 ± 0.5b	16.1 ± 0.0c
Ser	51.1 ± 4.3ab	55.0 ± 3.1a	43.5 ± 1.9bc	53.4 ± 2.3a	39.3 ± 2.1c
Glx	95.9 ± 4.9b	96.0 ± 2.3b	124 ± 5.6a	93.2 ± 2.9b	131 ± 3.9a
Pro	54.5 ± 2.5ab	54.4 ± 3.5ab	49.7 ± 4.4b	60.7 ± 2.2a	45.5 ± 6.3b
Gly	42.0 ± 0.6bc	44.9 ± 1.1b	39.9 ± 1.4c	41.2 ± 1.2c	50.1 ± 1.6a
Ala	49.8 ± 1.0a	51.2 ± 0.6a	46.7 ± 1.0b	45.7 ± 0.6b	38.1 ± 0.9c
Val	42.8 ± 3.2	42.2 ± 4.5	36.7 ± 1.4	42.5 ± 1.4	39.2 ± 0.7
Ile	32.2 ± 1.7	30.8 ± 3.9	30.7 ± 0.7	32.8 ± 1.3	31.6 ± 0.4
Leu	65.5 ± 2.1a	64.9 ± 1.8a	60.5 ± 2.3ab	60.7 ± 1.3ab	58.1 ± 2.6b
Tyr	56.5 ± 3.8a	59.4 ± 1.2a	44.7 ± 3.6b	62.9 ± 5.0a	45.1 ± 0.7b
Phe	38.9 ± 0.2ab	40.2 ± 0.5a	34.5 ± 2.8bc	39.4 ± 1.5a	34.0 ± 1.7c
Met	26.3 ± 1.4ab	27.6 ± 2.0ab	23.6 ± 0.9b	29.7 ± 3.3a	22.8 ± 0.8b
His	70.2 ± 0.7a	72.8 ± 1.9a	40.9 ± 0.9c	64.0 ± 3.3b	33.6 ± 1.2d
Lys	107 ± 2.9ab	101 ± 3.4b	98.7 ± 1.6b	116 ± 8.1a	103 ± 5.7ab
Arg	48.8 ± 0.8cd	45.6 ± 2.0d	80.8 ± 0.8b	56.8 ± 5.2c	92.5 ± 3.7a
NH3	4.3 ± 0.4c	4.2 ± 0.5cd	7.4 ± 0.3a	3.3 ± 0.8d	6.1 ± 0.3b
Total	923 ± 5.1	931 ± 3.5	874 ± 6.1	926 ± 9.3	878 ± 18.1

Values are means ± SD), Mean values with different letters in the same row are significantly different (P value <0.05). (adapted from Horax *et al.*, 2010)

Table 3. Mineral contents (mg/g) in immature, mature and ripe stage of pericarp and seeds from bitter melons

Amino acids	Pericarp		Seed	Pericarp	Seed
	Immature	Mature	Mature	Ripe	Ripe
P	5.2 ± 0.2c	5.8 ± 0.3c	7.4 ± 0.3b	8.7 ± 0.4a	8.0 ± 0.4ab
K	32.4 ± 1.5c	42.7 ± 2.1b	8.6 ± 0.6d	57.5 ± 2.5a	6.4 ± 0.4d
Mg	3.1 ± 0.1bc	3.0 ± 0.1c	4.2 ± 0.2a	3.6 ± 0.1b	4.4 ± 0.3a
S	1.2 ± 0.1b	1.1 ± 0.1b	2.0 ± 0.1a	1.4 ± 0.1b	2.0 ± 0.2a
Ca	2.3 ± 0.1b	2.7 ± 0.3b	0.82 ± 0.06c	3.8 ± 0.3a	0.49 ± 0.06c
Na	0.158 ± 13b	0.264 ± 19a	0.136 ± 7b	0.259 ± 18a	0.089 ± 9c
Fe	0.055 ± 6b	0.045 ± 3b	0.102 ± 12a	0.037 ± 2b	0.088 ± 8a
Mn	0.031 ± 2a	0.032 ± 2a	0.020 ± 0b	0.036 ± 4a	0.012 ± 2c
Zn	0.057 ± 4a	0.041 ± 5b	0.064 ± 6a	0.033 ± 2b	0.055 ± 5a
Cu	0.016 ± 2ab	0.013 ± 1b	0.023 ± 4a	0.014 ± 1b	0.023 ± 5a
Al	ND	0.011 ± 1b	ND	0.018 ± 2a	ND

Values are means ± SD; Mean values with different letters in the same row are significantly different (P value <0.05). (adapted from Horax *et al.*, 2010)

bitter gourd. Catechin and epicatechin contents in hot air dried bitter gourd flesh ranged from 68.16 to 82.45 and 16.61 to 24.10 mg/100g, respectively from different varieties (Horax *et al*., 2005). Horax *et al.* (2005) also reported that bitter gourd contains high amount of gallic acid (10.23 to 39.76 mg/100g dry material), gentisic acid (21.43 to 24.65 mg/100g dry material) and chlorogenic acid (6.42 to 14.15 mg/100g dry material). p-coumeric acid, tannic acid, benzoic acid ferulic acid, caffeic acid and so on were also identified. Moreover, freeze dried had lower phenolic acid in fleshes and seeds than those of air dried because of releases of bound phenolics (Horax *et al*., 2005). Budrat and Shotipruk (2009) also reported that catechin contents in subcritical water extraction, methanol extraction and soxhlet water extraction were 46.16, 1.61 and 1.77 mg/g dry material respectively. Kubola *et al*. (2008) mentioned that gallic acid was the major phenlic constituents found in all parts (leaf, stem and fruits) of bitter gourd.

Total antioxidant capacity in bitter gourd

Different methods such as ferric reducing antioxidant powder (FRAP), organic radical-scavenging capacity [ABTS-2, 2-azino-bis93-ethyl-benz-thiazoline-6-sulfonicacid)], DPPH (2, 2-Diphenyl-1-picrylhydrazil) and peroxyl radical scavenging capacity (ORAC-oxygen radical absorbance capacity), β-carotene and linoleic acid bleaching methods are used to determine the antioxidant capacity. Previously many researchers reported that bitter gourd had excellent antioxidant and free radical scavenging activity (Horax *et al.*, 2005; Wu and Ng, 2007; Kubola *et al.*, 2008). Different phenolic compounds have different antioxidant activity. All ready many researchers showed that there are high correlation between total phenolics and antioxidant activity (Sorifa *et al.*, 2010). However, some studies found that there is no correlation between antioxidant activity and total phenolic content (Kubola *et al.,* 2008; Sorifa *et al.*, 2010). This may be due to the presence of different different antioxidant substance in different ratio rather than total phenolic content itself. In addition, total antioxidant activity depends on the presence of individual phenolic acid constituents rather than total phenolic content in bitter gourds. Kubola *et al.* (2008) observed that the antioxidant activity of bitter gourd in DPPH radical-scavenging activity, hydroxyl radical-scavenging

Table 4(a). Phenolic acid constituents (mg per 100 g of flour dried basis) in bitter melon fleshes by oven dried and freeze dried

Phenolic acid	Oven dried				Freeze-dried			
	IG	IW	CG	CW	IG	IW	CG	CW
Gallic acid	10.23 ± 0.21	15.85 ± 0.59	39.76 ± 0.75	20.66 ± 0.29	8.04 ± 0.14	8.69 ± 0.40	13.74 ± 0.23	12.42 ± 0.09
Protocatechuic acid	3.59 ± 0.17	6.14 ± 0.23	2.07 ± 0.18	5.66 ± 0.09	3.85 ± 0.23	2.41 ± 0.03	3.17 ± 0.05	5.51 ± 0.21
Gentisic acid	21.43 ± 1.95	24.34 ± 1.71	24.00 ± 0.64	24.65 ± 0.52	20.07 ± 0.68	16.99 ± 0.81	20.34 ± 0.12	27.47 ± 1.21
Catechin	70.03 ± 3.06	82.45 ± 0.66	78.67 ± 0.21	68.16 ± 2.30	23.06 ± 0.47	25.26 ± 0.34	23.79 ± 0.37	34.50 ± 0.78
Vanillic acid	2.15 ± 0.12	2.42 ± 0.09	1.84 ± 0.10	2.01 ± 0.00	1.25 ± 0.03	Tr	1.29 ± 0.03	1.35 ± 0.05
Chlorogenic acid	10.73 ± 0.68	6.42 ± 0.10	14.15 ± 0.25	8.66 ± 0.07	16.37 ± 0.45	4.55 ± 0.29	15.83 ± 0.19	11.64 ± 0.13
Syringic acid	2.10 ± 0.35	3.15 ± 0.09	2.91 ± 0.14	2.85 ± 0.06	1.77 ± 0.08	1.77 ± 0.09	2.14 ± 0.15	3.67 ± 0.29
Epicatechin	21.14 ± 0.74	20.98 ± 0.78	16.61 ± 0.73	24.10 ± 0.56	18.90 ± 1.96	17.44 ± 0.33	32.03 ± 0.96	32.38 ± 1.34
p-Coumaric acid	4.97 ± 0.16	3.07 ± 0.10	1.83 ± 0.04	3.90 ± 0.12	8.23 ± 0.17	3.85 ± 0.13	7.37 ± 0.06	8.19 ± 0.33
Benzoic acid	3.12 ± 0.18	2.99 ± 0.10	3.96 ± 0.09	3.65 ± 0.05	Tr	ND	2.90 ± 0.06	3.05 ± 0.11
o-Coumaric acid	ND	ND	1.96 ± 0.12	2.43 ± 0.02	2.18 ± 0.15	ND	2.47 ± 0.03	2.33 ± 0.11
trans-Cinnamic acid	Tr	Tr	1.31 ± 0.04	Tr	Tr	ND	Tr	
Total phenolic acids	149.5	167.8	189.1	166.7	103.7	81.0	125.1	142.5

Values are means ± SD, IG, bitter melon var. India Green; IW, bitter melon var. India White; CG, bitter melon var. China Green; CW, bitter melon var. China white;
ND, not-detectable; Tr, trace (less than 1 mg per 100 g dried basis).(adapted from Horax *et al*., 2005)

Table 4(b). Phenolic acid constituents (mg per 100 g of flour, dried basis) in bitter melon seeds by oven dried and freeze dried

Phenolic acid	Oven dried				Freeze-dried			
	IG	IW	CG	CW	IG	IW	CG	CW
Gallic acid	8.93 ± 0.25	18.90 ± 0.20	11.60 ± 0.74	6.82 ± 0.51	4.61 ± 0.21	4.28 ± 0.31	5.08 ± 0.22	7.14 ± 0.07
Protocatechuic acid	4.26 ± 0.02	5.75 ± 0.03	4.30 ± 0.02	4.16 ± 0.01	1.02 ± 0.09	1.56 ± 0.06	2.41 ± 0.06	1.89 ± 0.04
Gentisic acid	ND	21.67 ± 0.03	14.42 ± 0.20	16.01 ± 0.29	ND	ND	ND	ND
Catechin	49.50 ± 0.53	57.61 ± 0.86	44.65 ± 0.97	55.23 ± 0.92	24.85 ± 0.50	33.85 ± 0.99	36.37 ± 0.56	37.00 ± 0.82
Vanillic acid	1.05 ± 0.06	1.60 ± 0.01	1.16 ± 0.03	1.27 ± 0.02	Tr	Tr	Tr	Tr
Chlorogenic acid	4.08 ± 0.09	5.53 ± 0.15	3.18 ± 0.22	3.03 ± 0.24	2.94 ± 0.20	3.18 ± 0.15	3.56 ± 0.04	3.85 ± 0.07
Syringic acid	2.31 ± 0.04	6.19 ± 0.08	3.11 ± 0.01	2.88 ± 0.15	1.45 ± 0.23	3.21 ± 0.02	2.29 ± 0.07	2.39 ± 0.04
Epicatechin	29.89 ± 0.62	40.08 ± 1.10	31.15 ± 0.49	32.50 ± 0.61	10.90 ± 0.56	17.24 ± 0.16	22.75 ± 0.11	18.45 ± 0.46
p-Coumaric acid	3.01 ± 0.27	3.55 ± 0.24	2.88 ± 0.13	2.67 ± 0.12	1.47 ± 0.10	2.25 ± 0.15	2.85 ± 0.24	2.72 ± 0.07
Benzoic acid	3.74 ± 0.08	4.54 ± 0.24	3.63 ± 0.10	3.92 ± 0.16	1.38 ± 0.09	2.31 ± 0.01	2.70 ± 0.80	1.88 ± 0.08
o-Coumaric acid	1.82 ± 0.07	1.96 ± 0.06	1.56 ± 0.02	1.44 ± 0.06	1.04 ± 0.08	1.48 ± 0.03	1.41 ± 0.06	1.34 ± 0.06
trans-Cinnamic acid	4.47 ± 0.09	4.63 ± 0.02	3.95 ± 0.10	1.25 ± 0.01	1.30 ± 0.09	1.23 ± 0.05	1.26 ± 0.14	
Total phenolic acids	113.1	172.0	125.6	131.2	51.0	70.6	80.7	76.7

[a]Values are means ± SD, IG, bitter melon var. India Green; IW, bitter melon var. India White; CG, bitter melon var. China Green; CW, bitter melon var. China white; ND, not-detectable; Tr, trace (less than 1 mg per 100 g dried basis).(adapted from Horax *et al.*, 2005)

Table 4(c). Phenolic acid constituents (mg per 100 g of flour, dried basis) bitter melon inner tissues by oven dried and freeze dried

Phenolic acid	Oven dried				Freeze-dried			
	IG	IW	CG	CW	IG	IW	CG	CW
Gallic acid	8.46 ± 0.80	15.59 ± 1.09	4.97 ± 0.20	10.29 ± 0.16	2.57 ± 0.02	8.03 ± 7.47	3.51 ± 0.10	18.05 ± 1.06
Protocatechuic acid	5.05 ± 0.48	7.82 ± 0.15	4.34 ± 0.22	4.81 ± 0.08	1.49 ± 0.09	2.69 ± 0.05	2.37 ± 0.09	2.59 ± 0.03
Gentisic acid	21.78 ± 0.26	32.61 ± 2.22	18.61 ± 1.51	18.19 ± 0.17	6.98 ± 0.36	13.34 ± 0.69	11.81 ± 0.39	13.35 ± 0.63
Catechin	17.43 ± 1.07	25.87 ± 2.09	19.49 ± 0.92	39.74 ± 1.21	13.54 ± 0.05	18.87 ± 0.80	21.63 ± 0.32	20.24 ± 1.92
Vanillic acid	1.90 ± 0.12	2.19 ± 0.19	1.74 ± 0.22	1.84 ± 0.03	1.38 ± 0.01	1.48 ± 0.03	1.50 ± 0.03	2.15 ± 0.03
Chlorogenic acid	6.30 ± 0.31	9.91 ± 0.69	8.33 ± 0.77	3.91 ± 0.06	4.11 ± 0.06	4.69 ± 0.45	7.49 ± 0.12	4.17 ± 0.12
Syringic acid	1.34 ± 0.18	3.66 ± 0.37	1.28 ± 0.07	1.24 ± 0.03	Tr	1.04 ± 0.06	1.03 ± 0.05	2.08 ± 0.05
Epicatechin	19.15 ± 0.39	40.91 ± 1.97	26.42 ± 0.16	8.55 ± 0.23	6.51 ± 0.16	14.79 ± 0.44	15.08 ± 0.29	ND
p-Coumaric acid	1.88 ± 0.03	2.91 ± 0.38	1.58 ± 0.05	2.53 ± 0.04	1.15 ± 0.04	1.57 ± 0.02	3.99 ± 0.15	4.16 ± 0.14
Benzoic acid	1.80 ± 0.37	2.69 ± 0.18	1.90 ± 0.16	1.80 ± 0.02	Tr	ND	ND	ND
o-Coumaric acid	1.28 ± 0.05	2.08 ± 0.21	1.39 ± 0.03	1.35 ± 0.01	1.02 ± 0.01	ND	1.63 ± 0.04	ND
trans-Cinnamic acid	Tr	1.09 ± 0.03	Tr	Tr	Tr	Tr	ND	ND
Total phenolic acids	86.4	147.3	90.1	94.3	38.7	66.5	70.0	66.8

[a]Values are means ± SD, IG, bitter melon var. India Green; IW, bitter melon var. India White; CG, bitter melon var. China Green; CW, bitter melon var. China white; ND, not-detectable; Tr, trace (less than 1 mg per 100 g dried basis).(adapted from Horax *et al*., 2005)

activity, β-carotene–linoleate bleaching assay, ferric reducing/antioxidant power (FRAP) assay and the total antioxidant capacity were evaluated and FRAP assay showed the highest (R^2=0.948) correlation with the total phenolic content. Tan *et al.* (2014) also found a strong correlation between the total phenolic content and antioxidant capacity in three different assay such as ABTS (R = 0.94), DPPH (R = 0.95) and FRAP (R = 0.99) using different solvent extracts of bitter gourd. Budart *et al*. (2009) reported that subcritical water extraction of bitter gourd had the highest antioxidant activity (IC_{50} value was 5.49) and there was a high correlation between the total antioxidant capacity and the total phenolic content.

Health benefits properties of bitter gourd

Several researchers showed that the various medicinal properties of bitter gourd such as antidiabetic, antihyperglycemic anticancerous, anti-HIV, antitumour, antimutagenic, antibacterial, antiulcerogenic, anti-tumour, antihelminthic, antileukemic, antilipogensis, abortifacient and antifertility (Rathi *et al.*, 2002; Uebanso *et al.,* 2007; Kandangath *et al.*, 2015). Some healths benefits are described below especially those have huge health benefit for human being:

Effects of bitter gourd on blood sugar levels and antidiabetic activity

Previously many studies have proven that consumption of bitter gourds such as whole fruit, juice, extract and dried powder are very effective in lowering blood glucose level (Basch *et al.,* 2003; Lawrence *et al*., 2009) and bitter gourd has positive effects on antidiabetic activity. Glycosides, saponins, alkaloids, triterpenes, polysaccharides, proteins, steroids, charantin, a polypeptide-p, momordin Ic, oleanolic acid 3-O-monodesmoside, and oleanolic acid 3-O-glucuronide are found in bitter gourd those compounds have hypoglycaemic activity. Ali *et al.* (1993) found that insulin-dependent diabetes mellitus (IDDM) rats and normal rats were showed that significant hypoglycemic effect in fasting and post-prandial states after consumed the saponin free methanolic extract of bitter gourd juice than non-insulin-dependent diabetes mellitus (NIDDM) rats. Bitter gourd also enhance glucose tolerance and dominate the postprandial hyperglycaemia in rats (Uebanso *et al.,* 2007; Leung *et al.,* 2009) as well as increase the insulin sensitivity and lipolysis in rat (Leung *et al*., 2009). Some reviewer also found that similar effects on the hypoglycaemic effects between bitter gourd and oral medications such as tolbutamide, chlorpropamide and glibenclamide (Virdi *et al*., 2003; Ojewole *et al*., 2006; Leung *et al*., 2009). Baldwa *et al.* (1977) mentioned that 21.5%, 49.2%, 28% reduction in blood glucose at 30 mins, 4 hr and 12 hr respectively after consume of bitter gourd whereas control (placebo ijection) showed 5% reduction in glucose level. After consume of fried karela as daily basis also produced significant development in glucose level in diabetic patients subsequently serum insulin levels also did not increase (Leatherdale *et al*., 1981). Ahmad *et al.* (1999) also found reduction of 86% cases post-prandial serum glucose and 5% reduction of fasting glucose after consume of bitter gourd pulp for 100 cases of moderate NIDDM patient. There are many mechanisms of blood sugar levels and antidiabetic activity with bitter gourd. Bitter gourds enhance the beta cells (Ahmed *et al*., 1998) and acts as vegetable insulin (Leung *et al*., 2009) as well as bitter gourd could increase the uses of glucose in liver and muscle. (Sarkar *et al*., 1996). On the other hand, bitter gourd could also destroy of carbohydrate enzyme activity such as hexokinase, glucokinase, phosphofructokinase and substrate glucose-6-phosphate also revived after treatment with bitter gourd in liver of diabetic mice (Rathi *et al*., 2002).

Anti-bacterial activity

Water, ethanol and methanol of bitter gourd leaves extract exhibited the inhibition capacity against various microorganisms such as *Escherichia coli, Salmonella paratyphi, Shigella dysenterae Streptomyces griseus in vitro* (Ogata *et al*., 1991). Khan *et al*. (1998) found entire of bitter gourd extract also showed positive activity against Entamoeba histolytica. Helicobacter pylori-organism also could be suppressed using of bitter gourd fruit extract. Frame *et al.* (1998) mentioned that Mycobacterium tuberculosis growth might be inhibited using bitter gourd leaves extract through BACTEC 460 method.

Wound-healing activity

It was reported that bitter gourd extract have therapeutic agent for tissue regeneration. It posses wound healing properties and stimulated the proliferation of dermal fibroblasts of human (Tan *et al*., 2016)

Anti-HIV activity

Alpha- and beta-momorcharin protein are present in seeds, fruit, and leaves of bitter gourd those protein showed Anti HIV activity *in vitro* (Zheng *et al*., 1999; Au *et al*., 2000) and alpha- and beta-momorcharin protein also could suppressed of HIV-1 integrase (Au *et al*., 2000). MRK29 protein also found in bitter gourd and MRK29 protein has able to inhibition of viral reverse transcriptase (Wang and Ng, 2001). Tumor necrosis factor (TNF) activity could increase and subsequently HIV-infected cells expressed by viral core protein p24 also 82% reduced using salt-precipitated fraction of MRK29 protein reported by (Jiratchariyakul *et al*., 2001).

Anticancer and antitumor properties

It was found that Thai bitter gourd contained anti-carcinogens and chemopreventive agent whereas Chinese variety did not have that property. Various in vivo as well as in vitro studies demonstrated that bitter gourd extract inhibits cancer cell growth and the development of mammary tumors in mice and liver cancer and leukemia in human (Grover *et al*., 2004; Fang *et al.*, 2012a). MAP30 protein is present in bitter gourd. Various *in vivo* and *in vitro* studies suggested that the efficacy and safety of MAP30 against liver cancer (Fang *et al*., 2012a). 14-kDa Ribonuclease, known as RNase MC2 which is isolated from seeds of bitter gourd and have an activities against MCF-7 breast cancer cells reported by Fang *et al.* (2012b). Fang *et al.* (2012b) also reported that RNase MC2 had the anticarcinogenic effects toward human liver cancer cells. RNase MC2 have an effect on both cytostatic and cytotoxic activity against MCF-7 breast cancer cells which indicated the apoptotic response of the RNase MC2 in both mice and HepG2 cells which cause nuclear damage resulting in early or late aoptotic response.

Anticancer mechanisms of bitter gourd have been mentioned elsewhere. Bitter gourd phytochemicals could be inhibited DNA, RNA and cellular protein synthesis as well as bitter gourd also might be suppressed the cell cycle G2 and M phases through inhibit the uptake of thymidine, uridine and leucine into DNA (Claflin *et al.*, 1978). Bitter gourd suppressed the guanylate cyclase activity (Claflin *et al*., 1978; Takemoto *et al.*, 1982) and promoted the activation of NK cells (Porro *et al.* 1993). Sun *et al.* (2001) showed induction of apoptosis by treatment with bitter gourd. Bitter gourd also showed modulatory effect on biotransformation and detoxification enzymes.

Value added products from bitter gourd

Genarally, bitter gourds are very much consumed as fresh or in different recipes such as soups, salads, stir fried, deep fried, boiled, steamed, microwaved, juiced, pickled, snacks, curries, bakery products, stuffed products of meat, and oven dried to drink as tea (Aminah and Permatasari, 2013; Singh and Sagar, 2013). Different value-added products using bitter gourd are shown in Figure 1d. Various processing technologies were investigated to produce widely acceptable products, extending shelf life and availability of all the year round and adding value of the raw products.

Juice and beverage from bitter gourd

Generally bitter gourd juices are unacceptable to various communities due to its tremendous bitter taste. For this reason, it is needed to develop a suitable formulation, processing and storage using bitter gourd fortified juice and thus make it palatable and acceptable to consumers. Kaur and Aggarwal (2014) reported that bitter gourd juice treated potassium metabisulfite (KMS) had higher nutrient

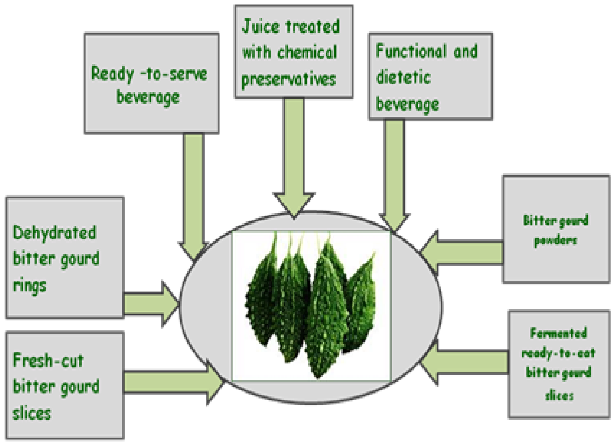

Figure 1(d). Various Value-added products from bitter gourd

stability than Na-benzoate. On the other hand, bitter gourd extract (15%) with artificial sweetener was employed to develop functional and dietetic beverage and preserved at refrigerated temperature for six months with good flavour and palatability as well as other nutritional properties (Din *et al*., 2011). On the other hand, different concentration of bitter gourd juice, sugar and citric acid was used to prepare ready to serve bitter gourd beverages (Satkar *et al.*, 2013). These research groups reported that ready –to-serve bitter gourd beverage could be made using the levels of juice 12.5% sugar -15 g, citric acid 0.29 g and water 76 mL for 100 mL of beverage and kept refrigerated (5±1ºC) temperature up to 3 months without changing the chemical and sensory qualities.

Dehydrated products from bitter gourd

Solar drying, low temperature drying and cabinet drying was applied to manufacture the bitter gourd rings and found that the cabinet drying method was the best method for making or drying of bitter gourd because the retention of all the bioactive compounds such as ascorbic acid, total carotenoids, β-carotene and total chlorophyll content than those of other drying methods (Singh and Sagar, 2013). Kumar *et al.* (2016) produced osmo-air drying of bitter gourd chips using soaking with 0.2% KMS for 10 mins followed by 2%, 6%, 10% of NaCl and 1%, 3% and 5% acetic acid for 90 mins, blotting and dried at 60^0C for 8 hr. These research groups revealed that bitter gourd chips prepared with 10% NaCl had better in color and over all acceptability and might be kept at ambient conditions for 3 months without loss of organoleptic quality and microbiologically safe. Lyophilized and hot-air dried superfine powder was produced using bitter gourd reported by Zhu *et al.* (2012). These research groups also demonstrated that lyophilized superfine powder had a higher antidiabetic activity than hot-air dried powder because of reducing fasting blood glucose level was higher in lyophilized powder as compared to hot-air dried powder. Therefore bitter gourd powder could be used as suitable functional food ingredients. Bitter gourd extract might be applied as natural antioxidant instead of synthetic antioxidant in food sector for extending shelf life of food commodity owing to higher natural plant phenolics and antiradical power (Horax *et al*., 2005; Horax *et al.*, 2010).

Bitter gourd slices

Fresh-cut bitter gourd slices (1 cm thick) might be kept in modified atmosphere packaging with low density polyethylene bag for 15 days at 8^0C without deterioration nutritional quality (Preetha *et al.*, 2015). Fermented bitter gourd slices was made with 3% dry salts and 3% saturated brine solution, and 3% dry salts with 1% saturated brine solution in refrigerated condition for 4 weeks. Results showed that treated with 3% dry salt was in highly acceptable levels as a fermented ready to eat vegetables and maximum overall acceptability also found during storage period (Silva *et al.,* 2016).

Conclusion

Nowadays various diseases such as cardiovascular disease, cancer, diabetes, HIV and so on have been spread worldwide. It is confirm that antioxidant could contribute to prevent many diseases. Bitter gourd could be used as different sources of phytochemicals those are worthy of human being. However processing methods and consumption way the influences of contain of phytochemicals in human body. Therefore, it can be considered that from this review Bitter gourd could be used as health promising phytochemicals those are beneficial for human health. There are limitation researches on human studies using bitter gourd. Thus, the much more researches are needed on specific diseases using bitter gourds.

References

Abdullah, A. and Kamarudin, A.P. 2013. Effect of drying and cooking methods on antioxidant properties of bitter gourd *(Momordica charantia)*. Journal of Tropical Agriculture and Food Science 41: 249 – 256.

Ahmad, N., Hassan, M.R., Halder, H. and Bennoor, K.S. 1999. Effect of *Momordica charantia* (Karolla) extracts on fasting and postprandial serum glucose levels in NIDDM patients. Bangladesh Medical Research Council Bulletin 25: 11–13.

Ahmed, I., Adeghate, E., Sharma, A.K., Pallot, D.J. and Singh, J. 1998. Effects of *Momordica charantia* fruit juice on islet morphology in the pancreas of the streptozotocin-diabetic rat. Diabetes Research and Clinical Practice 40: 145–151.

Alam, M.A., Uddin, R., Subhan, N., Rahman, M.M., Jain, P. and Reza, H.M. 2015. Beneficial Role of Bitter Melon Supplementation in Obesity and Related Complications in Metabolic Syndrome. Journal of Lipids 2015: 1-18.

Ali, M.S., Sayeed, M.A., Reza, M.S., Yesmeen, S. and Khan, A.M. 2008 .Characteristics of seed oils and nutritional composition of seeds from different varieties of *Momordica Charantia* Linn. Cultivated in Bangladesh. Journal of Food Science 26: 275-283.

Ali, L., Khan, A.K., Mamun, M.I., Mosihuzzaman, M., Nahar, N., Nur-ealam, M. and Rokeya, B. 1993. Studies on hypoglycemic effects of fruit pulp, seed, and whole plant of *Momordica charantia* on normal and diabetic model rats. Planta Medica 59: 408–412.

Aminah, A. and Permatasari, K. A. 2013. Effect of drying and cooking methods on antioxidant properties of bitter gourd *(Momordica charantia).* Journal of Tropical Agriculture and Food Science 41(2): 249-256.

Assubaie, N.F. and El-garawany, M.M. 2004. Evaluation of some important chemical constituents of *Momordica charantia* cultivated in Hofuf, Saudi Arabia. Journal of Biological Science 4: 628–630.

Au, T.K., Collins, R.A., Lam, T.L., Ng, T.B., Fong, W.P. and Wan, D.C. 2000. The plant ribosome inactivating proteins luffin and saporin are potent inhibitors of HIV-1 integrase. FEBS Letters 471: 169–172.

Baldwa, V.S., Bhandari, C.M., Pangaria, A. and Goyal, R.K. 1977. Clinical trials in patients with diabetes mellitus of an insulin-like compound obtained from plant source. Upsala Journal of Medical Sciences 82: 39–41.

Basch, E. and Gabardi, S. and Ulbricht, C. 2003. Bitter melon *(Momordica Charantia)*: a review of efficacy and safety. American Journal of Health-System Pharmacy 60: 199-204.

Bian, H.X., Wu, Z.Y., Bao, B., Cai, J., Wang, X., Jiang, Y., Liu, J. and Qu, W. 2016. 1H NMR-based metabolic study reveals the improvements of bitter melon *(Momordica charantia)* on energy metabolism in diet-induced obese mouse. Pharmaceutical Biology 54: 3103-3112.

Budrat, P. and Shotipruk, A. 2009. Enhanced recovery of phenolic compounds from bitter melon *(Momordica charantia)* by subcritical water extraction. Separation and Purification Technology 66: 125–129.

Cefalu, W.T., Ye, J. and Wang, Z.Q. 2008. Efficacy of dietary supplementation with botanicals on carbohydrate metabolism in humans. Endocrine, Metabolic and Immune Disorders-Drug Targets 8:78-81.

Cerda, A., Martínez, M.E., Soto, C., Poirrier, P., Perez-correa, J.R., Vergara-salinas, J.R. and Zúñiga, M.E. 2013.The enhancement of antioxidant compounds extracted from *Thymus vulgaris* using enzymes and the effect of extracting solvent. Food Chemistry 139:

138–143.

Chuang, C.Y., Hsu, C., Chao, C.Y., Wein, Y.S., Kuo, Y.H. and Huang, C. J. 2006. Fractionation and identification of 9c, 11t, 13t-conjugated linolenic acid as an activator of PPARalpha in bitter gourd (*Momordica charantia* L.). Journal of Biomedical Science 13: 763-772.

Claflin, A.J., Vesely, D.L., Hudson, J.L., Bagwell, C.B., Lehotay, D.C., Lo, T.M., Fletcher, M.A., Block, N.L. and Levey, G.S. 1978. Inhibition of growth and guanylate cyclase activity of an undifferentiated prostate adenocarcinoma by an extract of the balsam pear (*Momordica charantia* abbreviata). Proceedings of the National Academy of Sciences USA 75: 989–993.

Cousens, G. 2008.There is a cure for diabetes: the tree of life 21 day program, p. 191-192. California: North Atlantic Books.

Darchivio, M., Filesi, C., Di benedetto, R., Gargiulo, R., Giovannini, C. and Masella, R. 2007. Polyphenols, dietary sources and bioavailability. Ann Ist Super Sanita 43: 348-361.

Din, A., Bukhari, A.H., Salam, A. and Ishfaq, B. 2011. Development of Functional and Dietetic beverage from bitter gourd. International Journal of Food Safety 13: 355-360.

Fang, E. F., Zhang, C. Z., Wong, J. H., Shen, J. Y and Ng, T. B. 2012a. The MAP30 protein from bitter gourd *(Momordica charantia)* seeds promotes apoptosis in liver cancer cells *in vitro* and *in vivo.* Cancer Letters 324(1): 66-74.

Fang, Zhang, Fong, *et al.* 2012b. RNase MC2: a new *Momordica charantia* ribonuclease that induces apoptosis in breast cancer cells associated with activation of MAPKs and induction of caspase pathways. Apoptosis 17: 377–387.

Frame, A.D., Rios-olivares, E., De jesus, L., Ortiz, D., Pagan, J. and Mendez, S. 1998. Plants from Puerto Rico with anti-*Mycobacterium tuberculosis* properties. Puerto Rico Medical Sciences 17: 243–252.

Grover, J.K. and Yadav, S.P. 2004. Pharmacological actions and potential uses of *Momordica charantia*: a review. Journal of Ethnopharmacology 93: 123–132.

Habicht, S.D., Kind, V., Rudloff, S., Borsch, C., Mueller, A.S., Pallauf, J., Yang, R. and Kraawinkel, M.B. 2011. Quantification of antidiabetic extracts and compounds in bitter gourds varieties. Food Chemistry 126: 172-176.

Horax, R., Hettiarachchy, N. and Chener, P. 2010. Extraction, Quantification, and Antioxidant Activities of Phenolics from Pericarp and Seeds of Bitter Melons *(Momordica charantia)* Harvested at Three Maturity Stages (Immature, Mature, and Ripe). Journal of Agricultural and Food Chemistry 58: 4428–4433.

Horax, R., Hettiarachchy, N. and Islam, A.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: C275- C280.

Huang, T.N., Lu, K.N., Pai, Y.P., Hsu, C. and Huang, C.J. 2013. Role of GLP-1 in the Hypoglycemic Effects of Wild Bitter Gourd. Evidence-Based Complementary and Alternative Medicine 2013: 1-13.

Islam, S., Jalaluddin, M. and Hettiarachchy, N.S. 2011. Bioactive compounds of bitter melon genotypes (*Momordica charantia* L.) in relation to their physiological functions. Functional Foods in Health and Disease 2: 61-74.

Jiratchariyakul, W., Wiwat, C., Vongsakul, M., Somanabandhu, A., Leelamanit, W., Fujii, I., Suwannaroj, N. and Ebizuka, Y. 2001. HIV inhibitor from Thai bitter gourd. Planta Medica 67: 350–353,

Joseph, B. and Jini, D. 2013. Antidiabetic effects of *Momordica charantia* (bitter melon) and its medicinal potency. Asian Pacific Journal of Tropical Disease 3: 93-102.

Kandangath, R.A., Garlapati, P.K. and Nallamuthu, I. 2015. Nutritional, pharmacological and medicinal properties of *Momordica charantia*. International Journal of Nutrition and Food Sciences 4: 75-83.

Kaur, G. and Aggarwal, P. 2014. Storage studies on bitter gourd juice preserved with different chemical preservatives. International Journal of Research in Engineering and Technology 3: 2319-1163.

Khan, M.R., Omoloso, A.D. and Khan, M.R. 1998. *Momordica charantia* and *Allium sativum*: Broad spectrum antibacterial activity. Korean Journal of Pharmacognosy 29: 155–158.

Kubola, J. and Siriamornpun, S. 2008. Phenolic contents and antioxidant activities of bitter gourd (*Momordica charantia* L.) leaf, stem and fruit fraction extracts in vivo. Food Chemistry 110: 881–890.

Kumar, A.M., Naik, K.M., Pathare, J., Balfour, D. and Kotecha, P.M. 2016. Studies on osmo-air drying of bitter gourd chips-physica, chemical composition. International Journal of Advanced Scientific Technical Research 3: 175- 196.

Lawrence, L., Richard, B., Jyoti K., Susan H. and Sharon, C. 2009. Anti-diabetic and hypoglycaemic effects of *Momordica charantia* (Bitter melon): A mini review. British Journal of Nutrition 102: 1703-1708.

Leatherdale, B.A., Panesar, R.K., Singh, G., Atkins, T.W. and Bailey, C.J., Bignell, A.H. 1981. Improvement in glucose tolerance due to *Momordica charantia* (karela). British Medical Journal 282: 1823–1824.

Leung, L., Birtwhistle, R., Kotecha, J., Hannah, S. and Cuthbertson, S. 2009. Anti-diabetic and hypoglycaemic effects of *Momordica charantia* (bitter melon): a mini review. British Journal of Nutrition 102: 1703–1708.

Li, B.B., Smith, B. and Hossain, M.M. 2006. Extraction of phenolics from citrus peels I. Solvent extraction method. Separation and Purification Technology 48: 182–188.

Lin, J.Y. and Tang, C.Y. 2007. Determination of total phenolic and flavonoid contents in selected fruits and vegetables, as well as their stimulatory effects on mouse splenocyte proliferation. Food Chemistry 101: 140–147.

Ogata, F., Miyata, T., Fujii, N., Yoshida, N., Noda, K., Makisumi, S. and Ito, A., 1991. Purification and amino acid sequence of a bitter gourd inhibitor against an acidic amino acid-specific endopeptidase of Streptomyces griseus. Journal of Biological Chemistry 266: 16715–16721.

Ojewole, J.A., Adewole, S.O. and Olayiwola, G. 2006.

Hypoglycaemic and hypotensive effects of *Momordica charantia* Linn(Cucurbitaceae) whole-plant aqueous extract in rats. Cardiovascular Journal of Africa 17: 227–232.

Piskin, A., Altunkaynak, B.Z., Tümentemur, G., Kaplan, S., Yazici1, Ö.B. and Hökelek, M. 2014. The beneficial effects of *Momordica charantia* (bitter gourd) on wound healing of rabbit skin. Journal of Dermatological Treatment 25: 350–357.

Porro, G., Bolognesi, A., Caretto, P., Gromo, G., Lento, P., Mistza, G., Sciumbata, T., Stirpe, F. and Modena, D. 1993. *In vitro* and *in vivo* properties of an anti-CD5-momordin immunotoxin on normal and neoplastic T lymphocytes. Cancer Immunology, Immunotherapy 36: 346–350.

Preetha, P., Varadharaju, N. and Vennila, P. 2015. Enhancing the shelf life of fresh-cut bitter gourd using modified atmospheric packaging. African Journal of Agricultural Research10: 1943-1951.

Raman, S. and Manimegalai, G. 1998. Effect of pretreatments on the quality characteristics of dehydrated bittergourd rings. Indian Food Packer 52: 7-14.

Rathi, S.S., Grover, J.K. and Vats, V. 2002. The effect of *Momordica charantia* and *Mucuna pruriens* in experimental diabetes and their effect on key metabolic enzymes involved in carbohydrate metabolism. Phytotherapy Research 16: 236–243.

Sandra, D.H., Veronica, K., Silvia, R., Christian, B., Andreas, S.M., Joseph, P., Yang, R.Y. and Krawinkel, M.B. 2011. Quantification of antidiabetic extracts and compounds in bitter gourd varieties. Food Chemistry 126: 172-176.

Sarkar, S., Pranava, M. and Marita, R. 1996. Demonstration of the hypoglycemic action of *Momordica charantia* in a validated animal model of diabetes. Pharmacological Research 33: 1–4.

Sathishsekar, D. and Subramanian, S. 2005. Beneficial effects of *Momordica charantia* seeds in the treatment of STZ-induced diabetes in experimental rats. Biological Pharmaceutical Bulletin 28: 978–983.

Satkar, K.P., Kulthe, A.A. and Chalke, P.R. 2013. Preparation of bitter gourd ready to serve beverage and effect of storage temperature on its keeping quality. The Bioscan 8:115-117.

Silva, G.M.S.W., Premathilaka, U.L.R.R.W., Maduwanthi, S.D.T. and Uthpala, T.G.G. 2016. Development of fermented *Momordica charantia* and analysis of biochemical properties. International Journal of Scientific Engineering and Research 7: 362-366.

Singh, U. and Sagar, V. R. 2013. Effect of drying methods on nutritional composition of dehydrated bitter gourd (*Momordica Charantia* L.) rings . Agriculture Sustainable Development 1: 83-86.

Sorifa, A. M., Ahmed, M. and Eun, J.B. 2010. Solvent effects on antioxidant properties of persimmon (*Diospyros kaki* L. cv. Daebong) seeds. International Journal of Food Science and Technology 45: 2258–2264.

Soundararajan, R., Prabh, P., Rai, U. and Dixit, A. 2012. Antileukemic Potential of *Momordica charantia* Seed Extracts on Human Myeloid Leukemic HL60 Cells. Evidence Based Complementary Alternative Medicine 2012: 1-10.

Sun, Y., Huang, P.L., Li, J.J., Huang, Y.Q., Zhang, L., Huang, P.L. and Lee-huang, S. 2001. Anti-HIV agent MAP30 modulates the expression profile of viral and cellular genes for proliferation and apoptosis in AIDS-related lymphoma cells infected with Kaposi's sarcomaassociated virus. Biochemical Biophysical. Research Communication 287: 983–994.

Takemoto, D.J., Dunford, C., Vaughn, D., Kramer, K.J., Smith, A. and Powell, R.G. 1982. Guanylate cyclase activity in human leukemic and normal lymphocytes. Enzyme inhibition and cytotoxicity of plant extracts. Enzyme 27: 179–188.

Tan, Kha, Parks et al. 2016. Bitter melon (*Momordica charantia* L.) bioactive composition and health benefits: A review. Food Review International 2: 181–202.

Tan, Parks, Stathopoulos *et al.* 2014. Greenhouse-grown bitter melon: production and quality characteristics. Journal of the Science Food and Agriculture 94: 1896–1903.

Uebanso, T., Arai, H., Taketani, Y., Fukaya, M., Yamamoto, H., Mizuno, A., Uryu, K., Hada, T. and Takeda, E. 2007. Extracts of *Momordica charantia* suppress postprandial hyperglycemia in rats. Journal of Nutritional Science Vitaminology 53: 482-488.

Virdi, J., Sivakami, S., Shahani, S., Suthar, A.C., Banavalikar, M.M. and Biyani, M.K. 2003. Antihyperglycemic effects of three extracts from *Momordica charantia*. Journal of Ethnopharmacology 88: 107–111.

Wang, H.X. and Ng, T.B. 2001. Examination of lectins, polysaccharopeptide, polysaccharide, alkaloid, coumarin and trypsin inhibitors for inhibitory activity against human immunodeficiency virus reverse transcriptase and glycohydrolases. Planta Medica 67: 669–672.

Wang, L., Li, Q., Cao, J., Cai, T. and Jiang, W. 2007. Keeping quality of fresh-cut bitter gourd (*Momordica charantia*.) at low temperature of storage. Journal of Food Processing and Preservation 31: 571-582.

Weng, J.R., Bai, L.Y., Chiu, C.F., Hu, J.L., Chiu, S.J. and Wu, C.Y. 2013. Cucurbitane Triterpenoid from *Momordica charantia* Induces Apoptosis and Autophagy in Breast Cancer Cells, in Part, through Peroxisome Proliferator-Activated Receptor. Evidence Based Complementary Alternative Medicine 2013: 1-12.

Wu, S.J. and Ng, L.T. 2008. Antioxidant and free radical scavenging activities of wild bitter melon (*Momordica charantia* Linn var. abbreviata Ser.) in Taiwan. LWT: Food Science and Technology 41: 323–330.

Zheng, Y.T., Ben, K.L. and Jin, S.W. 1999. Alpha-momorcharin inhibits HIV-1 replication in acutely but not chronically infected T-lymphocytes. Acta pharmacological sinica 20: 239–243.

Zhu, Y., Dong, Y., Qian, X., Cui, F., Guo, Q., Zhou, X., Wang, Y., Zhang Y., and Xiong Z. 2012. Effect of superfine grinding on antidiabetic activity of bitter melon powder. International Journal of Molecular Science 13: 14203-14218.