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Review

FUNCTIONAL FOOD *MOMORDICA CHARANTIA*: BIOLOGICAL ACTIVITIES

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ABSTRACT

Complementary medicine history includes a lot of knowledge based on human history. In this context, different plant species are used in the treatment and prevention of diseases. Plants are important natural productsthat attract attention with their nutritive and non-nutritive compounds. They contain many bioactive compounds that are not particularly nutritious but very important from a medical point of view. In our study, the biological activities of *Momordica charantia* reported in the literature were compiled. In addition, mineral, nutrient and chemical contents reported in the literature were compiled. The fruits of *M. charantia* are known as bitter gourd. In different parts of the world, it is used for many purposes as salad, direct food product, dried and spiced. It is used locally for different purposes in different countries. It is used as a supplement or sweetener in many foods, especially in East Asian countries. In our study, in addition to the nutritional properties of the plant, its medicinal properties were emphasized. As a result of the research, it was determined that the plant has many biological activities such as antioxidant, antimicrobial, antiinflammatory, antihyperglycemic, antiulcer, DNA protective, cytotoxic, anthelmintic, antiepimastigote, antiviral, immunomodulative, radioprotective, hepatoprotective, antidiabetes, antitumor, antiproliferative, antistress, hypoglycaemic, antimutagenic, or antiaging. In addition, it stands out with its nutritional properties. It is thought that it may be a natural source for the compounds reported in the literature data. Based on these studies, it is thought that *Momordica charantia* may be an important natural agent.

KEYWORDS: Antioxidant, Bitter melon, Biological activities, Goya, Momordica.

1. Introduction

It is known that people around the world rely on natural products used in complementary medicine for the treatment and prevention of diseases. For thousands of years, people have tried to fight diseases by using natural products [1,2]. Plants are very valuable materials among these natural products. They contain many bio-active compounds. These bioactive compounds are not nutritional but have high medicinal properties [3,4]. Many studies have shown that plants have different properties such as nutritive, spice, cosmetic, warming [5,6]. In addition, it has been reported that many plant species around the world have different effects such as antimicrobial, anticancer, antiproliferative, antioxidant, DNA protective [7-14]. In this context, it is very important to research plants for the discovery of new natural products and their use in complementary medicine. The aim of this review is to evaluate the biological activities of *Momordica charantia*, a natural agent, by using literature data.

2. *Momordica charantia*

Although *Momordica charantia*, a member of the *Momordica* (Cucurbitaceae) genus, is consumed in different parts of the world, its consumption is the biggest in Asian coutries. Consumption of fruits is preferred. Although it varies regionally, it usually blooms in June-July and bears fruit in September-November. In Southeast Asia, its fruits are used in salads [15]. It is used to flavor many food products in China. It is also used in brewing. It is consumed in different ways such as soup and fried food in different parts of the world. In addition, dried fruits are consumed as tea by many people [16].

Table 1. Biological activities of *Momordica charantia*

Biological activities	Extraction	References
Antioxidant, antimicrobial, antiinflammatory, antihyperglycemic, antiulcer, DNA protective, cytotoxic, anthelmintic, antiepimastigote, antiviral, immunomodulative, radioprotective, hepatoprotective, antidiabetes, antitumor, antiproliferative, antistress, hypoglycaemic, antimutagenic, antiaging	Ethanol, methanol, chloroform, n-butanol, petroleum ether, ethyl acetate, aqueous, water, essential oil, hexane	20-31, 36-45, 51, 52, 54, 57, 59, 61, 62, 66, 65

3. Biological activities

It has been observed that ethanol, methanol, chloroform, n-butanol, petroleum ether, ethyl acetate, and aqueous extracts are used in in vitro and in vivo biological activity studies of *M. charantia* plant in the literature. The findings obtained in the literature review are shown in Table 1.

3.1. Antioxidant activity

The antioxidant defense system plays an active role in suppressing or repairing the negative conditions caused by free radicals [17,18]. In cases where the antioxidant defense system is insufficient, supplemental antioxidants can be used. In this context, plants are important natural materials [19]. In our study, antioxidant activities of *M. charantia* plant in the literature were compiled. The DPPH free radical scavenging activity of the ethanol extract of *M. charantia* plant samples collected from India was examined. As a result of the study, it was reported that the plant has DPPH activity (1,738.81 ± 67.53 µg/g) [20]. In a study conducted in the USA, it was reported that the DPPH free radical scavenging activity of the plant was 30.48±2.49 mg/g [21]. Antioxidant activity of samples collected from Vietnam was determined by ABTS test. As a result of the study, it was shown to be 0.36 ± 0.04 mg/mL (IC50) [22]. In a study conducted in Korea, DPPH, peroxidation and iron/copper reducing power tests were used and it was reported that plant fruit extracts have antioxidant activity [23]. In another study conducted in Korea, it was reported that plant leaves had high antioxidant activity with 84% inhibition using the DPPH test [24]. In another study, antioxidant potential of *M. charantia* samples obtained from different regions was determined by using DPPH, ABTS and Nitrite scavenging tests. As a result of the study, it was reported that the plant sample had significant antioxidant activity [25]. In a study conducted in Turkey, it was reported that the plant has a significant antioxidant effect on rats [26]. In another study conducted in Korea, hydroxyl radical scavenger, ABTS and FRAP tests were used to determine the antioxidant activity of the plant sample. It has been reported that the best result was obtained from the hydroxyl scavenging test [27]. In another study conducted in Malaysia, DPPH and iron reduction test were used and it was reported that the plant has antioxidant potential [28]. In addition to these studies, studies conducted in India and Bangladesh have reported that the plant has antioxidant potential using different tests [29-31]. In a study conducted in Pakistan, it was reported that ethanol and methanol extracts of leaves, seeds and peel parts of *M. charantia* showed inhibition of DPPH activity between 44.2-71.2% [52]. In a study conducted in Malaysia, it was reported that DPPH activities of ethanol and chloroform extracts of fruit parts of *M. charantia* ranged from 1.12 to 81.22% [53]. In a study conducted in China, antioxidant activity of *M. charantia* was reported [55]. In a study conducted in Senegal, it was reported that the seed parts of *M. charantia* had an antioxidant activity of 49-55.75% [65]. In this context, considering the literature data, it is thought that the plant may be an important natural antioxidant source.

3.2. Antimicrobial activity

In recent years, the possible side effects of synthetic drugs and the increase in the number of resistant microorganisms have led researchers to the discovery of new antimicrobial drugs [32,33]. Many researchers have suggested different natural products as antimicrobial agents [34,35]. Plants have shown very exciting results among these natural products. In our study, it was seen that there are studies on antimicrobial properties of *M. charantia* species in the literature. The antimicrobial activity of *M. charantia* extracts against *Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli, Fusarium oxysporum* and *Aspergillus niger* was investigated. The highest effect was demonstrated against *E. coli* bacteria [17]. In a different study, it was demonstrated that it has strong effects against *Candida albicans, C. tropicalis* and *C. krusei* strains using the microdilution method [36]. In another study, it was reported that the plant extract has an antibacterial effect against *S. aureus* [37]. In a different study using the disk diffusion method, the effects of the plant extract against *P. aeruginosa, E. coli, Klebsiella pneumoniae* and *Bacillus subtilis* strains were investigated. It has been reported that the best effect is against *E. coli* [29]. In another study, it was reported that the plant has an antimicrobial effect against *E. coli, P. aeruginosa, S. aureus* and *K. pneumoniae* strains [38]. In another study using the disc diffusion method, it was reported that the plant extract has antimicrobial effects against *B. subtilis, E. coli, P. aeruginosa* and *S. aureus* [39]. In an Italian study, the MIC values of ethanol extract of *M. charantia* seeds was reported to be effective against *E. coli*, *C. albicans*, *S. aureus*, and *S. aureus* clinical isolates between 125 and >500 µg/mL [48]. It has been reported that the MIC values of the essential oil of M. charantia seeds collected from Nigeria ranged between 15.63-125 mg/mL against *Streptococcus aureus*, *E. coli, B. subtilis, P. aeruginosa*, *Salmonella typhi, K. pneumoniae*, *C. albicans, Penicillium notatum, Rhijoptius stoloniter* and *Aspergillus niger* [57]. In a study conducted in Vietnam, hexane, chloroform and ethyl acetate extracts of *M. charantia* fruits were reported to be effective against *E. coli*, *B. subtilis* and *A. niger* [59]. In a study conducted in India, the MIC values of essential oils of the seeds of *M. charantia* were reported to be effective between 14.0-68.1 mg/mL against *E. coli*, *P. aeruginosa, K. pneumoniae*, *S. auerus* and *C. tropicalis*

[61]. Ethanol, ethyl acetate and hexane extracts of the seed part of *M. charantia* collected from Brazil have been reported to be effective at different concentrations against *K. pneumoniae*, *Proteus mirabilis* and *S. aureus* [62]. Based on these data, the antimicrobial activity of the plant was investigated with different methods and it was determined that it was effective against bacteria and fungus strains.

3.3. Other activities

It has been reported that the plant has different activities in addition to antioxidant and antimicrobial activities. It has been reported in the literature that extract obtained from *M. charantia* has anthelmintic effect against *Caenorhabditis elegans* at 500 µg/mL and antiviral effect against Herpes simplex type 1 viruses [14]. In a different study, it was reported to have an antidiabetic effect by inhibiting α-amylase, α-glucosidase and pancreatic lipase [21, 27,31]. In another study, it was reported that *M. charantia* inhibited inflammatory nitric oxide and inhibited hydrogen peroxide induced DNA damage [22].

In a different study, it was reported to have antidiabetic effects due to α-glucosidase inhibition, tyrosinase inhibition and fibrinolytic effects [23]. In another study, it was reported to have antiepimastigote, cytotoxic and anthelmintic effects [30,36]. In a study on rats, it was reported that it has hepatoprotective and antihyperglycemic effects [26,40].

In a different study, it was reported that it has antitumor effects on HeLa and liver cancer (HepG2) cell lines [41]. It has also been reported in other studies to have antiproliferative, anti-stress and antimalarial effects [42-44]. In another study, it was reported that it has a cytotoxic effect on the ovarian cell line (SpLi-221) [45].

In a study conducted in England, the effects of oral administration of *M. charantia* fruits in diabetic mice were investigated. As a result of the study, it has been reported that orally administered bitter gourd extracts induce lower glucose concentrations independent of intestinal glucose absorption and have an extrapancreatic effect [46]. In a study conducted in India, the antihyperglycemic effects of *M. charantia* fruits were investigated by oral administration of methanol, chloroform and water extracts to diabetic rats. As a result of the study, it was reported that the aqueous extract powder of fresh unripe whole fruits at a dose of 20 mg/kg body weight reduced fasting blood sugar by 48% [47].

In a study conducted in India, it was reported that methanol extracts of *M. charantia* fruits enhanced the healing of gastric ulcers and prevented the development of gastric ulcers and duodenal ulcers in mice [52]. In a study conducted in the Philippines, it was reported that *M. charantia* fruits reduced the number of micronuclear polychromatic erythrocytes, induced by the well-known mutagen mitomycin C, by approximately 80% in mice at a dosage range of 50–12.5 µg extract/g [54]. In a study conducted in China, it was reported that *M. charantia* fruits increased the development of consciousness and reduced aging in mice [63].

4. Chemical contents

In this study, the chemical contents reported to be present in different parts of *M. charantia* from different parts of the world in the literature were compiled. The obtained results are shown in Table 2.

Table 2. Chemical contents of *Momordica charantia*

Chemical contents	Parts used	References
1,3,5-cycloheptatriene, 3,4,5-cycloheptatriene, o-xylene, p-xylene, n-decane, decahydronaphthalene, spiro(4.5) decane, 2,7,10-trimethyldodecane, hexadecanoic acid, eicosane, phytol, 8-hexyl-pentadecane, heneicosane, oleic acid, trans-9-octadecenamide, nonadecanamide	Leaves and stems	60
A-Pinene, ß-Pinene, Octanal, p-Cymene, Limonene, 1,8-Cineole, ß-Phellandrene, Linalool, cis-Dihydrocarveol, trans-Dihydrocarveol, Carvone, (E)-Anethole, Safrole, Methyl eugenol, Germacrene D, ß-Selinene, α-Selinene, Myristecin, δ-Cadinene, trans-Nerolidol, Spathulenol, Cedrol, ß-Bisabolol, Apiole, Cyclohexanol, 2-methyl-5-(1-methylethenyl)-, (1α,2α,5ß), Isopulegol acetate, trans-(+)-Carveol, 2-Cyclohexen-1-one, 2-methyl-5-(1-methylethenyl)-, (R), 3,5-Heptadienal, 2-ethylidene-6-methyl, 2-Allyl-6-methoxyphenol, Bourbonene, Aromadendrene, Ylangene, Copaene, Acorenol, 1-Hydroxy-cyclohexyl-phenyl-ketone, Cyclopentanetridecanoic acid, methyl ester, Hexadecanoic acid, 2,3-dihydroxypropyl ester, 5-(Hydroxymethyl)-2-(1-methyl-2-imidazolyl)-1H-benzimidazole, Caffeine, Hexadecanoic acid, methyl ester, 6-Octadecenoic acid, methyl ester, Octadecanoic acid, methyl ester, Melibiose, dihydrobenzoic acid pentose, hydroxy-2,4,4-trimethyl-3-(3-oxobutyl)-2-cyclohexen-1-one glucoside, quercetin-O-sambubioside, rutin, quercetin-O-glucoside, kaempferol-O-glucoside-O-pentoside, luteolin-O-rutinoside, quercetin-O-glucosyl-6″-acetate, kaempferol-O-glucoside, 4-hydroxybenzoic acid, isorhamnetin-O-glucoside, quercetin-O-acetylpentoside, icariside B6, quercetin, trihydroxy octadecadienoic acid isomer, trihydroxy octadecenoic acid, momordicoside L isomer, hederagenin base-2H + 1O, O-AcetylHex, hederagenin-O-AcetylHex, triterpene glycosides derivative, 1-Hexadecanoyl-sn-glycero-3-phospho-(1′-myo-inositol) isomer	Seeds	48,61, 62

(10E)-3-hydroxyl-dodeca-10-en-9-olide, monordicophenoide A, 4-hydroxyl-benzoic acid, 4-O-beta-D-apiofuranosyl O-beta-D-glucopyranoside, dihydrophaseic acid, 3-O-beta-D-glucopyranoside, 6,9-dihydroxy-megastigman-4,7-dien-3-one blumenol, guanosine, adenosine, uracil cytosine, Momordicoside O, Momordicoside E, Momordicoside S, Momordicoside A, Goyaglycoside h, Momorcharaside B, Momordicoside Q/Karaviloside XI, Momorcharaside M/N/Karaviloside X), Goyasaponin I, Goyasaponin II, Goyalycoside e/f, Momordicoside L, Momordicoside P, Momordicin II	Fruits	56,63

As a result of the literature research, it can been seen that the leaves, stems, seeds and fruits of the plant have different contents. In this context, it seems that it can be used as a natural source for the compounds reported in the literature data.

4.1. Nutritional and mineral contents

In this review, the nutritional and mineral contents reported to be present in different parts of *M. charantia* from different parts of the world in the literature were compiled. The obtained results are shown in Table 3. As a result of the literature research, it has been seen that the mineral and nutritional contents of the seed, leaf and fruit parts of the plant vary. In this context, it is thought that the plant may be an important source of nutrients.

5. Toxic and adverse effects

Possible side effects of *M. charantia* plant have been reported in the literature depending on the use. In a study conducted in India, it was reported that the hydroalcoholic pulp extract of *M. charantia* at 400 mg/kg had antifertility activity [67]. In addition, it has been reported that *M. charantia* plant has many side effects such as hypoglycemic coma and convulsions in children, decreased fertility in mice, a favism-like syndrome, increases in gamma-glutamyltransferase and alkaline phosphatase levels in animals, and headaches [68]. In this context, it is recommended to determine the usage doses of *M. charantia* plant and pay attention to their use.

Table 3. Nutritional and Mineral contents of *Momordica charantia*

Parameters	Leaf (ppm)	Fruit (ppm)	Seed (ppm)	References
Moisture	17.97	10.74-93.20	4.7-20.69	[49,50,66]
Total ash	15.42	7.36-8.12	1.8-9.73	[49,50,58,66]
Crude fat	3.68	0.76-6.11	11.50	[49,50]
Crude fibre	3.31	13.60	29.60	[49]
Crude protein	27.46	18.02-27.88	19.50	[49,50]
Carbohydrate	32.34	34.31	9.18	[49]
Caloric value kcal/100 g	213.26	241.66	176.61	[49]
Calcium	20.51	47.41-137.69	721.21-807.05	[49,50,64,65]
Magnesium	0.255	46.42-119.92	126.07-198.34	[49,50,64,65]
Sodium	2.2	7.55	37.056-98.76	[49,64,65]
Potassium	0.413	192.43	882.82-936.38	[49,64,65]
Iron	0.098	2.33-5.97	-	[49,50,64]
Zinc	0.12	1.38-3.53	-	[49,50,64]
Manganese	0.156	0.068	-	[49,64]
Copper	0.032	0.19959-3.54	-	[49,50,64]
Phosphorus	-	54.34	-	[64]

6. Conclusions

In this review, the biological activities of *M. charantia*, which draws attention with its nutritional properties, in the literature were compiled. It has been evaluated in many studies and it has been seen that the plant has important biological activities. It has been determined that especially antioxidant and antimicrobial activities are high. In addition, it is seen that it has different effects such as antidiabetic, antiviral or antitumor. In this context, M. charantia is thought to be a natural resource in pharmacological studies. In addition, it has been observed that it can be a natural source in terms of minerals, nutrients and other chemical contents.

Author(s) contributions

Conceptualization, F.S.M and M.S.; methodology, F.S.M and M.S.; validation, I.U., F.S.M and M.S.; investigation, I.U., F.S.M and M.S.; resources, I.U., F.S.M and M.S.; data curation, I.U., F.S.M and M.S.; writing—original draft preparation, I.U., F.S.M and M.S.; writing—review and editing, I.U., F.S.M and M.S. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare no conflict of interest.

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