Chapter

Bitter Melon: A Multifunctional Medicinal Plant with Powerful Bioactive Compounds

Fadime Eryilmaz Pehlivan

Abstract

Nature is full of poisons as well as life-saving entities. Extracts of natural products in medicinal plants have been used for thousands of years in traditional medicine throughout the World. Bitter melon (*Momordica charantia)* is a member of Cucurbitaceae family, widely distributed in tropical regions of the World, that has been used in folk medicine for the treatment of diabetes mellitus, and its fruit has been used as a vegetable for thousands of years. It contains phytochemicals, flavonoids, triterpenes, saponins, ascorbic acid, steroids, proteins, and polysaccharides. This plant is a traditional herbal medicine, possesses various biological, medicinal activities and pharmacological functions, namely antidiabetic, anthelmintic, contraceptive, antimalarial, laxative, antihyperglycemic, antimutagenic, antiulcer, antilipolytic, antifertility, hepatoprotective, anticancer, antibacterial, antiviral, antitumor, immunomodulation, antioxidant, antidiabetic, and anti-inflammatory activities of *M. charantia* have been reported. Its fruit has a special bitter taste, parts of *M. charantia,* such as fruits, vines, leaves and even roots have been used as folk medicine for the remedy of diseases like toothache, diarrhea, and diabetes. It is also used for the treatment of eczema, gout, jaundice, pneumonia, psoriasis, and rheumatism. These beneficial effects are attributed to the various bioactive components of *M. charantia*, which are important sources of phytoconstituents used to treat various diseases since ancient times. This chapter reviews various aspects of the results of investigations involving *M. charantia* in the recent years, providing a comprehensive overview of the phytochemical application of *M. charantia* to attract more attention to their biological activities for better utilization of *M. charantia*; focusing on the review of benefits that bitter melon offers in terms of its potential as a source of bioactive compounds and its role in the control of different diseases.

Keywords: Bitter melon, medicinal, biologicl, bioactive compounds, phytochemicals

1. Introduction

Bitter melon (*Momordica charantia* L.) commonly called bitter melon, is also known as bitter gourd, bitter apple, bitter squash, balsam-pear, belongs to Cucurbitaceae family. It is a plant found in tropical and subtropical regions of Asia and Africa, where it is valued for its various health benefits. This traditional tropical plant has been claimed to have therapeutic effects for ages for its pharmacological activities, and nutritional properties due to its content of bioactive compounds.

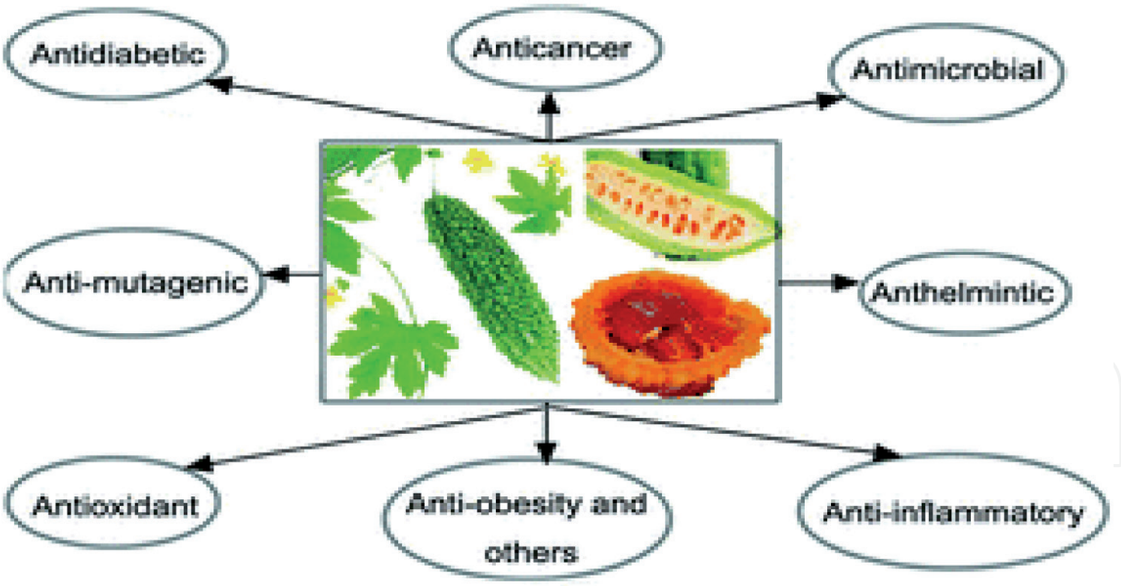

Figure 1.
Momordica charantia: *A popular health-promoting vegetable with multifunctionality [1].*

The presence of many bioactive compounds, some of which possess potent biological actions, this plant is used in folk medicine all over the world for the treatment of different pathologies. It has been used in a wide range of medical applications, such as diabetes, cancer, hypertension, obesity, bacterial and viral infections, and even AIDS (**Figure 1**) [1, 2]. It is also used for pain relief, against chronic fever, in cases of jaundice and illnesses of the liver or the digestive system [2]. In Turkish traditional medicine the oil obtained from the ripe fruits of bitter melon, macerated in olive oil warmed by the sun, was combined with honey, and used for the prevention and healing of gastric ulcers [3]. In African folk medicine it is mainly used for worm infections, inflammation, fever, syphilis, rheumatism, and skin diseases [4].

Momordica charantia L. is a widely cultivated medicinal plant around the world. All parts of *M. charantia* possess important medicinal properties, including anti-inflammatory, antidiabetic, anticancer, hypotensive, anti-obesity, antimicrobial, anti-hyperlipidemic, antioxidant, immuno-modulatory, anthelmintic, neuro-protective, as well as hepato-protective properties both in vitro and in vivo (**Figure 1**).

2. Nutritional value and chemical composition of *Momordica charantia*

Bitter melon (*Momordica charantia*) is an unique bitter tasting herbaceous medicinal plant, cultivated in tropical and subtropical regions of many countries; which is one of the nature's most valueable gifts although it is one of the discarded vegetables by people, just because of its bitter taste. All parts of the plant, including the fruit, taste very bitter, mainly because of the presence of three pentacyclic triterpenes, momordicinin, momordicin and momordicilin. It contains lipids, fiber, protein, carbohydrates, calcium, sodium, potassium, iron, manganese, copper, phosphorus and vitamins. It also contains phytochemicals, vitamins, antioxidants, and bioactive chemicals. It is a plant high in health-beneficial compounds such as antioxidants, flavonoids, phytosterols, and saponins. Since antiquity, it is used in different countries as a folk medicine traditionally. It possess rich nutritive values among cucurbits and being a good source of medicinal products, it contains carbohydrates, proteins, fibers, vitamins (C, A, E, B1, B2, B3, and B9 as folate), and minerals (potassium, calcium, zinc, magnesium, phosphorous and iron) [5, 6]. Fruits are reported to contain vitamin C, A and P, thiamine,

riboflavin, niacin, and minerals with 93.2% of water content, while protein and lipids account for 18.02 and 0.76% of its dried weight, respectively [7, 8]. Its seeds also represent a good source of lipids, polyunsaturated fatty acids and conjugated linolenic acid [9].

Bitter melon has been associated with anti-cancer, anti-microbial, anti-inflammatory and anti-diabetic properties. The medicinal values of the bitter gourd fruit are linked to its high content of phenolics, which act as antioxidants. Phenolic compounds containing phenolic acids, coumarins, lignins, tannins, lignanes and flavonoids are among the secondary metabolites that are abundant in the plant. *M. charantia* is also a good source of phenolic compounds, which can protect from oxidative damage by acting directly on reactive oxygen species and to activate endogenous defense systems [10]. The biological activity of *M. charantia* depends on its major phytochemical constituents, containing phenyl-propanoids, and other bioactive compounds, such as polyphenols, phenolic acids, flavonoids, essential oils, fatty acids, amino acids, lectins, sterols and saponins, tocopherols, monoterpenes, sesquiterpenes, [11, 12], including cucurbitane-type triterpenoids, cucurbitane-type triterpene glycosides, and some proteins present in fruits, seeds, roots, leaves and vines [13]. The most prevalent chemical constituents are cucurbitane-type triterpenoids, the bitterness of *M. charantia* is the consequence of cucurbitane-type triterpenoids: cucurbitacins, momordicines I and II and triterpene glycosides: momordicosides, exhibiting a broad range of biological activities, mainly anti-inflammatory and anti-diabetic [14]. Different major constituents found in different varieties and different parts of the plants are summarized below (**Table 1**) [14, 15].

M. charantia is one such sample that holds rich phytochemicals and is an effective agent in dietary regimens to prevent against different maladies. Brief about the *M. charantia*, it is used as a vegetable in many countries but since time immemorial, it is also used for administration of numerous ailments comprising wide range of pharmacological activities for instance, antioxidant, anti-inflammatory,

Major Bioactive Components	Functions	Distribution	References
Polysaccharides	Antioxidant, antidiabetic, immune enhancement, neuroprotective, antitumor	Various parts of plants	[11–14, 16, 17]
Peptides and proteins	RNA N-glycosidase, polynucleotide adenosine glycosidase (PAG), DNase-like, phospholipase, superoxide dismutase, anti-tumor, immune suppression, antimicrobial	Seed	[18–21]
Lipids	Antitumor, antioxidant	Seed, flesh	[11–14, 16, 17]
Terpenoids	Anticancer, antioxidant, antidiabetic, hypoglycemic, cancer chemoprevention	Stem, leave, fruit	[11–14, 16, 17, 19–22]
Saponins	antihyperglycemic, hypolipidmic, antiviral	Fruit, root, seed	[18–21, 23–29]
Phenolics	Antioxidant, anti-inflammation, immune enhancement	Fruit, pericarp, seed	[11–14, 16, 17, 19–22]
Sterols	Antimicrobial	Pericarp, fruit	[25–31]

Table 1.
Major bioactive components of bitter melon and their related functions [15].

antimicrobial, antidiabetic, antiobesity, antiulcer, anticancer, hypotensive, and blood cholesterol lowering effects that are demonstrated in **Figure 1** and **Table 1**. The following is an overview of its common pharmacological activities.

3. Antioxidant and anticancer activity of *Momordica charantia*

Secondary metabolites are attracting attention for their effects in preventing diseases due to oxidative stress, which leads to degeneration of cell membranes and leads to many pathological diseases. They play a major role in preventing disease due to oxidative stress, which leads to many pathological diseases [11–14]. Recent investigations have shown that antioxidants with free radical scavenging properties have great importance as therapeutic agents in preventing aging process and in scavenging free radical mediated diseases [11–14]; such as diabetes, atherosclerosis and other complications [15].

Many studies have shown that *M. charantia* is a good natural source of antioxidants such as bioactive phytochemicals mainly include polysaccharides, saponins and phenolics; that possess an activity against oxidant damage in vitro and in vivo [32]. *M. charantia* and its ethanolic extracts are analyzed to contain high antioxidant activities that are well correlated with phenolic compounds [32]. Bitter melon and its extracts are demonstrated to have stronger antioxidant activity than other solvent extracts, by increasing the activities of catalase and levels of reduced glutathione, bitter melon is proved to exhibit inhibited stress-induced lipid peroxidation [32, 33].

Several phytochemicals, including bitter melon extracts, are described to possess potentials in anticancer therapies [34]. The extracts of bitter melon have been investigated for their potential use as anticancer agents; suggesting that dietary consumption of bitter melon could help to lower risk of several cancers [34]. *M. charantia* extracts and its monomer components have shown strong anticancer activity against various tumors such as lymphoid leukemia, lymphoma, choriocarcinoma, melanoma, breast cancer, skin cancer and prostate cancer [35]. Furthermore, bitter melon extracts are shown to decrease human prostate cancer cell growth due to the selective induction of apoptosis [35, 36].

Anticancer properties of bitter melon extracts are reported to have ability to modulate several deregulated signaling pathways in different type of cancer, like MAPK pathway, through the modulation of cell cycle proteins, thereby inducing cell cycle arrest, inducing apoptosis or other cell death pathways. Cucurbitane-type triterpene glycosides have been showed to have significant antitumor activity in hepatic carcinoma derived cell lines [36].

It is well known that tumor progression toward malignity is strongly related to chronic inflammation that is responsible for tumor invasion of surrounding normal tissues and angiogenesis. Bitter melon components are suggested to exert their antitumor effects by modulation of the inflammation status.

4. Antiinflammatory activity of *Momordica charantia*

Inflammation is known to be a complicated immune process that can be defined by the sequential release of mediators such as pro-inflammatory cytokines, including interleukin (IL)-1, interferon (IFN)-c, IL-6, IL-12, IL-18, tumor necrosis factor (TNF), and the granulocyte-macrophage stimulating factor. It is settled by anti-inflammatory cytokines such as IL-4, IL-10, IL-13, IFN-a, and the transforming growth factor (TGF)-b [37]. Inflammation is known as an overall a

protective response against xenobiotics, but chronic inflammation is also known to be detrimental to tissues; causing in chronic inflammation-derived diseases, such as autoimmune diseases, cardiovascular diseases, systemic lupus erythematosus (SLE), aging-associated diseases, such as Alzheimer's or Parkinson's disease; and cancers. It is known that oxidative stress and inflammation activate each other and oxidative stress plays a role in chronic infectious diseases [37]. Chronic inflammation is shown to promote tumor initiation and malignant progression of many cancers, considering the importance of inflammatory changes in different cancer types, preventing or reversing inflammation has become an important approach to control cancer progression [16, 37]. Thus, inhibition of the overproduction of inflammatory mediators, especially pro-inflammatory cytokines IL-1b, IL-6, and TNF-a, may prevent or suppress a variety of inflammatory diseases [16, 37].

Dietary habits contribute to a chronic state of inflammation, which can alter gut microbiota and immune status. Various dietary components have demonstrated to modulate chronic inflammatory conditions and to be helpful in their therapy [16]. Bitter melon dietary supplementation has been widely studied to treat several diseases, such as obesity and cancer, promising to possess hypoglycemic and lipid-lowering properties [17]. Chronic inflammation is involved in the pathogenesis of different diseases, such as metabolic syndrome, obesity, cancer, cardiovascular disease, and a neurodegenerative diseases [16, 17]. In diabetic patients, inflammation contributes to increase blood glucose concentration in developing cardiovascular diseases and obesity. The beneficial properties of *M. charantia* appear to be due to anti-inflammatory and antioxidant activities by acting on several important signal pathways involved in inflammation [38].

Several investigations suggest that oxidative stress plays a role in chronic inflammatory diseases; which are closely related in pathophysiological processes that can activate each other [39–41]. Bitter melon has shown to have beneficial properties dependent on its anti-inflammatory and anti-oxidant activities [41–43]; regulating inflammation mainly through NF-κB signaling pathway inhibition, reducing TNF-α production [44]. It is also reported that bitter melon extracts reduced TNF-α-induced expression of inflammatory markers, including inducible NO synthase, p65 subunit of NF-κB, TNF-α, and IL-1β [45]. The bitter melon containing diet also reported to normalize serum levels of the cytokines suggesting its role in reducing inflammation, obesity and insulin resistance in obese mice [46]; suggesting that bitter melon supplementation may be useful as a preventive agent in individuals at risk for inflammatory-related diseases [47]. Therefore, bitter melon has anti-inflammatory effects by acting on several important signaling pathways involved in inflammation.

Xanthine oxidase, which is a key enzyme for the induction of hyperuricemia and gout, it is involved in many inflammation related diseases [48]. Cucurbitane-type triterpene glycosides isolated from bitter melons fruits is proved to inhibit xanthine oxidase activity [49]. Antioxidant compounds in bitter melon showed potential natural antioxidant activity to inhibit the lipid peroxidation [50]. demonstrating anti-inflammatory effects of phenolic compounds present in the bitter melons extract [51].

The wound-healing activity of the olive oil macerate of *M. charantia* was investigated in wound models. Experimental data have shown that *M. charantia* has wound-healing and anti-inflammatory effects [52]. *M. charantia* has been investigated and reported to play a role in suppressing gastric inflammation against gastric ulcers from ethanol [53]. It is also shown that *M. charantia* can suggest an alternative in reducing the need for analgesic drug consumption by reducing pain and improving symptoms in diseased individuals [54].

5. Antidiabetic (Hypoglycemic) activity

Diabetes mellitus is known as a metabolic disease that is the fastest growing diseases in the world, and is characterized by hyperglycemia resulting from defects in insulin secretion and insulin action [55]. Drugs obtained from the plants used all over the world to treat diabetes. Bitter melon is used to treat many diseases with good medicinal values, but more emphasis is given to its anti-diabetic properties. As an antidiabetic drug, bitter melon has been widely used in different countries for thousands of years is suggested as a remedy for the treatment of diabetes [56].

It contains active compounds, including charantin that reduce blood sugar levels. In addition, bitter melon contains lectin which also reduce blood glucose level that is a major factor of hypoglycemic effect [57]. Some other compounds present in bitter melon such as steroids, inorganic, triterpene, proteid, lipid and phenolic compounds also offer anti-diabetic properties. The aqueous extract of bitter melon fruits is reported to stimulate insulin secretion of β cells in pancreatic islets isolated from obese-hyperglycemic mice [23, 24, 57]. Antidiabetic mechanism of bitter melon extracts is suggested to enhance insulin secretion by the islets of Langerhans, reducing glycogenesis in liver tissue, enhancing peripheral glucose utilization and increasing serum protein levels [23, 24, 57].

Oral administration of the aqueous extract *M. charantia* fruits are observed to lower blood glucose level in diabetic rats [24]; they are shown to stimulate insulin secretion of β cells in pancreatic islets isolated from obese-hyperglycemic mice [24]. They are also indicated to play a role in the renewal of β cells in diabetic rats or recovery of destroyed β cells [24]. *M. charantia* fruit juice is examined to reduce blood glucose levels in diabetic rats due to enhancing insulin secretion by the islets of Langerhans, reducing glycogenesis in liver tissue, enhancing peripheral glucose utilization and increasing serum protein levels [23, 24, 57].

6. Antihyperlipidemic activity and weight loss

Hyperlipidemia is a major health problem and associated with diabetes due to increase in morbidity and mortality. High blood lipid concentration is associated with cerebrovascular disease, ischemic heart diseases, and atherosclerosis. *M. charantia* is proved to have an antihyperlipidemic effect. A component of *M. charantia*, metformin, and other components such as alkaloids, flavonoids, saponins, tannins, and triterpenes have suggested to lower total cholesterol level in diabetic rats. Moreover, bitter melon has been described to repair damaged β-cells, resulting in increasing the levels of insulin and its sensitivity [23, 56, 57]; by enhancing the release and synthesis of thyroid hormones and adiponectin, and also by inhibiting the activity of glucosidase that inhibits the absorption of glucose. The action of AMPK (adenosine-5-monophosphate kinase) is shown to be increased by bitter melon consumption that is associated with fat release from fatty tissues and glucose uptake and thus resulting in weight loss [23, 24]. Diabetic rats that are treated with *M. charantia* extract are also exhibited significant reduction of blood lipid levels [23, 24]. Bitter melon has also shown to reduce the cholesterol and trigliceride levels by increasing Apo-A-1 (Apo lipoprotein A-1) which is basic protein component compulsory for HDL synthesis [23, 24]. Recently, it is observed that bitter melon has ability to reduce body weight and the accumulation of high fat due to its anti-hyperlipidemic activity [24].

7. Antimicrobial activity

M. charantia extract has been suggested to have broad-spectrum antimicrobial activity, clinical signs of broad-spectrum antimicrobial activity has been delivered by the extract of bitter melon leaf [25]. Polysaccharides isolated from *M. charantia* have been reported to have significant inhibitory effects on bacteria. It has been shown that the main components of *M. charantia* responsible for antimicrobial functions are polysaccharides [26]. It is also suggested that antibacterial properties of *M. charantia* oil is related to its high trans-nerolidol and conjugated linolenic acids content [25, 26]. *M. charantia* is a basis of natural products which derived from plant with antimicrobial activity. A component of bitter melon, α-momorcharin, due to its ribosome-inactivating protein (RIP) ability is effectual in inhibiting the fungal and bacterial growth [25, 26, 30]. It has been reported that *M. charantia* polysaccharides have a good bacteriosis activity in *B. subtilis*, *S. aureus*, *S. typhimurium* and *E. coli* and the most obvious effect is the effect on *S. aureus* [26]. Essential oils of *M. charantia* seeds have significant inhibitory effect on *S. aureus*, while having less impact on *E. coli* and *C. albicans* [26, 30]. It has been demonstrated that the whole plant extract has antiprotozoal activity and methanol, water, and ethanol extract of the bitter melon leaves are considered to have an antibacterial action against *Salmonella, Pseudomonas aeruginosa, E. coli, Bacillus*, and *Streptococcus* chain [26, 30]. *M. charantia* fruit also has an anti-*Helicobacter pylori* activity that is a causal agent of ulcer [26, 30].

8. Anti-parasitic (anti-anthelmintic) activity

Helminthic infection is a problem, which is caused by nematodes, cestodes, and trematodes. The main target of helminthic infection is gastrointestinal system that affects human and livestock's in the world. Nowadays, in spite of using medicines, functional foods such as bitter melon is considered as an important therapeutic medicinal food with anthelmintic action. The presence of functional ingredients including saponins, momordin, momordicoside, momordicin, the worms are paralyzed by inhibiting the acetyl cholinesterase [30]. Anthelmintic effect of *M. charantia* also include the inhibition of arachidonic acid metabolism, mico nicotinic agonists, oxidative phosphorylation inhibition, increased calcium permeability, acetyl cholinesterase inhibitors, and β-tubulin binding [24, 30]. Saponins are observed to affect the permeability of the cell membrane of worms and lead disintegration and vacuolization of tegument; irritating the mucous membrane channel gastrointestinal of worms that interfere with the absorption of food [30]. Flavonoid compounds especially apigenin is shown to inhibit larval growth and inhibit the arachidonic acid metabolism which may lead to the degeneration of neurons in the worm's body and lead to death [24, 30].

9. Anti-HIV activity

Bioactive components which are present in *M. charantia* are analyzed to be useful in the management of HIV infection [31]. Ethanolic extracts from leaves and stems of *M. charantia* have shown highly antiviral activity [31]. The root of *M. charantia* is suggested to have moderate anti-HIV-1 activity [31]. Bitter melon proteins is examined to inhibit HIV activity, depress the expression of the virus core protein [27]. Compounds such as momorcharin, and lectin are isolated from

M. charantia, these compounds have a protective effect against viral infections. That are shown to have a strong influence on HIV, but these compounds are not well absorbed in patients. In infected people, oral intake of *M. charantia* is demonstrated to slow the progression of HIV [27, 31]. Leaf extracts are provided immunostimulant effects against viral infections particularly HIV and has an ability to treat various viral diseases [27, 31].

10. Wound healing activity

Growth factor deficiencies, neovascularization, abnormalities such as impaired immune response and decreased synthesis of collagen are known to be associated with diabetes and to the delayed wound healing [18, 19, 28, 29]. Treatment with *M. charantia* fruit ointment is suggested to enhance wound closure in diabetic rats, and upregulate TGF-β expression in wound tissue, which plays an important role in regulating cell growth and differentiation [18, 19]. The juice of *M. charantia* is demonstrated to have a healing potential against psoriasis, scabies, and ringworm. In rats modeling wound healing potential of *M. charantia* fruit powder has been assessed with a significant response by powder ointment in terms of period of epithelization, wound-contracting ability and wound closure time [19].

11. Immunomodulatory activity

In vitro experiments have shown that *M. charantia* polysaccharides can increase immunity by stimulating the activation of lymphocytes and macrophages [20]. It has been reported that the water-soluble polysaccharide isolated from *M. charantia* may increase endothelium-derived relaxing factor production in the cell proliferation, the development of the inflammatory and immune response, and stimulate splenocytes and thymocytes [21].

12. Other biological activities

There are also some reports on other bioactivities. Components in *M. charantia* have an inhibitory effect on gastrointestinal nematodes [22]. Momordin is reported to have hypotensive effects [58]. A fruit extract has been demonstrated to possess activity against *Helicobacter pylori*, which could induce stomach ulcers [59]. It has been reported that *M. charantia* polysaccharides have a neuroprotective effect that can reduce neuronal death caused by thrombin in primary hippocampal neurons [60]. The hepatoprotective effect of *M. charantia* water soluble polysaccharides has been investigated on the CCl4 liver damaged mouse model [61].

13. Toxicity and side effects

Although the plant is basically harmless to human body under normal conditions, it may induce adverse reactions according to different uptakes, processing methods, physical differences and other conditions. There have been reports of toxicity since 1960s, mainly including acute toxicity, chronic toxicity and reproductive toxicity.

Intake of *M. charantia* leaves is known to be used to prevent childbirth in India [62]. Moreover, the aqueous extract was reported to significantly decrease

hemoglobin concentration of albino rats [63]. *M. charantia* lectin had a cytotoxic effect, which significantly inhibited DNA and protein synthesis in human peripheral blood lymphocytes of normal or leukemic cells [64]. Clinical findings indicating that long-term use of *M. charantia* at high doses may cause kidney conditions should be tested by better organized clinical trials. People who report allergies to other herbs from the Cucurbitaceae family should avoid the use of *M. charantia* [65].

14. Conclusion

It is known that the majority of the world population prefer traditional folk medicine products to industrial products. One of the main reason for the increased interest in herbal medicinal products is that natural products will be considered less toxic, but this is often a false perception. In health problems, many components of vegetable origin obtained from natural products have the potential to act as supplements, alone or in mixtures. Due to the synergistic effect, many active compounds may have therapeutic potential much higher than the effects they can give alone when given as a herbal preparation. It is helpful for different diseases such as inflammatory, leukemic, diabetic, mutagenic, mycobacterial, microbial, tumor, ulcer, aphrodisiac, viral, astringent, carminative, cytotoxic, hormonal, depurative, hypotensive, immuno-stimulant, etc. Bitter melon is the most important medicinal plant having good therapeutic values. Therapeutic importance bitter melon is traditionally famous due to its medicinal importance. It has as anticancer, antiviral, antidiabetic, anti-inflammatory, immune-stimulant and cholesterol reduction properties. It contains many phenolic compounds, due to this reason, it has antioxidant and antimutagen properties. Its fruit, leaves, stem and roots all are used for the treatment of many diseases such as hyperlipidaemia, digestive disorders, microbial infection and menstrual problems. It has antiviral and anticarcinogenic properties which can boost the immune system. Other medicinal properties such as wound-healing activity have revealed that the bitter melon extract has high amount of therapeutic compounds for the regeneration of tissues that encouraged the proliferation of dermal fibroblasts of human.

Bitter melon is also shown to express anti-HIV activity with alpha- and beta-momorcharin proteins that are present in seeds, leaves, and fruit. Investigation on the bioactivities of *M. charantia* has developed rapidly. Application of bitter melon in food and medicinal fields are still in the initial processing stages; the health benefits are still far from being fully utilized. Due to its numerous health functions, the plant can be utilized in tumor therapy, lowering blood glucose and other aspects of clinical applications with broad prospects under the premise of ensuring safety.

As conclusion, bitter melon has different medicinal properties due to the presence of high bioactive compounds that is beneficial for the human health This chapter provides information about nutritional profile and food value of bitter melon to highlight the bioactive composition that is linked to its therapeutic effects, aiming to fully utilize bitter melon and add further value to this medicinal plant.

Author details

Fadime Eryılmaz Pehlivan
Botany Section Fatih, Department of Biology, Faculty of Science, Istanbul University, Istanbul, Turkey

*Address all correspondence to: eryilmazfadime@gmail.com

IntechOpen

References

[1] Wang S, Li Z, Yang G, Ho CT, Li S. *Momordica charantia*: a popular health-promoting vegetable with multifunctionality. Food Funct. 2017; 8(5):1749-1762. DOI: 10.1039/c6fo01812b

[2] Grover JK, Yadav SP. Pharmacological actions and potential uses of *Momordica charantia*: A review. J. Ethnopharmacol. 2004; 93:123-132. DOI: 10.1016/j.jep.2004.03.035

[3] Gürdal B, Kültür Ş. An ethnobotanical study of medicinal plants in Marmaris (Muğla, Turkey). J Ethnopharm. 2013; 146 (1):113-126.

[4] Bortolotti M, Mercatelli D, Polito L. *Momordica charantia*, a Nutraceutical Approach for Inflammatory Related Diseases. Front Pharmacol. 2019; 10: 486. DOI: 10.3389/fphar.2019.00486.

[5] Sing PT, Tuyen CK, Sophie EP & Paul DR. Bitter melon (*Momordica charantia* L.) bioactive composition and health benefits: A review, Food Reviews International. 2016; 32(2):181-202.

[6] Saeed F, Afzaal M, Niaz B, Arshad MU, Tufail T, Hussain MB & Javed A. Bitter melon (*Momordica charantia*): a natural healthy vegetable, International Journal of Food Properties. 2018; 21(1):1270-1290.

[7] Gupta M, Sharma S, Gautam AK, Bhadauria R. *Momordica charantia* Linn, (karela): nature's silent healer. Int. J. Pharm. Sci. Rev. Res. 2011; 11: 32-37.

[8] Saad DY, Soliman MM, Baiomy AA, Yassin MH, El-Sawy HB. Effects of Karela (Bitter Melon; *Momordica charantia*) on genes of lipids and carbohydrates metabolism in experimental hypercholesterolemia: biochemical, molecular and histopathological study. BMC Complement. Altern. Med. 2017; 17:319. DOI: 10.1186/s12906-017-1833-x

[9] Yoshime LT, de Melo ILP, Sattler JAG, de Carvalho EBT, Mancini-Filho J. Bitter gourd (*Momordica charantia* L.) seed oil as a naturally rich source of bioactive compounds for nutraceutical purposes. Nutrire 2016; 41:12 DOI: 10.1186/s41110-016-0013-y

[10] Nyam KL, Tan CP, Lai OM, Long K, Che Man YB. Physicochemical properties and bioactive compounds of selected seed oils. LWT-Food Sci. Technol. 2013; 42:1396-1403. DOI:10.1016/j.lwt.2009.03.006.

[11] Zhang M, Hettiarachchy NS, Horax R, Chen P, Over KF. Effect of maturity stages and drying methods on the retention of selected nutrients and phytochemicals in bitter melon (*Momordica charantia*) leaf. J Food Sci. 2009; 74:441-448.

[12] Cuong DM, Kwon S-J, Jeon J, Park YJ, Park JS, Park SU. Identification and Characterization of Phenylpropanoid Biosynthetic Genes and Their Accumulation in Bitter Melon (*Momordica charantia*). Molecules. 2018; 23(2):469. DOI:10.3390/molecules 23020469

[13] Ahmed S and Beigh SH. Ascorbic acid, carotenoids, total phenolic content and antioxidant activity of various genotypes of *Brassica oleracea encephala*. J. Med. Bio. Sci. 2009; 3(1): 1-8.

[14] Rios JL, Escandell JM, Recio MC. Studies in Natural Products Chemistry, ed. Atta-ur-Rahman, Amsterdam: Elsevier; 2005. 429 p.

[15] Jia S, Shen M, Zhang F, Xie J. Recent Advances in *Momordica charantia*: Functional Components and Biological Activities. Int J Mol Sci. 2017;18(12): 2555.

[16] Minihane AM, Vinoy S, Russell WR, Baka A, Roche HM, Tuohy KM, Teeling JL, Blaak EE, Fenech M, Vauzour D, McArdle HJ, Kremer BH, Sterkman L, Vafeiadou K, Benedetti MM, Williams CM, Calder PC. Low-grade inflammation, diet composition and health: current research evidence and its translation. Br J Nutr. 2015 14;114(7): 999-1012. DOI:10.1017/S0007114515002093.

[17] Alam MA, Uddin R, Subhan N, Rahman MM, Jain P, Reza HM. Beneficial role of bitter melon supplementation in obesity and related complications in metabolic syndrome. J Lipids. 2015; 49:61-69. DOI: 10.1155/2015/496169.

[18] Qing C. The molecular biology in wound healing & non-healing wound. Chin J Traumatol. 2017; 20(4):189-193. DOI:10.1016/j.cjtee.2017.06.001

[19] Hussan F, Teoh SL, Muhamad N, Mazlan M, Latiff AA. *Momordica charantia* ointment accelerates diabetic wound healing and enhances transforming growth factor-β expression. J Wound Care. 2014; 23(8):400, 402, 404-7. DOI: 10.12968/jowc.2014.23.8.400.

[20] Deng YY, Yi Y, Zhang LF, et al. Immunomodulatory activity and partial characterisation of polysaccharides from *Momordica charantia*. Molecules. 2014; 19(9):13432-13447. DOI:10.3390/molecules190913432

[21] Kunde DA, Chong WC, Nerurkar PV. *et al.* Bitter melon protects against ER stress in LS174T colonic epithelial cells. BMC Complement Altern Med 2017:2. DOI:10.1186/s12906-016-1522-1

[22] Buckner JH and Ziegler SF. Regulating the immune system: The induction of regulatory T cells in the periphery. Arthritis Research and Therapy. 2004; 6(5):215-222.

[23] Jia S, Shen M, Zhang F, Xie J. Recent Advances in *Momordica charantia*: Functional Components and Biological Activities. Int J Mol Sci. 2017; 18 (12):2555.

[24] Perera WH, Shivanagoudra SR, Pérez JL, Kim DM, Sun Y, K. Jayaprakasha G, S. Patil B. Anti-Inflammatory, Antidiabetic Properties and In Silico Modeling of Cucurbitane-Type Triterpene Glycosides from Fruits of an Indian Cultivar of *Momordica charantia* L. Molecules. 2021; 26(4):1038. https://doi.org/10.3390/molecules 26041038

[25] Singh B, Jain M, Singh SV, Dhama K, Aseri GK, Jain N, et al. Plants as future source of anti-mycobacterial molecules and armour for fighting drug resistance. Asian J Anim Vet Adv. 2015; 10:443-460.

[26] Coutinho HD, Costa JG, Falcão-Silva VS, Siqueira-Júnior JP, Lima EO. Effect of *Momordica charantia* L. in the resistance to aminoglycosides in methicilin-resistant *Staphylococcus aureus*. Comp Immunol Microbiol Infect Dis. 2010; 33(6):467-471. DOI: 10.1016/j.cimid.2009.08.001.

[27] Jiratchariyakul W, Wiwat C, Vongsakul M, Somanabandhu A, Leelamanit W, Fujii I, Suwannaroj N, Ebizuka Y. HIV inhibitor from Thai bitter gourd. Planta Med. 2001; 67(4):350-353. DOI: 10.1055/s-2001-14323.

[28] Wang HX, Ng TB. Examination of lectins, polysaccharopeptide, polysaccharide, alkaloid, coumarin and trypsin inhibitors for inhibitory activity against human immunodeficiency virus reverse transcriptase and glycohydrolases. Planta Med. 2001; 67(7):669-672. DOI: 10.1055/s-2001-17359.

[29] Jia S, Shen M, Zhang F, Xie J. Recent Advances in *Momordica charantia*:

Functional Components and Biological Activities. International Journal of Molecular Sciences. 2017; 18(12): 2555. DOI:10.3390/ijms18122555

[30] Swamy MK, Akhtar MS, Sinniah UR. Antimicrobial Properties of Plant Essential Oils against Human Pathogens and Their Mode of Action: An Updated Review. Evid Based Complement Alternat Med. 2016; 2016:3012462. doi:10.1155/2016/3012462

[31] Abad MJ, Guerra JA, Bermejo P, Irurzun A and Carrasco L. Search for antiviral activity in higher plant extracts. Phytotherapy Research 2000; 604-607.

[32] Aljohi A, Matou-Nasri S, Ahmed N. Antiglycation and Antioxidant Properties of *Momordica charantia*. PLoS ONE. 2016; 11(8).

[33] Tan SP, Stathopoulos CPS. & Roach P. An Optimised Aqueous Extract of Phenolic Compounds from Bitter Melon with High Antioxidant Capacity. Antioxidants. 2014; 3(4):814-829. DOI:10.3390/antiox3040814

[34] Salehi B, Zucca P, Sharifi-Rad M, Pezzani R, Rajabi S, Setzer WN, Varoni EM, Iriti M, Kobarfard F, Sharifi-Rad J. Phytotherapeutics in cancer invasion and metastasis. Phytother Res. 2018; 32(8):1425-1449. DOI: 10.1002/ptr.6087

[35] Scartezzini P, Speroni E. Review on some plants of Indian traditional medicine with antioxidant activity. J. Ethnopharmacol. 2000; 71:23-43.

[36] Yue J, Sun Y, Xu J, Cao J, Chen G, Zhang H, Zhang X, Zhao Y. Cucurbitane triterpenoids from the fruit of *Momordica charantia* L. and their anti-hepatic fibrosis and anti-hepatoma activities. Phytochemistry. 2019; 157:21-27. DOI: 10.1016/j.phytochem.2018.10.009.

[37] Hussain T, Tan B, Yin Y, Blachier F, Tossou MC, Rahu N. Oxidative Stress and Inflammation: What Polyphenols Can Do for Us? Oxid Med Cell Longev. 2016; 74:32797. DOI:10.1155/2016/7432797.

[38] Farooqi AA, Khalid S, Tahir F, Sabitaliyevich UY, Yaylim I, Attar R. *et al.* Bitter gourd (*Momordica charantia*) as a rich source of bioactive components to combat cancer naturally: are we on the right track to fully unlock its potential as inhibitor of deregulated signaling pathways. Food Chem. Toxicol. 2018; 119 98-105. DOI: 10.1016/j.fct.2018.05.024

[39] Kwatra D, Dandawate P, Padhye, S. *et al.* Bitter Melon as a Therapy for Diabetes, Inflammation, and Cancer: a Panacea?. Curr Pharmacol Rep. 2016; 2:34-44.

[40] Rosângela FF de Araújo, Danyelly Bruneska G. Martins and Maria Amélia C.S.M. Borba. Oxidative Stress and Disease, A Master Regulator of Oxidative Stress - The Transcription Factor Nrf2, editors. Jose Antonio Morales-Gonzalez, Angel Morales-Gonzalez and Eduardo Osiris Madrigal-Santillan, 2016; IntechOpen, DOI: 10.5772/65366.

[41] Biswas SK. Does the Interdependence between Oxidative Stress and Inflammation Explain the Antioxidant Paradox? Oxid Med Cell Longev. 2016; 56:9893. DOI: 10.1155/2016/5698931

[42] Chao CY, Sung PJ, Wang WH, Kuo YH. Anti-inflammatory effect of *Momordica charantia* in sepsis mice. Molecules. 2014; 19:12777-12788. DOI:10.3390/molecules190812777

[43] Dandawate PR, Subramaniam D, Padhye SB, Anant S. Bitter melon: a panacea for inflammation and cancer. Chin J Nat Med. 2016;14(2):81-100. DOI: 10.1016/S1875-5364(16)60002-X.

[44] Kobori M, Nakayama H, Fukushima K, OhnishiKameyama M, Ono H. Fukushima T, Akimoto Y, Masumoto S, Yukizaki C, Hoshi Y, Deguchi T & Yoshida M. Bitter gourd suppresses lipopolysaccharideinduced inflammatory responses. Journal of Agricultural and Food Chemistry 2008a; 56:4004-4011.

[45] Cheng HL, Kuo CY, Liao YW, Lin CC. EMCD, a hypoglycemic triterpene isolated from *Momordica charantia* wild variant, attenuates TNF-alpha-induced inflammation in FL83B cells in an AMP-activated protein kinase-independent manner. Eur. J. Pharmacol. 2012; 689:241-248.

[46] Bao B, Chen YG, Zhang L, et al. *Momordica charantia* (Bitter Melon) reduces obesity-associated macrophage and mast cell infiltration as well as inflammatory cytokine expression in adipose tissues. PLoS One. 2013; 8(12):e84075. DOI:10.1371/journal.pone.0084075

[47] Sung HC, Liu CW, Hsiao CY, Lin SR, Yu IS, Lin SW, et al. The effects of wild bitter gourd fruit extracts on ICAM-1 expression in pulmonary epithelial cells of C57BL/6J mice and microRNA-221/222 knockout mice: involvement of the miR-221/-222/PI3K/AKT/NF-κB pathway. Phytomedicine. 2018; 42:90-99. DOI:10.1016/j.phymed.2018.03.023

[48] Battelli, MG, Polito L, Bortolotti M, and Bolognesi A. Xanthine oxidoreductase-derived reactive species: physiological and pathological effects. Oxid. Med. Cell Longev. 2016; 35:275-279. DOI: 10.1155/2016/3527579

[49] Lin ZY, Liu X, Yang F, Yu YQ. Structural characterization and identification of five triterpenoid saponins isolated from *Momordica cochinchinensis* extracts by liquid chromatography/tandem mass spectrometry. Int. J. Mass Spectrom. 2012; 32:43-66.

[50] Padmashree A, Sharma GK, Semwal AD, and Bawa AS. Studies on antioxygenic activity of bitter gourd (*Momordica charantia*) and its fractions using various in vitro models. J. Sci. Food Agric. 2010; 91:776-782. DOI: 10.1002/jsfa.4251

[51] Huang WC, Tsai TH, Huang CJ, Li YY, Chyuan JH, Chuang LT., et al. Inhibitory effects of wild bitter melon leaf extract on *Propionibacterium* acnes-induced skin inflammation in mice and cytokine production in vitro. Food Funct. 2015; 8:2550-2560.

[52] İlhan M, Bolat IE, Süntar İ, Kutluay Köklü H, Uğar Çankal DA, Keleş H, Küpeli Akkol E. Topical application of olive oil macerate of *Momordica charantia* L. promotes healing of excisional and incisional wounds in rat buccal mucosa. Arch Oral Biol. 2015; 60(12):1708-1713. DOI: 10.1016/j.archoralbio.2015.09.006.

[53] Raish M, Ahmad A, Ansari MA, Alkharfy KM, Aljenoobi FI, Jan BL, Al-Mohizea AM, Khan A, Ali N. *Momordica charantia* polysaccharides ameliorate oxidative stress, inflammation, and apoptosis in ethanol-induced gastritis in mucosa through NF-kB signaling pathway inhibition. Int J Biol Macromol. 2018; 111:193-199. DOI: 10.1016/j.ijbiomac.2018.01.008.

[54] Soo May L, Sanip Z, Ahmed Shokri A, Abdul Kadir A, Md Lazin MR. The effects of *Momordica charantia* (bitter melon) supplementation in patients with primary knee osteoarthritis: a single-blinded, randomized controlled trial. Complement. Ther. Clin. Pract. 2018; 32:181-186. DOI: 10.1016/j.ctcp.2018.06.012

[55] Jia S, Shen M, Zhang F, Xie J. Recent Advances in *Momordica charantia*:

Functional Components and Biological Activities. Int. J. Mol. Sci. 2017; *18:*2555.

[56] Day C, Cartwright T, Provost J, Bailey CJ. Hypoglycaemic effect of *Momordica charantia* extracts. Planta Medica. 1990; 56:426-429.

[57] Joseph B, Jini D. Antidiabetic effects of *Momordica charantia* (bitter melon) and its medicinal potency. Asian Pac J Trop Dis. 2013; 3(2):93-102. DOI:10.1016/S2222-1808(13)60052-3

[58] Wang HX, Ng TB. Studies on the anti-mitogenic, anti-phage and hypotensive effects of several ribosome inactivating proteins. Comp Biochem Physiol C Toxicol Pharmacol. 2001;128(3):359-366. DOI: 10.1016/s1532-0456(00)00208-8. PMID: 11255109.

[59] Dhasan PB, Jegadeesan M, Kavimani S. Antiulcer activity of aqueous extract of fruits of *Momordica cymbalaria* Hook f. in Wistar rats. Pharmacognosy Res. 2010; 2(1):58-61. DOI:10.4103/0974-8490.60575

[60] Malik ZA, Singh M, Sharma PL. Neuroprotective effect of Momordica charantia in global cerebral ischemia and reperfusion induced neuronal damage in diabetic mice. J Ethnopharmacol. 2011; 133(2):729-734. DOI: 10.1016/j.jep.2010.10.061.

[61] Deng Y, Tang Q, Zhang Y, et al. Protective effect of *Momordica charantia* water extract against liver injury in restraint-stressed mice and the underlying mechanism. Food Nutr Res. 2017; 61(1):1348864.

[62] Khan MF, Abutaha N, Nasr FA. *et al.* Bitter gourd (*Momordica charantia*) possess developmental toxicity as revealed by screening the seeds and fruit extracts in zebrafish embryos. BMC Complement Altern Med. 2019; 184.

[63] Adedji GT & Olapade SL. Effect of *Momordica charantia* (Bitter Melon) Leaves on Haemoglobin Concentration in Male Albino Rats. 2014; 2(2):82-86.

[64] Sur S, Ray RB. Bitter Melon (*Momordica Charantia*), a Nutraceutical Approach for Cancer Prevention and Therapy. Cancers (Basel). 2020; 12(8):2064.

[65] Peter EL, Deyno S, Mtewa A. *et al.* Safety and efficacy of *Momordica charantia* Linnaeus in pre-diabetes and type 2 diabetes mellitus patients: a systematic review and meta-analysis protocol. Syst. Rev. 2018; 7:192.