Bitter Gourd

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Abstract

Momordica charantia (bitter gourd) is utilized as traditional medicinal plant and food in Indo-China and Southeast Asia. This nutrient plant-based food contains abundant of bioactive components such as polypeptide, minerals vitamins, alkaloids, flavonoids, isoflavones, terpenes, anthroquinones, and glucosinolates. In the present study, physicochemical properties, nutritional values, and health promoting phytochemicals, as well as value added products of bitter gourd are described. Majority of the bioactive compounds in bitter gourd confer bitter taste. A large number of value-added products can be prepared from bitter gourd such as bitter gourd juice, slices, pickle, dried rings, and chips. These valued products in addition to being healthy are more palatable than raw fruit, thus increasing consumption of this bitter fruit. Hence, besides having the health-enhancing properties, it might be considered proficient option in value-added foodstuffs.

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9.1 Introduction

Bitter gourd or *Momordica charantia* is originated from the Latin word "momordica," meaning "to bite," refers to the grooved ends of its seed that seems like it has been chewed. Bitter gourd as bitter squash, wild cucumber (Eng), bitter apple, bitter melon, bitter gourd, balsam-pear, paria, pare (Indonesian), margose (French), Balsambirne (German), balsamito (Spanish), peria (Malay), concombre (African), and with many more similar names is a subtropical and tropical vine of the family Cucurbitaceae, extensively grown-up in Africa, Asia, also can be found in South America and the Caribbean (Krawinkel and Keding 2006) for its edible fruit. Bitter gourd is of previous world origin and is indigenous of tropical Asia, predominantly in the Indo Burma region. In India, common names are Hagala Kayi in Kannada; Karla in Marathi; Beet, Kakara kaya in Telugu; Pavakai in Tamil; Pavakka in Malayalam, Karela in Hindi, Gujarati, and Punjabi, and Karela in Assamese. The genus *Momordica* have12 species in Asia and Australia plus 47 species in Africa, and, interestingly, bitter gourd is not an Asian origin by a three genome phylogeny but is of African origin (Schaefer and Renner 2010). Bitter gourd in India is an essential vegetable in states, mainly in Karnataka, Tamil Nadu, Maharashtra, Uttar Pradesh, and Kerala.

Bitter gourd is a nutritious and healthy food having a typical bitter flavor, and is broadly subjugated in folklore drug (Fang and Ng 2011). Bitter gourds have been linked with antidiabetic, anticancer, antimicrobial, and anti-inflammatory characteristics. In Ayurveda, the fruit is said to have tonic, stomachic, antibilious, stimulant, alterative, emetic, and laxative properties. Several countries particularly in tropics it is an important vegetable crop. When bitter gourd is compared to other cucurbits, it has fairly elevated nutritional value, in respects of vitamin C and iron contents. Although the major use of bitter gourd is in folk medicine and vegetable crop, but it is also cultivated as a decoration due to its showy flowers (Janick and Paull 2008). It possesses a plain genome having $2n = 22$ chromosomes with a genome size of about 339 Mb. Bitter gourd is mostly monoecious in nature whose pistillate and staminate flowers are produced on separate nodes. Every portion of this plant, mostly the seeds and the fruits, holds further 60 phytomedicines active next to more than 30 illnesses, as well as diabetes and cancer.

In India to which bitter gourd belongs is genus *Momordica* having four species namely *M. charantia* (cultivated bitter gourd), *M. balsamina* (fruits that are not mature are used as vegetable or picked), *M. charantia* var. *muricata* (extremely small and bitter-fruited wild bitter gourd), *M. cochinchinens* is (sweet gourd of Assam) and *M. dioica*. Generally, bitter gourd fruits are 1.0- to 5.9-inch-wide and 1.0- to 9.8-inch-long with oblong, round, oval, and club in shape, and its color varies

from dark green to white. Its size and shape varies with the different varieties (Kumar et al. 2016). The bitter gourd fruit takes 45–80 days to get mature, and the harvesting starts from 60 days of planting and it is continued up to 150 days (Kumar et al. 2016). Diverse kinds of bitter gourds are available in around the world. India long green, India long white, and Hybrid India baby are available in India, whereas Japan Green Spindle, Green Lover, and Hong Kong Green are famous in Japan, China, and Hong Kong, respectively. In Bangladesh, mainly two varieties are found: large size is called Korolla and small size is locally called Ucche (Alam et al. 2015).

9.1.1 Hierarchy Classification of Bitter Gourd

Species: *Momordica charantia.*
Genus: Momordica.
Family: Cucurbitaceae.
Order: Violales.
Class: Dicotyledonae.
Subphylum: Angiospermae.
Phylum: Spermatophyta.
Kingdom: Plantae.
Domain: Eukaryota.

9.1.2 Nutritional Profile of Bitter Gourd

Consumption of vegetables has amplified due to their elevated percentage of bioactive components such as ascorbic acid, phenolic acids, carotenoids, flavonoids, proteins, minerals, and dietary fibers while insufficient source of sugar (Cefalu et al. 2008; Cousense 2007). Among a variety of vegetables, bitter gourd is one of most nutritionally rich and has plentiful medicinal properties around the world. The quality and quantity of bioactive compound present in bitter gourd could possibly be dependent on various factors such as harvest time, temperature, state of maturity, and postharvest storage, as well as its size, shape, and color (Singh et al. 2014). Nutritional profile of bitter gourd is specified in Table 9.1. The bitter gourd fruit is perishable and has storage life of only 4 days at ambient conditions. However, it can be preserved for more than 3–4 weeks in cold storage at 0–70 °C. Fresh cut bitter gourds have only 4 days shelf life when stored at 20 °C. The fruits, seeds, leaves, vines and roots of bitter gourd are utilized as food and remedy for various types of diseases (Islam et al. 2011). It is a vital source of essential amino acids, niacin, vitamin C, carotenoids, vitamin A, folic acid, thiamin, riboflavin, and minerals and has a significant role in human diet to maintain sound health. The seeds of bitter gourd are also loaded with protein and oil (Ali et al. 2008). It is an excellent source of antioxidants such as catechin, chlorogenic acid, and gallic (Budrat and Shotipruk 2009) and saponin compounds (Tan et al. 2014). Pericarp and seeds of bitter gourd could be used as sources of different antioxidant agents (Horax et al. 2010). Habicht

Table 9.1 Nutritional Parameters of Bitter Gourd

Parameters	Amount
Moisture (%)	93.8
Ash (%)	0.8
Protein (g)	0.90
Fat (g)	0.1
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
Riboflavin (mg)	0.03
Thiamin (mg)	0.05
Vitamin A (mg)	0.04
Niacin (mg)	0.40
Phosphorus (mg/100 g)	69.0
Calcium	22.0
Potassium	26.0
Magnesium	16.0
Iron	0.9
Sodium	3.0
Zinc	0.1

(Source: Horax et al. 2010; Islam et al. 2011; Satkar et al. 2013)

et al. (2011) reported total fat content of whole fruit from 2.9% to 6.4% of dry matter. Bitter gourd also contains high number of vitamins B1, B2, B3, and B9 and vitamin A (Joseph and Jini 2013). Bitter gourd vegetables also hold diverse kinds of amino acids such as glutamine, asparagines, glycine, lysine, alanine, leucine, valine, arginine, proline, serine, isoleucine, phenylalanine, tryptophan, histidine, threonine, and methionine (Islam et al. 2011).

9.2 Value-Added Products from Bitter Gourd

Bitter gourd postharvest losses are about 25%. During transportation, mechanical damage and ripening are the main reasons for this huge loss. Also because of the watery nature of fruit, the damage by transportation is extremely high. Polysack bags that are used to pack bitter gourds can cause severe damage to the fruit. Postharvest losses could be reduced to a larger extent if the fruits are carefully transported. This

perishable fruit could be stored at room temperature for about 4–6 days if at immature stage they are harvested. Moreover, by storing those at 13 °C, the shelf life can also be prolonged.

Bitter gourd value addition could be done by many ways. For example, for domestic purposes, thin slices are dehydrated, and this technology is adopted in a small scale. Bitter gourds in the shape of rings and cubes may be used for different curry preparations. Bitter gourd tea is made by Brown Bitter gourd. The chief function of bitter gourd dehydration is to prolong the storage life and minimize bulk storage, packaging, and transportation. An improved quality of product could be prepared if driers are used for dehydration. Bhattacharjee et al. (2016) reported the dehydration and rehydration properties of bitter gourd fruits. Alteration in drying temperatures and blanching methods were involved, and it was concluded that, among the temperatures and blanching methods, better dehydration and rehydration characters were reported in samples dried at 60 °C and blanched in water for 2 minutes. Additionally, bitter gourd fruits can be canned (Krawinkel and Keding 2006). This vegetable is one of nature's plentiful gifts and is considered an undesirable vegetable by most of the consumers due to its unacceptable bitterness and unpleasant taste, as it has a bitter component called momordicin. Snee et al. (2011) performed a pilot study that was conducted in Hawaii. Their study reported that incorporation of bitter foods in regularly utilized food dishes could shield bitter melon's bitter taste. For example, the bitterness of bitter melon is shielded by tomato-based recipes having sour flavor and was liked by most participants.

Usually 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. Naturopaths recommend fresh bitter gourd juice. In many Ayurvedic medicines, stem and roots of wild bitter gourd are used. The immature fruits are used in a wide range of culinary preparations. It could be deep fried, fried, juiced, boiled, pickled, and dehydrated and also dried that can be used to drink like tea (Myojin et al. 2008). The fruit has immense potential as a food source in both industrialized and developing nations. Various processing technologies produce widely acceptable products, extending shelf life and availability of all the year round and adding value of the raw products.

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 making it palatable and acceptable to consumers. Additionally, the regular vegetable could be available for the customers throughout the year also in the shape of beverage. A common method of preparation of bitter gourd beverage is that fresh bitter gourds are rinsed carefully and peeled from the top. The pulp of this vegetable is extracted in an extractor juicer/pulper/blender/filter press and then strained. The pasteurization of juice is done at 83 °C for 3 min, and vitamin C at 0.15% is supplemented. This regular vegetable could be prepared and make available for the customers in off-seasons also in the form of beverage. Shelf life could be extended by adding chemical preservatives mainly potassium metabisulfite (KMS). Kaur and Aggarwal

evaluated the influence of various chemical additives specifically sodium benzoate, (KMS) and their mixture, on the phytochemical, physicochemical factors, and antioxidant activity of the beverage made from the bitter gourd. Among all preservatives added, KMS uphold the highest nutrient stability. Blending of different ratios of lemon and bitter gourd are used to prepare ready-to-use functional beverages. The sensory properties and physicochemical compounds of blended beverage were estimated for 60 days at 15 days of storage interval. The study concluded that bitter gourd–lemon functional drink made at 50:150 was mainly acceptable for lowest alteration in total soluble solids, acidity, and pH (Singh and Gaikwad 2012). 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, water 76 mL for 100 mL of beverage, and citric acid 0.29 g, and kept refrigerated (5 ± 1 °C) up to 3 months without changing the chemical and sensory qualities. Bitter gourd juice has been known as nutraceutical on the basis of presence of some bioactive components. The juices of other fruit like lemon, amla, etc. can be added to bitter gourd juice to enhance the nutritional value, as well as palatability and overall wholesomeness.

9.2.1 Fried Bitter Gourd Chips

The most significant attributes of fried food are texture, appearance, and flavor. In the United States, chips are most popularly consumed snacks and contains oil percentage of about 35.3%–44.5% w.b. that provides the distinctive quality attribute making the chips more advantageous (Garayo and Moreira 2002). Bitter gourd chips are well known for their taste and texture. Borse and Mishra 2014 studied the physicochemical characteristics of bitter gourd chips. Different frying temperatures were involved, and their effect was studied. Furthermore, bitterness was masked off by treating the bitter gourd slices with 1% turmeric and 2% salt and then allowed to rest for 30 min. Corn flour increased the crispiness of chips and the nutritional quality of bitter gourd chips. Evaluation of different physicochemical and sensory parameters such as taste, texture, flavor, and color was found satisfactory when bitter gourd chips were fried at 160 °C. It was concluded that given treatments decreased the bitterness from bitter gourd and thus their utilization was capitalized. Bitter gourd chips should be packed in the low-density polyethylene bags (LDPE) and then sealed using sealing machine and labeled properly. Packed bitter gourd chips should be kept in the dry or cool place.

9.2.2 Bitter Gourd Slices

Dehydrated bitter gourd slices, rings, and cubes are hold good import and export market potential. Preetha et al. (1943) carried out an experiment to enhance the bitter gourd slices shelf life by modified atmospheric packaging. Polypropylene (PP) and

low-density polyethylene (LDPE) films were preferred as a packaging material because of their low permeability to O_2. The results showed that bitter gourd slices can be kept for 15 days at 80 °C without deteriorating its nutritional quality when kept in modified atmosphere packaging with low-density polyethylene bag. Various modern drying methods such as infrared (IR)-dependent hybrid drying and dry blanching concerning IR-hot air were used as a substitute to hot air drying and wet blanching (water and steam). The hybrid drying and infrared (IR)-assisted blanching caused reduction in processing time with greater nutrient retention and thus have immense industrial potential to decrease processing time and also energy, and further produces the product of better quality. Silva et al. developed the fermented bitter gourd slices (3% dry salts and 3% saturated brine solution, and 3% dry salts with 1% saturated brine solution in refrigerated condition for 4 weeks), and physiochemical and sensory parameters were assessed. Results showed that bitter gourd slices treated with 3% dry salt was highly acceptable as fermented ready-to-eat vegetables, and maximum overall acceptability also increased during storage period.

Thus, value addition of bitter gourd not only improves the economic status of people, especially women and farmers, but also aids in fighting against several chronic diseases.

9.3 Antioxidant Evaluation of Bitter Gourd Fruit

Recognizing and searching safe natural antioxidants, especially of plant origin, has been particularly improved in current years. Physiological function of natural foods could be attributed to the antioxidative capacity of their bioactive components. The antioxidant property of fruit is well associated with the amount of oxygen radical scavengers, such as phenolic components (Giampieri et al. 2012). Different assays are used to determine the antioxidant potential of natural products such as 2,2-azino-bis (3-ethyl-benz-thiazoline-6-sulfonicacid) (ABTS), ferric reducing antioxidant powder (FRAP), peroxyl radical scavenging capacity (PSC), DPPH (2, 2-diphenyl-1-picrylhydrazil), oxygen radical absorbance capacity (ORAC), linoleic acid bleaching, and β-carotene. Many studies have previously reported that bitter gourd is an antioxidant-rich vegetable (Horax et al. 2005; Wu and Ng 2008; Kubola and Siriamornpun 2008). Due to higher content of phenolics in bitter gourd, it is said to be the richest source of antioxidants (Horax et al. 2005). However, the quantity and kinds of phenolics might alter with maturity and growth of Bitter gourd and collectively these alterations can influence the antioxidant activity of the extracted phenolics. Commonly known solvents used for extraction of phenolics are ethyl acetate, acetone, methanol, ethanol, propanol, water, dimethyl formamide, and their combination (Antolovich et al. 2000).

Lee et al. (2017) investigated the carotenoid and phenolic acid compounds of bitter melon to estimate its antioxidant activity. The concentration of phenolic components such as gallic acid, catechin, and chlorogenic acid enhanced with maturation; meanwhile, the concentration of caffeic acid, ferulic acid, and p-coumaric acid reduced with maturation. Furthermore, free radical scavenging

behavior improved with growing maturation. They concluded that antioxidants are naturally present in abundant amount in bitter melon and could have possible health promoting benefits as a value-added ingredient or functional food. In vitro antioxidant evaluation (namely DPPH, FRAP, hydroxyl radical-scavenging activity, β-carotene-linoleate bleaching assay, and entire antioxidant ability) of the aqueous leaf extract, fruit, and stem was investigated. The leaf extract illustrated the maximum value of ferric reducing power and DPPH radical-scavenging activity, as the extract of green fruit illustrated the maximum values of antioxidant activity, depend on total antioxidant activity, hydroxyl radical-scavenging activity, and β-carotene-linoleate bleaching assay. The major phenolic components were gallic acid, caffeic acid, as well as catechin (Kubola and Siriamornpun 2008). A study on antioxidant characteristics of bitter gourd after removing seeds and pith and entire fruits of two varieties (var. maxima and var. minima) in Malaysia was conducted, and the effect of processing conditions such as boiling and blanching was investigated. DPPH and FRAP assays were used for antioxidant evaluation. It was observed that boiling and blanching of fruits devoid of pith and seeds of *M. charantia* var. minima and var. maxima prompted alteration in the antioxidant activity unusually. The radical scavenging activity of the fruits devoid of pith and seeds of *M. charantia* var. minima and var. maxima improved due to boiling and blanching although their ferrous ion chelating activity became unnoticeable. There was no apparent relationship between the antioxidant activities and antioxidant content (Choo et al. 2014). The antioxidant capacity of bitter gourd polysaccharides is considerably influenced by cultivars (Li et al. 2010). The chemical structure of isolated polysaccharides was analyzed by FTIR (Fourier-transform infrared spectroscopy) and GC (gas chromatogram). Superoxide radical-scavenging activity and hydroxyl radical–scavenging activity were used as antioxidant assays. D-galactose (Gal), D-glucose (Glu) and L-arabinose (Ara) were the main polysaccharides with antioxidant activities (Li et al. 2010). The anthocyanin (main flavonoid group that is responsible for cyanic colors) content is also present in abundant amount in bitter gourd. Total anthocyanins of *M. charantia* fruits could be used as easy available source of antioxidants as a potential food supplement or in medical and pharmaceutical industries (Aytaç Güdr 2016). Water can be suitable solvent to extract phenolic components and their related antioxidant activities from freeze-dried bitter melon when compared with other organic solvents such as acetone, methanol, 80% ethanol, and butanol (Tan et al. 2014).

This vegetable has conjugated α-linolenic acids and tocopherols (mostly γ-tocopherol) and phytosterols (primarily β-sitosterol) in their seed oil. The α-linolenic acids have been related with several effects that are valuable to health such as anti-inflammatory and antioxidant characteristics. Hence, seed oil of bitter gourd that is a by-product of extraction and processing could be a vital and excellent source of polyunsaturated fatty acids (Yoshime et al. 2018). Aqueous extract of seeds of two varieties, specifically a hybrid and country variety of bitter gourd (MCSEt2 and MCSEt1), has antioxidant activity in streptozotocin (STZ)-induced diabetic rats. It was observed that upon incorporation of seed extract of bitter gourd,

there was a fast-defensive effect against lipid peroxidation by scavenging of free radicals (Sathishsekar and Subramanian 2005).

9.4 Health Benefits of Bitter Gourd

Public attentiveness of the perceived dietary antioxidants health benefits has improved the requirement for vegetable and fruit products with known and enhanced antioxidant quality and has led to new chances for the horticulture industry to enhance vegetable and fruit quality by improving antioxidant percentage. Medicinal importance of bitter gourd is attributed to its elevated antioxidant characteristics owing in part to flavonoids, phenols, terpenoids, etc. In the current day's situation, also, the medicinal properties of bitter gourd are widespread and that is the reason why they are grown everywhere. Preclinical, clinical, and epidemiological studies have confirmed a close correlation within dietary habits, such as bitter gourd ingestion and disease occurrence. Bitter gourd is said as one of the greatest disease-protective food based on its possible and diversified properties (Amagase 2006). Some of important health benefits of bitter gourd are described below.

9.4.1 Antihyperglycemic Activity

Diabetes mellitus (DM) has turned out to be the world's third most fatal metabolic disorder attributed to hyperglycemia (Wang et al. 2013). This chronic disorder is described by many consequences and causes. It is forecasted that adults who are expected to suffer from diabetes mellitus by the year 2020 will be around 300 million (Jeszka-Skowron et al. 2014). Although a broad spectrum of allopathic antidiabetics is currently present in market, but these drugs have ample side effects. The treatment of diabetes using herbal methods has relatively less or no side effects and is locally present. Medicinal plants are the "backbone" of conventional medicine and is considered to be the better source of life for people because of its immense therapeutic characteristics and being absolutely natural (Asija and Charanjeet 2016).

Bitter gourd has been broadly reported and used because of its hypoglycemic effects in many studies (Hasan and Khaton 2012). Saponins, glycosides, triterpenes, alkaloids, polysaccharides, proteins, charantin, steroids, a polypeptide-p, 3-O-glucuronide, and oleanolic acid and 3-O-monodesmoside are the important compounds found in bitter gourd with hypoglycemic activity. A number of preclinical reports have studied the hypoglycemic and antidiabetic effects of bitter gourd by several postulated mechanisms, though, with human subjects clinical trial data are flawed and limited by deprived study design and little statistical power (Joseph and Jini 2013). Polypeptide k and oil separated from bitter gourd have in vitro α-amylase (53.55%) and α-glucosidase (79.18%) inhibition activity. Jointly, the in vitro assay of this study powerfully suggested that both seed oil and polypeptide k from bitter gourd can be a potential source of hypoglycemic agents (Ahmad et al. 2012). It is essential to recognize, characterize, and isolate the bioactive components and

biochemical mechanism accountable for these effects in type II diabetes. An oral dosage of 150 mg/kg body weight on daily basis for 5 weeks, a 4-week-old male db/db mice were orally administered with bitter gourd. It was studied that there was a considerable decline in weight gain in every bitter gourd–treated groups. Glycated Hb levels were the highest in the control mice than the bitter gourd–treated mice (Klomann et al. 2010). STZ-induced male Wister rats were orally administered bitter gourd juice, which were diabetic (10 mL/kg/day as prophylaxis for 14 days before initiation of diabetes, then 21 days' treatment or after induction of diabetes treatment given for 21 days). After sacrificing of rats, histopathological inspection of pancreas was carried out. It was observed that bitter gourd juice resulted in considerable drop of serum glucose (135.99 $\pm$ 6.27 and 149.79 $\pm$ 1.90 vs. 253.40 $\pm$ 8.18) for prophylaxis and treatment correspondingly. Insulin (lIU/mL) level in diabetic rats was 2.39 $\pm$ 0.27, while that on bitter gourd–treated rats was 3.28 $\pm$ 0.08. In the end, this report confirmed that bitter gourd juice exhibited hypolipidemic, hypoglycemic, and great antioxidant characteristics when orally injected as prophylaxis or treatment to STZ diabetic rats (Mahmoud, et al. 2017). Bitter gourd could also destroy carbohydrate enzyme activity such as phosphofructokinase, glucokinase substrate glucose-6-phosphate, and hexokinase after treatment with bitter gourd in liver of diabetic mice (Rathi et al. 2002). Charantin, a hypoglycemic compound comprising of a mixture of (1:1) stigmasteryl glucoside (C35H58O6), sitosteryl glucoside (C35H60O6), and belongs to steroidal saponins. This compound when taken either intravenously or orally in rabbits exhibits potential hypoglycemic effect (Lolitkar 1966). This hypoglycemic loaded extract is a possible compound for raising insulin-sensitivity in type II diabetic patients (Wang et al. 2014).

Bitter gourd seeds contain vicine and pyrimidine nucleoside, which are reported to cause hypoglycemia in rats, when incorporated intraperitoneally (Dutta et al. 1981). Eight cucurbitane-type glycosides were isolated recently by bioactivity-guided fractionation showing hypoglycemic effect in vitro (Zhang et al. 2014).

9.4.2 Hypolipemic Activity

Hyperlipidemia is a disease of lipid metabolism caused by abnormal elevation in diverse lipoprotein and lipid fractions in plasma. It is identified by surplus fatty substances and cholesterol in the blood resulting a risk factor for cardiovascular disease. Hyperlipidemia is described as raise in low-density lipoproteins (LDL) and very-low-density lipoproteins (VLDL), total triglycerides (TG), high-density lipoprotein (HDL), and serum total cholesterol (TC) that are accountable for various health problems such as stroke, heart attack, atherosclerosis, coronary artery syndrome, pancreatitis, and myocardial infarction (Asija and Charanjeet 2016). Various experimental researches recommend that bitter gourd enhances metabolism of lipid in animal models of diabetes and dyslipidemia. Bitter gourd extract has been studied for the effects on metabolism of lipid with a one-month treatment time in Japanese adults (both men and women). The blood pressure, body weight, amount of low-density lipoprotein cholesterol (LDL-C), and other blood parameters (total

cholesterol, weight, systolic pressure, high-density lipoprotein cholesterol, diastolic pressure, body mass index, blood glucose, or triglycerides) of every matter were calculated after and before the study time. Among all the parameters, bitter melon extracts could efficiently lesser LDL-C levels in humans and show possible therapeutic importance to manage of dyslipidemic conditions (Kinoshita and Ogata 2018).

Bitter gourd fruit juice has hypolipidemic and also hypoglycemic effects in the STZ-induced diabetic rat. In one of the studies, there was a major reduction in triglycerides, phospholipids, and plasma nonesterified cholesterol in STZ-induced diabetic rats, escorted by a decline in HDL cholesterol in STZ-induced diabetic male Wistar rats when given bitter gourd juice (Ahemed 2001). TG and TC were significantly reduced in albino rats when given high-fat diet (HFD) supplemented by aqueous bitter gourd fruit extract (100 mg/kg) (Sethi and Dahiya 2019). Noguchi et al. (2001) studied the effect of bitter gourd oil (BGO) effects on the liver and blood lipids of rats. They reported that dietary BGO has strong influence on the fatty acid composition of liver lipids.

9.4.3 Antimicrobial Activity

There are widespread researches that are carried out on antimicrobial characteristics of medicinal plants around the world. As per the World Health Organization (WHO), 80% of the world's population utilizes extract or their active components as folk drug in traditional therapies. Medicines from natural origin help significantly in the treatment and prevention of human ailments. Between 1981 and 2002, around 61% of new medicines formed were depend on natural products and were conquering, mainly in the field of cancer and infectious disease (Cragg and Newman 2005).

Methanolic and petroleum ether crude extracts of leaves and fruits of bitter gourd showed potential antimicrobial activity by means of the disk diffusion technique on four types of microorganisms (*Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus*, and *Candida albicans*) and four clinical strains of *Proteus vulgaris*, *Klebsiellapneumoniae*, *Salmonellatyphi*, and *Cryptococcus neoformans*. Among the two extracts, methanolic extract showed widest antimicrobial spectrum by hindering majority (75%) of the tested microorganisms. Also, their study reported that bitter gourd fruit extracts exhibited elevated antimicrobial activity than leaf extract (Mwambete 2009).

An extract of the whole plant was revealed to possess an antiprotozoal activity against *Entamoeba histolytica*. The juice and fruit have illustrated the similar kind of antibacterial characteristics (Gupta et al. 2010), and in one more study, fruit extract illustrated activity against the *Helicobacter pylori* which are stomach ulcer-causing bacteria. Bitter gourd has also been familiar with in vitro antiviral property against several viruses, as well as HIV, Epstein-Barr, and herpes viruses.

Bitter gourd oral ingestion can counterbalance the detrimental impact of anti-HIV drugs, if the studies of test tube could be translated into clinical implementations. In

one preliminary clinical trial, an enema form of a bitter gourd extract exhibited some advantages in people affected with HIV (Zhang 1992).

Leaves of bitter gourd also show strong antimicrobial activity against some microorganisms. Aqueous and methanolic bitter gourd leaves extracts possess antimicrobial activity against *Escherichia coli*, *Bacillus subtilis*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae* and by using stokes disc diffusion and well diffusion methods (Leelaprakash et al. 2011).

9.4.4 Some Miscellaneous Health Benefits of Bitter Gourd

Bitter gourd extract has therapeutic agent for tissue regeneration. It possesses wound-healing properties and stimulated the proliferation of dermal fibroblasts of human (Tan et al. 2016). In Brazil, bitter gourd's traditional medicine is used for treating certain diseases such as menstrual problems, leucorrhea, tumors, rheumatism, wounds, malaria, fevers, colic, inflammation, worms, and can be used as an aphrodisiac and abortions inducer (Maiti et al. 2012). It is also utilized for skin diseases (itchy rashes, scabies eczema), hemorrhoids, vaginitis, and leprosy. In Mexico, for controlling dysentery whole plant is used. In Peruvian herbal medicine, the aerial parts or leaf of the plant helps to treat every type of inflammation, malaria, and measles. In Nicaragua, the leaf normally is employed for treating aliments such as diabetes, skin complaints, coughs, fevers, colds, headaches, menstrual disorders, aches, stomach pain, malaria, pains, and infections, as an aid in hypertension and childbirth. Principally, studies have shown positive association between eating bitter gourd and avoidance or reduction in tumor growth in prostate, cervical, and breast cancer patients. Bitter gourd ethanol seed extracts are also reported to possess potent male antifertility properties when fed to guinea pigs and dogs. Traditionally, equal proportion of bitter gourd leaves paste is mixed with the Tulsi leaves paste. This can be taken with honey every morning as a prevention and treatment for respiratory ailments such as pharyngitis, common cold, and asthma.

9.5 Conclusion

Due to diverse chemical constituents in bitter gourd, it could be used as an essential health-promoting functional food and nutraceutical. The study concluded the role and importance of bitter gourd in diverse areas, and from this discussion, it is sufficiently obvious that bitter gourd is a multifunctional natural plant having enormous vitality. Besides its incredible role in various food industries as functional food, it can also be used as nutraceutical in pharmaceutical industries. Therefore, bitter gourd is a multipurpose plant with potential pharmacological properties. Most of its chemical parameters have been explored for treating problems such as bacterial and viral infections, diabetes, pain, stomach problems, as well as life-threatening diseases such as cancer and HIV infections. There are many in vitro and in vivo studies on chemical constituents; however, there are limitation researches on human

studies using bitter gourd. Thus, the much more researches are needed on specific diseases using bitter gourds.

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