

A Review of Studies on Bitter Gourd (*Momordica charantia* L.) in Turkey

Sevil Sağlam Yılmaz\*

Department of Plant Biotechnology, Kirsehir Ahi Evran University, Kirsehir, Turkey

**\*Corresponding Author:** Sevil SAĞLAM YILMAZ, Department of Plant Biotechnology, Kirsehir Ahi Evran University, Kirsehir, Turkey

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### Abstract

Bitter gourd (*Momordica charantia* L.) is a vegetable and also an important medicinal plant with economic importance. There is a rapidly increasing demand for this plant in Turkey and its cultivation has started. However, no production status has entered the statistics yet. At the same time, this plant is not known enough in Turkey. There is a need for more scientific studies that reveal the importance of this plant for the production of bitter melon in Turkey. In Turkey, theses, research articles, review articles, and book chapters have been written, and congress presentations and projects have been made so far. A total of 50 studies on the subject have been reached. Studies on bitter gourd began in 1993 and have continued to increase until today. These studies were mostly focused on antioxidant and antimicrobial activity. The most recent studies have been studies on industrial use and Covid19 treatment. Biotechnological and nanotechnological studies on bitter gourd are not yet sufficient and no studies on gene transformation have been found. This review aims to bring together all the studies on the potency of bitter gourd in Turkey and to reveal a future perspective. As a result, it was concluded that more scientific studies should be done in Turkey.

**Keywords:** Bitter Gourd; *Momordica Charantia* L; Turkey; Research; Medicinal Plant

### Introduction

Bitter gourd is an important plant of the Cucurbitaceae family with high nutritional content. It is also used by people in the treatment of many diseases. It is also known as bitter gourd, African cucumber, balsam apple, balsam pear, papilla, and karela. Bitter melon is a tropical plant that likes moist and warm areas. Its homeland is India. It is grown in Yalova, Düzce, Bursa, Balıkesir, Istanbul, Antalya, Hatay, Rize, Mersin, Tokat, Adana and Urfa in Turkey. It is grown in open areas in temperate regions of Turkey and greenhouse environments in cold regions.

This plant is used both for treatment and food in many regions where it grows and is grown [1]. The bitter melon plant is grown in Turkey by sowing from its seed in May and the ripe fruits are harvested in August. The bitter melon is an annual, herbaceous, and climbing plant, and its delicate stem can be up to 1-2 m in length. The leaves come out of the armpits, and the body extensions called leeches extend from the same area. The leaves are hand-shaped,

long-stalked, and lobed, and the lobes are elongated, oval-shaped, toothed, and pointed. Its flowers are yellow and produce fruit in summer. The fruit, which looks like a lumpy shuttle, turns orange when ripe. The fruits are approximately 10 cm in width and 20 cm in length, with flat and 20-30 seeds that turn brown as they mature. Bitter melon seeds are very rich in oil and protein and contain high amounts of vitamins C and A, beta-carotene, alfa-carotene, potassium, magnesium, and zinc.

Studies on the bitter melon plant are limited to Turkey in this review. In Turkey, studies on bitter gourd have focused on antioxidant activity, antimicrobial activity, diabetes, wound, diabetic wound, cancer, ulcer, burn, menopause, fracture, Covid19 treatment, oil analysis, agronomy, extraction analysis, functional food, biotechnology, tissue culture and biological activity (Table 1). These studies are grouped and explained according to the purpose of construction.

**Studies by purpose on bitter gourd in turkey**

Studies on the potency of bitter gourd in Turkey have been conducted to reveal its antioxidant and antimicrobial activity, and its effect on diabetes, wounds, diabetic wounds, cancer, ulcers, burns, menopause, fractures, and Covid19 treatment. Moreover, Studies were also conducted on oil and extraction analysis, agronomy, in-

dustrial use, nanoparticle extraction, biotechnology, nanotechnology, *in vitro* reproduction, and biological activity (Table 1). Although the research on the potency of bitter gourd in Turkey has a history of thirty years, studies have gained momentum in the last ten years. Studies on its industrial use and the treatment of Covid19 have begun to be carried out in the last few years.

Main Purpose	Description of Topic
Antioxidant, Anti-microbial Activity	Investigation of antimicrobial activity of safflower ( <i>Carthamus tinctorius</i> ) and bitter melon ( <i>Momordica charantia</i> L.) extracts against fish spoilage and food-borne pathogens [2]
	Evaluation of total phenolic contents and antioxidant capacities of <i>Momordica charantia</i> L. (Bitter gourd) fruits [3]
	Comparison of antioxidant and antidiabetic components of commercial bitter melon products [4]
	The investigation of antioxidant and anticancer effects of some important medical plants [5]
	Bitter melon ( <i>Momordica charantia</i> L.) fruit extract ameliorates methotrexate-induced reproductive toxicity in male rats [6]
	Investigation of antioxidant activity in potency pomegranate ( <i>Momordica charantia</i> L.) [7]
	Antioxidant Activity and Phenolic Composition of Ethanol Extracts of <i>Momordica charantia</i> and <i>Datura stramonium</i> [8]
	The effects of different herbals on the rat hippocampus exposed to electromagnetic field for one hour during the prenatal [9]
Diabetes Treatment	Investigation of the hypoglycemic effect of (bitter melon) in hyperglycemic or normoglycemic mice [10]
	Bitter Melon ( <i>Momordica charantia</i> ) and the Effects of Diabetes Disease [11]
	Relation of <i>Momordica charantia</i> L. (Bitter melon) and TYPE 2 diabetes mellitus [12]
	Efficacy and Safety of Herbal Supplements Used in Diabetes [13]
Wound Treatment	The beneficial effects of <i>Momordica charantia</i> (bitter gourd) on wound healing of rabbit skin [14]
	Topical application of olive oil macerate of <i>Momordica charantia</i> L. promotes healing of excisional and incisional wounds in rat buccal mucosa [15]
	Investigation of activity dressing made with bitter melon extract by dressings made by using pure olive oil, nitrofurazone, and normal saline in ischemic wound healing [16]
	Effect of <i>Momordica charantia</i> Extract on Gene Expression in Wound Healing [17]
	The effect of <i>Momordica</i> on wound healing [18]
	Investigation of Cream Preparation, Quality Control and <i>In Vitro</i> Wounding Effect using <i>Momordica charantia</i> L. Fruits [19]
	Plants Widely Used in Wound Care in Veterinary Phytotherapy [20]
Diabetic Wound Treatment	Effects of bitter melon ( <i>Momordica charantia</i> ) oil on wound healing in an experimental type II diabetic wound model [21]
	Investigation of the effect of zinc oxide and bitter melon ( <i>Momordica charantia</i> ) combination on diabetic wound [22]
	Effects of <i>Momordica charantia</i> (Bitter gourd) extract on burns and resuscitation of stasis zone on diabetic rats [23]
Oil Analysis	Production and optimization of structured lipid with acidolysis of a mixture of corn oil and bitter melon fatty acids [24]
	Production of structured lipids with canola oil and bitter gourd fatty acids (CLNA) and optimization of reaction conditions [25]
	Studies on bitter melon ( <i>Momordica charantia</i> L.) oil standardization [26]
	Effect of bitter melon ( <i>Momordica charantia</i> L.) fruit on some physical and chemical properties of extra virgin olive oil [27]

Agronomy	The Effect of Different Doses of Phosphorus and Iron Fertilizer Application on Leaf Chlorophyll Content in Mycorrhiza Inoculated Bitter Melon ( <i>Momordica charantia</i> ) Plant [28]
	Effects of Different Planting Frequency on Some Agricultural Traits of Bitter Melon ( <i>Momordica charantia</i> L.) Grown in Rize Ecological Conditions [29]
	The Performances of Some Bitter Melon ( <i>Momordica charantia</i> L.) Genotypes in Open Field and Protected Cultivation at Bafra Condition [30]
	Medical and Aromatic Plants of the Eastern Black Sea Region Inventory, Commercial Use Research and Manufacturers Education Project Education Book [31]
	The Effects of Growing Technique and Harvest Period on Some Traits of Fruits and Seeds of Bitter Melon ( <i>Momordica charantia</i> L.) [32]
	Effects of Pruning and Topping on Yield and Fruit Characteristics of Fruit Setting on Stem in Bitter Melon ( <i>Momordica charantia</i> L.) [33]
Cancer Treatment	Effect of bitter melon ( <i>Momordica charantia</i> L.) against cisplatin and valproic acid-induced genotoxicity in drosophila melanogaster [34]
	Investigation of the Effects of <i>Momordica charantia</i> Extract on Cell Survival and Migration in U87G Glioblastoma Cell Line [35]
	Investigation of the effect of <i>Momordica charantia</i> extract on Sparc and Src-1 protein expression in U87G cancer cells [36]
	The Extract of <i>Momordica charantia</i> Inhibits Cell Proliferation and Migration in U87G Cells [37]
Ulcer Treatment	Investigation of the effect of various extracts of <i>Momordica charantia</i> L. (Pomegranate) plant in experimentally induced Peptic Ulcer in rats [38]
	Investigation of the Comprehensive Identification of the Molecular Mechanisms of the Healing Effects of <i>Momordica charantia</i> in Ulcerative Colitis Model [39]
Extraction Analysis	Process development for the extraction of bioactive compounds of bitter melon [40]
	Determination of Suitable Solvents for Extraction of Different Fruit Parts of Bitter Melon ( <i>Momordica charantia</i> L.) [41]
Industrial Using	Synthesis of Hybrid Nanoflowers Using the Purified Bitter Gourd ( <i>Momordica charantia</i> Descourt.) Peroxidase and its Usability of Direct Blue 1 Decolorization [42]
	Usage possibilities of the fruits of medlar ( <i>Mespilus germanica</i> ) and bitter melon ( <i>Momordica charantia</i> ) in functional biscuit production [43]
Burn Treatment	Comparison of the topical <i>Momordica charantia</i> (bitter melon) treatment and the effects of emergency treatment methods on wound healing in experimental contact burns [44]
Menopause Treatment	The effect of Bitter melon ( <i>Momordica charantia</i> ) on the gene levels of estrogen receptors ESR1 and ESR2 with on oxidative DNA damage [45]
Nanoparticle Obtaining	Formation of polymeric micro/nanoparticles and fibers including bitter melon ( <i>Momordica charantia</i> L.) extract by electrospinning method [46]
Biotechnology, Nanotechnology	In book: The Bitter Gourd Genome/Tissue Culture, Genetic Engineering, and Nanotechnology in Bitter Gourd [47]
<i>In vitro</i> Micropropagation	<i>In Vitro</i> Propagation of Bitter Gourd ( <i>Momordica charantia</i> L.) [48]
Fracture Treatment	Effects of <i>Momordica charantia</i> on fracture healing in rats [49]
Biological Activity	A Review: <i>Momordica charantia</i> L.'s Biological Active Components and Its Potential Use in Traditional Therapies [50]
	Characterization of volatile compounds nongrafted and pumpkin-grafted bitter gourd ( <i>Momordica charantia</i> L.) [51]
Covid19 Treatment	Medicinal Plants for Prevention and Treatment of Coronavirus Disease [52]
	Could <i>Momordica charantia</i> Be Effective in the Treatment of COVID19? [53]

**Table 1:** Studies by Purpose on Bitter Gourd (*Momordica charantia* L.) in Turkey.

### Studies on antioxidant and antimicrobial activity

The effects of safflower and bitter melon extracts on the deterioration factor in fish meat, the development of pathogenic bacteria, and biogenic amine production in fish infusion fluid were examined and it was seen that safflower and bitter melon extracts have the potential to be used as antimicrobial in foods [2].

In this study, in which raw and ripe fruits of 13 different genotypes of bitter melon collected from different regions of Turkey were used, phenolic content changed from genotype to genotype according to the results of extraction analysis [3].

Total phenolic contents, total antioxidant capacities, and  $\beta$ -sitosterol contents of some commercial bitter melon products were tried to be determined [4].

It was determined that extracts obtained from the fruits of bitter melon, pepino, and golden berry plants exhibited low levels of antioxidant effect. In addition, it was determined that the extracts applied to ovarian and breast cancer cell lines showed a strong cytotoxic effect [5].

Methotrexate (MTX) is a drug widely used in the treatment of malignant neoplastic and inflammatory diseases. Methotrexate causes inflammation and testicular damage by reducing spermatogenic cells and increasing apoptosis through oxidative stress, but bitter melon extract has been shown to improve testicular and epididymal damage [6].

SOD and CAT activities in the seeds of bitter melon were examined and it was reported that the highest CAT activity was measured in the endosperm part of the seed [7].

The phenolic composition and antioxidant potential of ethanol extracts of bitter melon, which have cytotoxic potential on human cancer cells, were investigated [8].

In this study, in which the possible effects of the electromagnetic field (EMF) on the hippocampus were investigated, it was investigated whether the potential effects of electromagnetism emitted from mobile phones could be reduced by antioxidant substances. Analysis results showed that the protective effect of MC from the groups given *Garcinia kola* (GK), *Momordica charantia* (MC), and thymoquinone (TQ) was stronger than other antioxidant substances [9].

### Studies on diabetes treatment

A total of five studies have been reached on the use of pomegranate in the treatment of diabetes in Turkey. The first research on the subject started in the early 1990s, but it was not studied again for a long time. However, in the last ten years, studies have started again.

Experimental hyperglycemia was induced with cyproheptadine in mice and the oral hypoglycemic activity of bitter melon extracts was investigated. The extract was found to show significant hypoglycemic activity in both hyperglycemic and normoglycemic mice. These results show that cyproheptadine-induced experimental hyperglycemia in mice is a suitable model for screening hypoglycemic activity [10].

Blood sugar-lowering chemicals include steroidal saponins, insulin-like peptides, and alkaloids known as charantins. Bitter melon is a primary alternative therapy used to lower blood glucose levels in patients with diabetes. Studies in animals and humans have shown that there are hypoglycemic substances in the potency of pomegranate [11].

Diabetes is one of the four diseases whose prevalence is increasing rapidly in the world. Phytotherapy is used in the treatment of the disease. Bitter melon is one of the plants widely used in the world for the treatment of diabetes. Quarantine, and polypeptide-p, contained in bitter melon are the major compounds responsible for the hypoglycemic effect of vicin. Therefore, it is recommended that the plant should not be used by people with a tendency to hypoglycemia [12].

There is an increase in the use of plants as a support for the modern treatment of diabetes. It has been determined that different extracts of bitter melon have a hypoglycemic effect in rats with high blood glucose levels. Triterpenic compounds (quarantine, vicin, etc.) in the composition of the fruit and insulin-like peptides such as polypeptide-p are thought to be the main compounds responsible for glycemic control. Among the suggested mechanisms for the hypoglycemic activity of bitter melon is stimulation of glucose utilization in skeletal muscles, decreased intestinal glucose absorption, suppression of adipocyte differentiation, suppression of gluconeogenesis, and preservation of  $\beta$ -cells and their functions [13].

### Studies on wound treatment

The wound healing process of *Momordica charantia* (MC) cream in rabbits was examined and its healing potential was compared with conventional creams used therapeutically. It was reported that inflammatory cells were abundant in the control group and cream application caused a decrease in the number of these cells, especially in the MC group showed that the administration of MC extract accelerated the wound healing process in rabbits compared to other extracts [14].

The potential effect of bitter melon on the buccal mucosal wound in rats was investigated and the wound-healing activity of the olive macerate of the plant was investigated. In conclusion, olive oil macerate has been reported to have significant wound healing activity in both incision (45.1%) and excision (89.8%) wound models [15].

Potency pomegranate extract with olive oil was applied to the wounds formed on the back of the rats in the bitter melon group, and the wounds were examined in terms of epithelialization, collagen, fibroblast, inflammatory cell, and new vessel formation criteria in histological examination. It was observed that epithelialization, collagen, fibroblast, and new vessel formation in the bitter melon group were higher than in the other groups. It has been suggested that bitter melon extract can be used as an alternative treatment option in the treatment of wounds [16].

In this study, which was carried out to reveal the effect of bitter melon on the expression levels of *vegfa*, *vegfb*, *vegfc*, *fgf2*, and *egf* genes in the wound and burn models created in mice, gene expression levels were found to increase in groups treated with bitter melon. At the end of the study, it was stated that bitter melon has a positive effect on wound healing and that it does this by increasing the expressions of *vegfa*, *vegfb*, *vegfc*, *fgf2*, and *egf* genes, but it does not have such an effect on burn healing [17].

It has been reported that bitter melon accelerates the wound-healing process and capillary circulation, and ensures the proliferation of fibroblast cells. It has also been reported to cause positive results in terms of wound contraction ability, wound closure time, epithelialization process, wound tensile strength, and wound healing rate [18].

The laboratory-scale cream form prepared using bitter melon-olive oil macerate and pharmaceutical quality excipients was standardized on the total flavonoid content and a positive effect on *in vitro* wound healing was observed [19].

In veterinary medicine, the effect of potency pomegranate on wound healing has been studied mostly in rats and rabbits, and it has been reported that studies in animals such as cats, dogs, and calves are not yet sufficient [20].

### Studies on Diabetic Wound Treatment

In this study, which was carried out to reveal the effect of bitter melon on diabetic wounds, malondialdehyde (MDA), superoxide dismutase (SOD), and glutathione reductase (GRx) analyzes were performed in blood samples and it was determined that bitter melon oil accelerated clinical healing in scar tissue [21].

Diabetes negatively affects the wound-healing process. For this reason, there is a need for applications that will positively affect the healing of diabetic wounds. In this study, the effect of dressing made with zinc oxide powder combined with bitter melon oil on wound healing was investigated in rats with diabetes. At the end of the study, the positive wound-healing effect of zinc oxide powder was observed [22].

The effects of potency pomegranate extract on the healing of burn wounds in diabetic rats were investigated. Wounds were dressed for 14 days with bitter melon extracts. It has been observed that the plant accelerates wound healing by providing new vessel formation and increasing epithelialization in the treatment of burn wounds. It has been recommended that it can be used as an effective and natural treatment for burn wounds after further research [23].

### Studies on oil analysis

Fats, one of the essential nutrients, are modified to improve their beneficial properties and quality. For this purpose, by producing structured oils, consumers are offered new alternative oils with different properties, enriched nutritional content, and many positive effects on health. Corn oil is a very beneficial oil for health with its various components. The bitter melon seed contains conjugated linolenic acid, which is a largely unsaturated fatty acid. In this study, the bitter melon seed was used as a source of conjugated linolenic acid (KLNA). Recent studies show that KLNA has many positive effects on human health. This study, it was aimed to enrich corn oil with conjugated linolenic acid obtained from potency pomegranate enzymatically and to turn it into a functional food that is beneficial to health and has many positive properties. In these conditions, the incorporation rate of conjugated linolenic acid into corn oil was determined as 41.4% [24].

The canola plant is obtained as a result of breeding rapeseed seeds through genetic modification. Canola oil obtained from canola seeds contains low saturated fatty acids and high monounsaturated fatty acids and is also seen as a rich source of polyunsaturated fatty acids. Conjugated linolenic acid (KLNA) isomers have a protective effect against heart diseases, control body weight, and strengthen the immune system. Bitter melon contains KLNA. This study, it was aimed to enrich canola oil with conjugated linolenic acid obtained from bitter melon seed oil and to produce structured oils with various functional properties. At the end of the study, 36.9% of conjugated linolenic acid was incorporated into canola oil [25].

The bitter melon is a plant that does not grow naturally in Turkey but is cultivated in some regions. Among the people, the olive oil extract of the fruit is used to heal wounds, and treat stomach ulcers; Honey extract has been used for many years in the treatment of ulcers. At the end of the study, marker substances thought to be characteristic of bitter melon oil were determined [26].

In this study, the effect of bitter melon (KN) fruit on some physical and chemical properties of Extra Virgin Olive Oil (NSZ) was investigated. It was recommended that the group containing NSZ-50% CN and kept for 16 weeks would be more appropriate to consume because it decreased the peroxide value and increased the total amount of phenolic substances [27].

### Studies on agronomy

Mycorrhizae increase the uptake of phosphorus and some other elements from the soil by the plants they live within controlled and field conditions. In this study, to see the effectiveness of mycorrhiza application; *Glomus mosseae* type mycorrhiza (500 spores/pot) seeds were applied during sowing under greenhouse conditions. In addition, fertilizer applications containing P2O5 and Fe were made to determine the appropriate amount of phosphorus and iron fertilizer for the plant. Accordingly, it was determined that mycorrhiza inoculation was effective on the amount of chlorophyll [28].

Potency pomegranate seedlings grown in viols in the greenhouse were planted at different frequencies (70 x 50 cm, 70 x 100 cm, 70 x 150 cm) in the field. In the study, fruit characteristics such as internal fruit rate, seed rate in fruit, seed weight in fruit and red cover rate in fruit; seed length, seed width, seed depth, and 1000 seed weight; Fruit yield, fruit yield per plant, single fruit weight per plant, the number of fruit per plant and fruit length were determined. According to the results obtained from the research, the

highest fruit yield, fruit weight, kernel fruit weight, fruit kernel ratio, seed length, and seed width were obtained from a 70 x 50 cm planting distance [29].

In this study, it was carried out to determine the performance of some bitter melon genotypes (Bafra, Tokat, Rize, Yalova, Bursa, Adana, Antalya, Mersin) in an open field and under protection (plastic greenhouses) aquaculture under Bafra conditions. At the end of the study, it was concluded that yield and yield elements changed between genotypes and according to the place of cultivation. The heaviest fruit and the highest yield were obtained from Bursa (137 gr) and Yalova (2440 gr/plant) genotypes, respectively, both in the open field and in the greenhouse. The average fruit weight in an open field and the greenhouse is 110 g and 137g, respectively; the average fruit length of 15 cm and 17 cm; the average fruit diameter of 5.5 cm and 6.0 cm; the average number of fruits is 18 pcs/plant and 22 pcs/plant; The marketable yield was determined as 1621 g/plant and 2440 g/plant [30].

Potency pomegranate, which has sterols and triterpenes, charantin, alpha and beta-momocarins, daucosterol, goyaglycosides, goyasaponins, momordicosides, cucurbitacins, glycosides, proteins, gallic acid, gentisic acid, catechin, epi-catephlin and natural chlorogenic acid in its chemical composition, is located in the tropical climate zone. It is grown as a medicinal plant. Since bitter melon is a plant with a high-temperature demand, it can be grown in open areas in areas where bananas are grown in Turkey (such as Antalya), and in a greenhouse environment in harsher climates [31].

This study, which was conducted to determine the effects of pruning and top intake of the bitter melon plant on fruit and seed characteristics depending on the harvest period of the plants, was carried out in Pazar/Rize. The experiment was established with the seedling planting method. In the study, it was concluded that depending on the harvest period, the effect of peak intake only on fruit length is important [32].

This study was carried out to determine the effects of pruning and topping practices on the properties of fruits in potency pomegranate. It has been reported that the effects of crowning and pruning applications and the interaction between these applications on fruit characteristics on the stem vary according to years [33].

### Studies on cancer treatment

Active substances of various plants are used in the treatment of many diseases such as cancer. In this study, the survival rates

of *Drosophila melanogaster* individuals who were treated with cisplatin (CP), valproic acid (VPA), and fruit extracts of the bitter melon (MC) plant were determined. As a result, the somatic mutation and recombination rates observed between the groups in which only chemical agents were applied and the experimental groups in which plant extracts were applied with chemical agents were found to be statistically significant [34].

Glioblastoma multiforme (GBM) is the cancer type with the highest mortality rate among brain cancers. In this study, the effects of the bitter melon extract on cell viability, cytotoxicity, and migration capacity in U87G cell line were investigated. In conclusion, it has been reported that bitter melon extract has a cytotoxic and significant anti-proliferative effect on U87G and can be used as a therapeutic agent against GBM [35].

Bitter gourd (MC) has proteins and metabolites in its structure that have hypoglycemic effects and act as anti-tumor and anti-viral agents. In addition, many studies have shown that MC has little or no cytotoxic effect on normal cells. Western blot analysis showed that treatment of glioblastoma cells with MC extract for 24 hours inhibited the protein expression levels of Sparc and Src-1. These results showed that the MC extract has a cytotoxic effect on the U87G cell line and has significant anti-proliferative and anti-invasive properties [36].

Glioblastoma multiforme is the most common brain cancer among central nervous system tumors. In this study, the effect of *Momordica charantia* fruit extract on the proliferation and migration of glioblastoma cells was investigated and it was stated that the cells were treated. The results were suggested to be due to the effect of bitter melon fruit extracts in the inhibition of cell proliferation and migration [37].

#### Studies on ulcer treatment

The antiulcer activity of dried and powdered pomegranate fruits with olive oil, ethanol, chloroform, hexane, and aqueous extracts in rats with experimental peptic ulcers was investigated. It was found that the olive oil extract significantly prevented the formation of gastric ulcers in rats, but the other extracts did not carry significant antiulcer activity [38].

There are two main types of chronic inflammatory bowel diseases: Crohn's Disease (CH), which involves the entire digestive tract from the mouth to the rectum, and ulcerative colite (UC), which only affects the colon. This study, it was aimed to elucidate

the healing effects of bitter melon in the ulcerative colitis model with molecular approaches and it was reported that it could be an alternative method in the treatment of the disease [39].

#### Studies on extraction analysis

For the extraction of bitter melon bioactive compounds, classical solvent, soxhlet, ultrasound, and pressure-assisted extraction methods were applied. The highest amount of charantin was obtained by using ethyl alcohol as a solvent in ultrasound-assisted extraction [40].

Similarly, it was determined that the best solvent (methanol, ethanol, hexane) used for the extraction of ripe and unripe fruits of bitter melon was 41.3% methane [41].

#### Studies on industrial using

Peroxidase enzymes are used in the removal of dyestuffs in industrial wastes. Bitter melon fruit is an important source of peroxidase. In this study, the usability of the peroxidase enzyme purified from bitter melon fruit in Direct Blue 1 dye removal was investigated. It was determined that the hybrid nanoflower form synthesized using raw fruit peroxidase performed the most successful dye removal [42].

In this study, the use of dried medlar and potency pomegranate powders in biscuit production instead of flour was investigated. In sensory evaluation, The examples using the 6% substitution ratio were the most liked by the panelists. It has been shown that medlar and bitter melon powder dried with different techniques can be used as functional food ingredients in the biscuit industry [43].

#### Studies on burn treatment

Sulfadiazine (GSD) is the most commonly used agent in burn wounds. In this study, topical GSD application and bitter melon application were compared in the healing of burn wounds and it was observed that bitter melon treatment reduced PMNL infiltration, collagen discoloration, vascular damage, hair root damage, and glandula sebacea damage, while protecting the number of vessels and epidermis thickness [44].

#### Studies on menopause treatment

In this study, the effects of bitter melon on estrogen receptor ESR1 and ESR2 gene levels and oxidative DNA damage were investigated. In ovariectomized rats, bitter melon fruit extract (KN) was administered for 30 days. This application gave effective results both at the gene level and at the protein level in rats [45].

### Studies on obtaining nanoparticles

To increase the usability of polymeric micro/nanostructures obtained by using maltodextrin, gelatin, and zein polymers in the food industry, the bitter melon extract was used. As a result of this study, it has been reported that better structures can be obtained with the electrospinning method using bitter melon extract and that the particles and fibers obtained can be used to increase the functional properties of foods [46].

### Studies on biotechnology, nanotechnology

There is very little research on the agronomy, breeding, biotechnology, and nanotechnology of the bitter melon plant. More studies should be done on micropropagation, secondary metabolite production, gene transformation, and nanotechnology of this plant, which has a wide ethnobotanical use. The first study on micropropagation started in 2004, gene transformation in 2005, and studies on secondary metabolite production and nanoparticle production started in 2013 [47].

### Studies on *in vitro* micropropagation

In this study conducted for *in vitro* propagation of bitter melon, differences in germination rates were observed between genotypes, *in vitro*, and *in vivo* conditions. Gazipaşa and Silifke genotypes were used. The callus formation ability of leaf and stem explants was investigated. Leaf explants formed more (100%) calli than stem explants. Plants have been successfully acclimatized to external conditions [48].

### Studies on fracture treatment

In this study, the effect of potency pomegranate (MC) on fracture union in rats with tibial shaft fractures was investigated. The results obtained showed that MC could be a promising therapeutic agent for fracture union [49].

### Studies on biological activity

It is extremely important to transform medicinal plants into industrial products. Bitter melon is a medicinal plant with rich bioactive substance content. In this study, antimicrobial, antimutagenic, antifertility, antidiabetic, antioxidant, antilipolytic, hypoglycemic, anticancer, antimicrobial, antiviral, and hepatoprotective activities of bitter melon were investigated [50].

This study was carried out to compare the essential oil contents of potency pomegranate grafted on the pumpkin and ungrafted potency pomegranate. As a result, it was reported that the grafted bitter melons were reshaped in terms of essential oil components in both leaves and fruits [51].

### Studies on Covid19 treatment

The coronavirus epidemic (COVID-19) was declared by the World Health Organization (WHO) on January 30, 2020. Plants are used in the treatment of viral diseases. It has been reported that bitter melon may be useful in the treatment of the coronavirus (SARS-CoV-2) [52].

SARS-CoV-2 is a virus with a very high spread rate. This study showed that the inhibitory activities of bitter melon extracts against the SARS-CoV-2 virus (Karaviloside III) were higher than other methods and FDA drugs [53].

### Conclusion

The source of the information and research presented in this review consists of all scientific studies on the bitter melon plant in Turkey. Kudret pomegranate is a plant that is used by people in Turkey for the treatment of many different diseases. It is more known to be used especially in the treatment of stomach disorders. Further specific studies are needed on the development of this plant, which has great economic importance all over the world, and its production both as a vegetable and as a raw material for medicine.

### Conflict of Interest

I declare no conflict of interest.

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