International Journal of Chinese Medicine
2017; 1(1): 1-9
http://www.sciencepublishinggroup.com/j/ijcm
doi: 10.11648/j.ijcm.20170101.11

A Review of Composition and Health Effects of *Lycium barbarum*

Emine Kocyigit, Nevin Sanlier*

Faculty of Health Sciences, Nutrition and Dietetic Department, Ankara, Turkey

Email address:
nevintekgul@gmail.com (N. Sanlier), kocyigitem@gmail.com (E. Kocyigit)
*Corresponding author

To cite this article:
Emine Kocyigit, Nevin Sanlier. A Review of Composition and Health Effects of *Lycium barbarum*. *International Journal of Chinese Medicine.* Vol. 1, No. 1, 2017, pp. 1-9. doi: 10.11648/j.ijcm.20170101.11

Received: December 24, 2016; **Accepted**: January 5, 2017; **Published**: January 24, 2017

Abstract: *Lycium barbarum* has a radical place in traditional Chinese medicine, also draws attention due to the potential health benefits in recent years. The antioxidant effects of *Lycium barbarum* have been studied in many aspects: as an anti-aging agent, for general health protection, against tumor growth, for the development of the immune system regulatory, to develop vision, and to protect against cancer and diabetes. High amounts of polysaccharide and carotenoid content are the main components of the antioxidant activity. The structure also contains a high percentage of B group vitamins, such as B_1, B_2, B_6, and minerals, such as Fe, Zn, and Cu. Although it is natively grown in China and other Asian countries, it's also cultivated in the Mediterranean countries, North America, and Australia. In this study, the components of *Lycium barbarum*, their properties, and its positive and negative effects on human health are presented.

Keywords: *Lycium barbarum, Lycium barbarum* Polysaccharide, Nutrition, Health Effect

1. Introduction

Lycium barbarum, a type of berry fruits, belongs to *Solanaceae* plant family and it is a functional food [1-3]. *Lycium barbarum* has been widely used as plant and supplement for more than 2000 years in traditional Chinese medicine, and it has been widely cultivated in China, Tibet, and other Asian countries. It is also known as Fruktus Iycii, Gougizi, and Goji berry in China [4]. *Lycium barbarum*, recently known as "wolfberry" in Europe and North America, has been gaining popularity thanks to its vitamin-mineral content (Group B vitamins such as B1, B2, B6, vitamin C, Fe, Zn, Cu etc.) and its high nutritional value. Today *Lycium barbarum* is planted primarily in the Mediterranean countries, as well as in North America and Australia [5].

Lycium barbarum is generally dried and then consumed. When dried, it looks like raisin. It is added to tea, alcoholic beverages, soups, yoghurt, vegetable and meat dishes, rice gruel, and porridge. There is a substantial demand for its juice and jelly in many countries because of its consumption is convenient in these forms. Its harvest period begins in August and lasts till October [2]. The size of *Lycium barbarum* fruits is about 1-2 cm and its color is bright orange-red [3]. Taste and ripening of this fruit are determined by the sugar and organic acids in it. Sugar and organic acids are also important factors in determining the organoleptic properties of the fruit [6]. This fruit has been used for its curative properties in Chinese medicine for more than 2300 years [7]. *Lycium barbarum* is very beneficial for human body with its many positive effects, such as anti-aging, preventing tumor development, regulating immune system, improving visual sense, and protecting against cancer [8]. Researchers have found records of ancient botanists stating that *Lycium barbarum* heals kidneys and increase the luster in eyes, and they have also highlighted that antioxidant activity is the source of these protective effects [8, 9]. Besides its vitamin and mineral content, *Lycium barbarum* is the focus of attention with its polysaccharide, betaine, lutein, and zeaxanthin content [9].

2. Composition of *Lycium barbarum*

Authorities define *Lycium barbarum* as an exotic super food due to its high amount of polysaccharide, vitamin, and carotenoid content [2]. Energy and nutrient content of edible fresh and dried *Lycium barbarum* fruit is given in Table 1.

Table 1. *Energy and nutrients content of edible fresh and dried Lycium barbarum fruit (100 g) [2, 10].*

Energy and nutrients content	Dried	Fresh
Energy (kcal)	349	-
Protein (g)	14.26	4.49
Fat (g)	0.39	2.33
Carbohydrate (g)	77.06	9.12
Pulp (g)	13.0	-
Ca (mg)	190	-
Fe (mg)	6.8	-
Na (mg)	298	-
Vitamin C (mg)	48.4	-
Vitamin A (IU)	26822	-
Thiamin (mg)	-	0.23
Riboflavin (mg)	-	0.33
Niacin (mg)	-	1.7

2.1. Polysaccharides

Approximately 5%-8% of the dry weight of *Lycium barbarum* consists of *Lycium barbarum* polysaccharides or glycoconjugates (LBP) [8]. Besides acidic heteropolysaccharide, polypeptide or protein including complex glycoproteins, it is also known to contain high amount of xylose and glucose, and low amounts of arabinose, rhamnose, mannose, and galactose. LBP also includes galacturonic acid and 18 amino acids. Furthermore, *Lycium barbarum* fruit also includes scopoletin (6-methoxy-7-hydroxycoumarin, also named chrysatropic acid, ecopoletin, gelseminic acid, and scopoletol), vitamin C analog 2-*O*-β-D-glucopyranosyl-L-ascorbic acid, carotenoids (zeaxanthin and β-carotene), betaine, cerebroside, β-sitosterol, flavonoids, amino acids, minerals, and vitamins (in particular, riboflavin, thiamin, and ascorbic acid) [4, 11]. Polysaccharides in *Lycium barbarum* are summarized in Table 2.

Table 2. *Polysaccharide Components Isolated from Lycium barbarum [14].*

Glycoconjugates	Carbohydrate Content (%)	Monosaccharides
LbGp2	90.71	Arabinose, galactose
LbGp3	93.6	Arabinose, galactose
LbGp4	85.6	Arabinose, galactose, Rhamnose, glucose
LbGp5	8.6	Rhamnose, arabinose, Xylose, galactose, mannose, Glucose
LbG5B		Rhamnose, arabinose, Glucose, galactose, Galactose (u)
LBP1a-1		Glucose
LBP1a-2		Glucose
LBP3a-1		GalactoseA
LBP3a-2		GalactoseA
LBP3p	92.4	Galactose, glucose, Rhamnose, arabinose, Mannose, xylose
LBPA1		Heteroglycan
LBPA3		Arabinose, galactose
LBPB1		Arabinose, glucose
LBPC2		Xylose, rhamnose, mannose
LBPC4		Glucose
LBPF1		-

2.2. Carotenoids

Carotenoids are known to have preventive effects against chronical diseases [12]. Carotenoid, the reason of red-orange color of *Lycium barbarum* and the focus of attention as the second essential bioactive component, exists in the dried fruit in approximately 2-4 mg per gram by weight (8, 13). Zeaxanthin dipalmitate comprises the 56% of the total carotenoid amount in the fruit. *Lycium barbarum* also contains β-cryptoxanthin palmitate, zeaxanthin monopalmitate, and low amounts of free zeaxanthin and β-carotene. High amounts of dipalmitates and the higher bioavailability of esterified zeaxanthin (1143.7 μg/g dried fruit) compared to free carotenoid make this fruit unique among other fruits [13].

2.3. Other Components

Lycium barbarum contains small molecules and various vitamins in its structure, such as p-coumaric acid [8]. Fruits contain 18 types of amino acids, 8 of which are essential amino acids, such as isoleucine and tryptophan. It is also the source of 21 trace minerals including zinc, iron, copper, calcium, selenium, and phosphor, and also thiamin (B_1), riboflavin (B_2), pyridoxine (B_6), vitamin E, and vitamin C [15].

In a study on *Lycium barbarum* fruit produced in 3

different regions of China, iron, manganese, copper, chrome, lead, and cadmium contents were analyzed, and the samples were detected to contain approximately 110 mg/kg Zn, 67 mg/kg Fe, 8.3 mg/kg Cu, 5.94 mg/kg Mn, 0.4 mg/kg Cr, <0.1 mg/kg Pb, and <0.01 mg/kg Cd. The supplement rate of 20 g dried *Lycium barbarum* was estimated for the required daily intake amount for adult females and males according to dietary reference intakes (DRI). It was found that iron, manganese, zinc, and copper are respectively supplied in 7.44%, 6.23%, 27.5%, 18.44%, 32% for women, and 16.25%, 5.26%, 25%, 18.44%, 22.86% for men [16].

3. Health Effects of *Lycium barbarum*

The fast increase in the development of various diseases brings along an increasing attention to preventive and curative foods. Food analyses as well as clinical and epidemiological studies focus on researching nutritional sources beneficial for organism [17-19]. Thanks to its countless various positive effects on health as stated above, *Lycium barbarum* has recently taken its place among the most researched herbal nutritional sources [20]. Positive health effects of *Lycium barbarum* are summarized in Fig. 1.

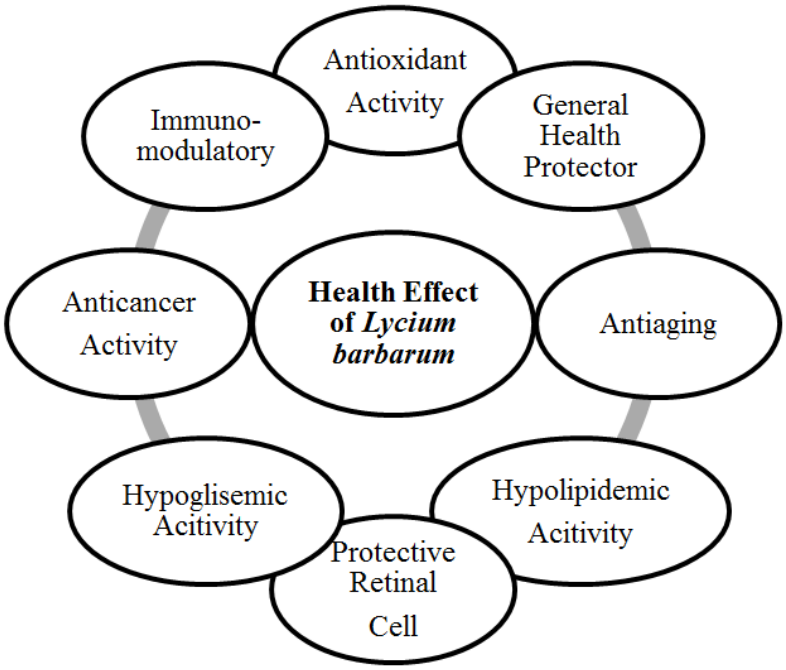


Figure 1. *Health Effects of Lycium barbarum.*

3.1. Antioxidant Activity

Lycium barbarum displays scavenging activity against free radicals in human body, such as superoxide anions and hydroxyl radicals [21]. The fruit has these properties thanks to the carotenoid pigments, flavonoids, polysaccharide fractions and 2-O-β-D-glucopyranosyl-L, a vitamin C analogue, in its structure [17]. Oxygen Radical Absorption Capacity (ORAC) is a method to examine the antioxidant capacity of nutrition, and in this method, this capacity is evaluated with respect to the inhibition degrees of peroxide radicals. However, these values are independent from the metabolism and absorption events of the organism [22]. ORAC values of some berry fruits are illustrated in Fig. 2.

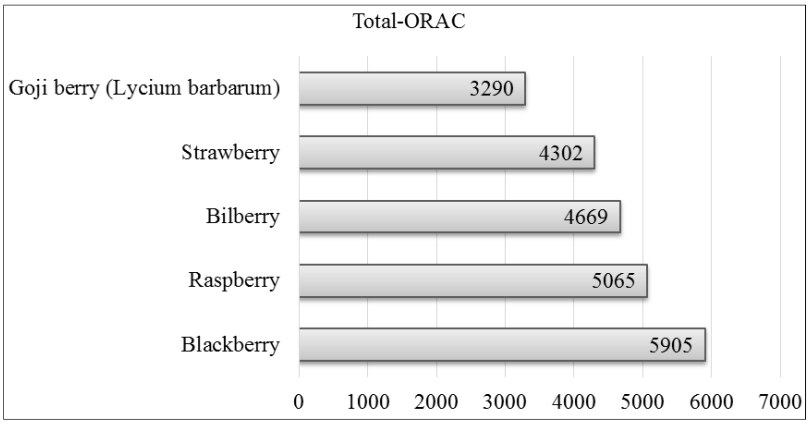


Figure 2. *Oxygen Radical Absorption Capacity (22).*

Alternative reagents used in determining the antioxidant capacity are composed of glutathione related enzymes (e.g., glutathione peroxidase (GSH-Px)), superoxide dismutase (SOD), DNA oxidation, and, as an indicator of the changes in prostaglandin levels and lipid peroxidation, malondialdehyde (MDA), and other determinants. In a placebo-controlled, randomized double-blind study, 50 male and female individuals between 55 and 72 were separated into two different groups, and then, for 30 days, one group was given 120 mL *Lycium barbarum* juice, while the other group was given placebo. A positive correlation was found between the consumption of *Lycium barbarum* juice and GSH-Px, SOD, and MDA levels [23].

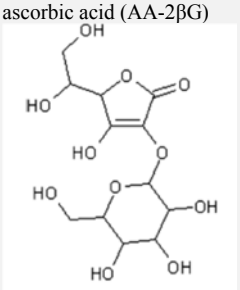
In another study conducted with rats, LBP extract in different amounts was administered to diabetic rats for 30 days (0 mg/kg, 50 mg/kg, 100 mg/kg, 200 mg/kg); hence, a decrease in the plasma insulin levels of diabetic rats and an increase in SOD activity and MDA levels were observed; furthermore, it was highlighted that LBP could be used as an anti-hyperglycemic agent [24]. In studies conducted with rats fed on high-fat diet, the effects of LBP on blood glucose, blood lipids, and oxidative stress were examined; as a result, it was observed that LBP significantly reduced the LDL-C (low density lipoprotein cholesterol), total cholesterol, triacylglycerol, blood glucose, and thiobarbituric acid reactive substance levels, while SOD, GSH-Px, and catalase (CAT) enzyme activities increased [25, 26].

3.2. Immunomodulatory and Anticancer Activity

Substances in Lycium barbarum display anti-proliferative and pro-apoptotic activity against cancer. This fruit also has an immune functions stimulating property [17]. It also has a preventive role against possible side effects of chemotherapy and radiotherapy. It has been stated that Lycium barbarum earns these properties with isolated Lycium barbarum polysaccharides (LBP), scopoletin (6-metoxy-7-hydrocumarine), 2-O-β-D-glucopyranosyl-L-ascorbic acid, and countless active components in its structure [27]. It was shown that *Lycium barbarum* extracts prepared in high doses (≥5 g/L) stimulate p53 protein, and thus, mediate for the apoptosis of hepatocellular carcinoma cells [28]. Another study showed that *Lycium barbarum* polysaccharides inhibit the proliferation of cervical carcinoma cells. It was reported that in the carcinoma cells to which LBP is applied, the mitochondrial transmembrane potential decreases and the entrance of Ca^{2+} ions into cells are enabled [29]. In a study conducted by Mao et al., it was found that *Lycium barbarum* polysaccharides applied to SW480 and Caco-2 cells for 8 days in the amounts ranging between 100–1000 mg/L inhibit the activity of colon cancer cells depending on dose increase. It was reported that the development of cancer cells are prevented in the G_0/G_1 phase, which is an important result of this study [30].

In another study in which healthy individuals (n=150) were given milk-based *Lycium barbarum* formulation (530 mg/g *Lycium barbarum*, 290 mg/g milk) and placebo for 3 months, and thus immune reaction against influenza vaccine was analyzed, it was observed that serum immunoglobulin G levels significantly decreased without any observed side effect in the group that received this formulation between 30 and 90 days [31]. In another study conducted with healthy adults (n=60), participants were given *Lycium barbarum* juice (120 mL) and placebo; as a result, it was reported that lymphocyte, interleukin-2, and immunoglobulin G levels of the group given *Lycium barbarum* juice increased without any side effect [32]. In another study, rats exposed to ionizing radiation were given different amounts of LBP (50 mg/kg, 100 mg/kg, 200 mg/kg) and when the bone marrow mononuclear cells of these rats, which were killed on the days 1, 7, and 14, were analyzed, it was observed that LBP significantly reduced the percentage of G_0/G_1 phase, apoptosis, MDA levels, and CD44 and CD49d expressions, while increasing the SOD activity [33]. Anticancer activity displaying *Lycium barbarum* components and molecular formulae are provided in Table 3.

Table 3. *Anticancer Activity Displaying Lycium barbarum Components and Molecular Formulae [28].*

Classification	Component	Molecular Formula
Proteoglycans	*Lycium barbarum* polysaccharides (LBP)	
Phytoalexin	Scopoletin	$C_{10}H_8O_4$
Vitamin C analogue	2-O-β-D-Glucopyranosyl-L-ascorbic acid (AA-2βG) 	$C_{12}H_{18}O_{11}$

3.3. Hypoglycemic and Hypolipidemic Effect

While 4% of the world population suffers from diabetes, it has been reported that this rate will reach up to 5.4% by 2025 [34]. Apart from exercise, diet, and medical treatments, antidiabetic herbs have also been a focus of attention recently. It is stated that there are more than 400 plants known to reduce blood glucose level and also 100 polysaccharides that display hypoglycemic activity. *L. barbarum* is also listed among plants having hypoglycemic and hypolipidemic activity with polysaccharides in its structure [35].

In a study conducted with 40 diabetic rats, rats were fed on a high-fat diet and separated into 5 groups (n=8) (control group, 100 mg/kg LBP administered group, and 50, 100, 200 mg/kg LBP IV administered group). HbA1c, blood glucose, triglyceride, total cholesterol, and LDL-C levels of rats that were treated with LBP (100 mg/kg) and LBP IV (200, 100, 50 mg/kg) extract significantly decreased compared to the diabetic control group. As a result of this study, it was

reported that *Lycium barbarum* and LBP isolated from *Lycium barbarum* can be used as an antidiabetic agent [36].

In another study, 35 rabbits that had developed hyperlipidemia and hyperglycemia through alloxan injection were given *Lycium barbarum* juice extract (0.25 g/kg/day), crude LBP (10 mg/kg/day), and LBP X (10 mg/kg/day), while the control group was given only saline solution. It was stated that there was a significant decrease in the blood glucose, serum total cholesterol, and triglyceride levels of the rats which were given LBP-X, a fraction of crude LBP, and isolated polysaccharide, and at the same time there was an increase in the HDL-C (high density lipoprotein cholesterol) levels [37].

In another study conducted with rats, rats (n=50) were separated into two groups as experimental and control. The experimental group was also separated into sub-groups according to the amount of LBP infusion administered (100 mg/kg, 200 mg/kg, and 300 mg/kg) and this group was fed on a high-fat diet. At the end of this 30-day treatment, it was found that there was a decrease in TG, LDL-C, triacylglycerol and glucose levels, but an increase in HDL-C levels of the experimental group depending on dose [38].

In a study conducted with 67 individuals with type 2 diabetes, the experimental group was given 300 mg/day LBP isolated from fruit for 3 months, and, as a result, it was reported that there was a significant decrease in postprandial glucose and TNF-α levels, and an increase in HDL-C levels at the same time [38]. In a study in which the experimental group was consisted of rats fed on a high-fat diet (n=56), rats were given different amounts of LBP (100 mg/kg, 250 mg/kg, 500 mg/kg) while the control group was only given saline. It was stated that LBP inhibited albuminuria, blood urea nitrogen concentration, and IL-2, IL-6, TNF-α, IFN-α, MCP-1, and ICAM-1 levels, while increasing SOD and GSH-Px activity and also inhibiting phosphor-nuclear factor kappa B (NF-κB) expression in renal tissues [39].

3.4. Preventive Effects on Retina Cells

Lycium barbarum extracts have a preventive function in the early phase of retina degeneration. *Lycium barbarum*, with zeaxanthin and luteolin, which are the carotenoids absorbing the light, contributes to the inhibition of neuron apoptosis, and plays a preventive role for the nerve cells in the retina [17]. In a study examining the effects of *Lycium barbarum* on the nerve cells in retina, it was found that caspase-2 enzyme activity, responsible for retina apoptosis, of the experimental group, which was given 1 mg/kg *Lycium barbarum* extract, significantly decreased on day 25 compared to the control group [40].

It was reported that when rats are given *Lycium barbarum* orally, there is a decrease in intraocular pressure and retina cell loss. It is considered that this effect is due to the light absorption feature of zeaxanthin [8].

3.5. Effects on General Health, Aging, and Weight Loss

Studies in recent years have shown that daily *Lycium barbarum* juice consumption (GoChi 120 mL=150 g fresh fruit) in the menstrual period improves the general health condition, neurological / psychological condition, and cardiovascular, joint/muscle functions, and gastrointestinal regulation at the end days 14 or 30 without any side effect [41]. It is also pointed out that, with the use of *Lycium barbarum,* there is an improvement in energy levels, athletic performance, sleep quality, stress, emotional status, and happiness, and a decrease in headache, depression, back pain, concentration impairment, and malaise [41, 42].

In another study in which the effect of *Lycium barbarum* juice in 35 individuals (n= 17 treatment group, n=18 placebo control group) was researched, participants were given GoChi for 14 days and the affected parameters were analyzed on day 15. It was found that athletic performance, sleep quality, and concentration power of the group given GoChi improved. While 70% of the treatment group stated that they could wake up easily, their mental sensitivity and concentration power improved, 50%-60% of the participants stated that they felt healthier and happier, 50% of participants stated that they felt less tired and more energetic on the days they consumed juice [43]. It is accepted that the accumulation of oxidative stress factors accelerates the aging process. *Lycium barbarum* displays its anti-aging effect by behaving like toxic agent against free radicals [44]. It is also stated that there is a decrease in the AGE serum levels, end products of advanced glycations, and an increase in the improvement of motor and cognitive activities and erythrocyte SOD levels in the rats fed with 100 mg/kg per day *Lycium barbarum* polysaccharides. It is stated that there is a decrease in the plasma triglyceride levels and an increase in plasma cAMP and SOD levels in humans administered 500 mg *Lycium barbarum* in total within a 10-day period of diet. Consumption of *Lycium barbarum* is also reported to have a positive effect on the prevention and treatment of geriatric-related diseases [45]. In another study, 29 individuals were separated into experimental and control groups; the experimental group was given 120 mL *Lycium barbarum* juice for 14 days while the control group was given placebo with the same color and taste with *Lycium barbarum* juice (a mixture made by mixing 10 mg sucralose, 30 mg artificial fruit flavor, 60 mg citric acid, and 12 mg caramel dye to 30 mL pure water). At the end of the study, it was observed that fruit juice, along with exercise and diet, leads to reduction in waist circumference and thus in central obesity, while increasing resting metabolic rate and energy expenditure [46]. In another study, the experimental group (n=81) was given 120 mL *Lycium barbarum* juice (GoChi) for 30 days; as a result, it was observed that sleep quality, concentration power, and mental activities of the participants increased, while stress and the sense of weakness decreased [47]. Another study found that, thanks to flavonoids in its structure, *Lycium barbarum* can be used as an antibacterial agent against Gram (+) and Gram (-) bacteria [48].

4. *Lycium barbarum* and Allergenicity

Along with its effects on geriatric-related diseases, *Lycium*

barbarum also is a focus of attention due to the side effects occurring with its sole use or with medicament [49].

In a study, skin prick test was administered to two individuals who were observed to show allergic reaction after the consumption of *Lycium barbarum* juice and their IgE levels were checked. While the first individual was observed to develop anaphylaxis and urticaria on hands, palms, and soles, the second individual was observed to have symptoms of urticaria, itch, and dysphagia on the whole body in general. It was stated that IgE levels increased in both individuals. Lipid transfer proteins are considered to cause the allergic sensitivity against *Lycium barbarum* [50].

Warfarin, the most frequently prescribed medicine as an anticoagulant in the USA, is known to interact with many plants, supplements, and foods [51]. The INR value (international normalized ratio) of a 71-year old female in whom 1.5 mg/day warfarin treatment was administered for 15 days after the knee surgery was measured as 1.7-2.4 (target 2-3). Then, it was observed that the female, who, thinking that it would purify her body, consumed 60 mL *Lycium barbarum* juice in total in the mornings and evenings for 4 days, developed rectal bleeding, bruising, and epistaxis at the end of day 4. *Lycium barbarum* and warfarin interaction has been claimed to be the cause of this incident. Even though its pharmacokinetic mechanism has not been clarified yet, it is pointed out that *Lycium barbarum* would be dangerous with medicament, and thus, further studies are required on this issue [52]. Recent studies on *Lycium barbarum* are provided in Table 4.

Table 4. *Summary of the Recent Leading Studies on Lycium barbarum.*

Reference	Scope of the Study	Duration of the Study	Relationship with
Du *et a*l., 2016	64 rats	> 4 weeks	Decrease in albuminuria, blood urea nitrogen concentration and IL-2, IL-6, TNF-α, IFN-α, MCP-1 and ICAM-1 levels; increase in SOD and GSH-Px activity and inhibition of NF-κB expression in renal tissues
Zhou *et al*., 2016	30 rats	14 days	Decrease in G_0/G_1 phase rates, apoptosis, MDA levels and CD44 and CD49d expression; increase in SOD activity in the marrow mononuclear cells of the rats killed on the 1., 7., and 14. days with different amounts of LBP
Cai *et al*., 2015	67 individuals with Type 2 diabetes	3 months	Decrease in postprandial glucose and TNF-α levels; increase in HDL-C levels with LBP consumption isolated from fruit
Zhao *et a*l., 2015	40 diabetic rats	> 6 weeks	Decrease in HbA1c, blood glucose, trigliserit, total cholesterol and LDL-C levels with LBP and LBP-IV extract treatment
Zhu and Zhang, 2013	Cervical carcinoma cells	2., 4., 6. days	Inhibition in the proliferation of cervical carcinoma cells with LBP application
Hsu *et al*., 2012	81 adults	30 days	Increase in sleep quality, concentration power, mental activity and healthy-feeling; decrease in stress and sense of weakness with juice consumption
Ni *et al*., 2012	40 rats	50 days in total	Decrease in the caspase-2 enzyme activity, responsible for retina apoptosis, with *L. barbarum* extract
Rivera *et al*., 2012	1 adults	<1 week	Development of rectal bleeding, bruising and nasal bleeding in an individual who has consumed juice with Warfarin treatment
Vidal *et al*., 2012	150 healthy individuals	3 months	Increase in immune reaction against influenza vaccine with milk based *Lycium barbarum* formulation
Amagase and Nance, 2011	29 adults	14 days	Reduction in waist circumference and central obesity with juice consumption and exercise and diet; increase in resting metabolic rate and energy expenditure
Ballarin *et al*., 2011	2 adults	<24 hours	Increase in IgE with fruit consumption
Cui *et al*., 2011	50 rats	30 days	Decrease in serum TG LDL-C, triacylglycerol and glucose levels, increase in HDL-C levels depending on dose with LBP infusion
Mao *et al*., 2011	SW480 and Caco-2 cells	8 days	Decrease in the activity of colon cancer cells and halt of cancer cells in G0/G1 phase with LBP application depending on dose
Wu *et al*., 2010 Ming *et al*., 2009	50 rats	2 months	Decrease in LDL-C, total cholesterol, triacylglycerol, blood glucose and thiobarbituric acid reactive substance levels; increase in SOD, GSH-Px and CAT activity with LBP application to rats fed on high-fat diet
Amagese, Sun and Borek, 2009	50 adults	30 days	Increase in GSH-Px, SOD and MDA levels with 120 mL *Lycium barbarum* juice
Amagese, Sun and Nance, 2009	60 healthy individuals	30 days	Increase in lymphocyte, interleukin-2 and immunoglobulin G levels with *Lycium barbarum* juice consumption
Amagase and Nance, 2008b	35 adults	14 days	Waking up easily, improvement in mental sensitivity, increase in concentration power and healthy, happy and energetic feelings; decrease in tiredness with fruit juice

5. Safe Intake Amount of *Lycium barbarum*

Considering the studies conducted in humans, it has been stated that 120 mL *Lycium barbarum* juice contains approximately the same amount of *Lycium barbarum* with 150 g fresh *Lycium barbarum* fruit. No toxic effect has been observed with fresh fruit or fruit juice consumption in healthy individuals. However, it is known to cause side effects in individuals with allergic sensitivity and in those who take Warfarin [8]. Although the safe intake amount has not been determined yet, ancient Chinese sources indicate that they

consumed 6-15 g/day fruit [53]. Individuals under medical treatment and with sensitivity to foods in the same family with *Lycium barbarum* such as tomatoes and eggplants should consume this fruit carefully. In 2006, FDA (Food and Drug Administration) banned the indication of products with *Lycium barbarum* contents as medicament or curative products. Furthermore, *Lycium barbarum* does not take place in GRAS (Generally Recognized as Safe) list of FDA.

6. Conclusion and Suggestions

Lycium barbarum has a long attitude of usage in nutirition and pharmaceutical in East Asian Countries. It is difficult to deduce a certain conclusion about clinical effects of *Lycium barbarum* very, which, with its nutritive and curative properties. It is, on the other hand, worth attention that the components isolated from this fruit can be used for the prevention of aging-related conditions, and the treatment of geriatric-related diseases.

Many products with such names as *Himalaya Lycium barbarum* or *Tibet Lycium barbarum* are on the shelves of markets all around the world. Commercial products are not limited to juices and beverages only, cookies, chocolates, mueslis, soups, and sauces with *Lycium barbarum* content have also been produced. Regarding the various products found on the food market, there are no scientific evidences to defend the claims made for products as a magical for well-being. People using anticoagulant and having allergic sensitivity should be careful with *Lycium barbarum* consumption to potential risk of drug interaciton.

It has been proven that *Lycium barbarum* has these positive effects on health including antiaging, antioxidant, anticancer, immunomodulating, hypolipidemic, and hypoglisemic thanks to the polysaccharides (LBP), zeaxanthin and other vitamin C analogue components displaying biological activity. More studies are needed to interpret detailed mechanisms of these diverse actions. Properly arranged long term extract studies in animals and humans are demanded in order to reach certain conclusions.

References

[1] Lasekan O. Exotic berries as a functional food. Current Opinion in Clinical Nutrition & Metabolic Care 2014; 17 (6): 589-595.

[2] Zhang J. Antioxidant properties of goji berry. Doctoral dissertation, Wayne State Unıversity, 2013.

[3] Bruno G. BACKGROUND & TRADITIONAL USE Goji, 2009.

[4] Cheng J, Zhou ZW, Sheng HP, He LJ, Fan XW, He ZX, Sun T, Zhang X, Zhao RJ, Gu L, et al. An evidencebased update on the pharmacological activities and possible molecular targets of *Lycium barbarum* polysaccharides. Drug design, development and therapy 2015; 9: 33-78.

[5] Potterat OG. Phytochemistry, pharmacology and safety in the perspective of traditional uses and recent popularity. Planta Med 2010; 76 (1): 719.

[6] Mikulic-Petkovsek M, Schmitzer V, Slatnar A, Stampar F, Veberic R. Composition of sugars, organic acids, and total phenolics in 25 wild or cultivated berry species. Journal of food science 2012; 77 (10): C1064-C1070.

[7] Sze SCW, Song JX, Wong RNS, Feng YB, Ng TB, Tong Y, Zhang KYB. Application of SCAR (sequence characterized amplified region) analysis to authenticate *Lycium barbarum* (wolfberry) and its adulterants. Biotechnology and Applied Biochemistry 2008; 51: 15-21.

[8] Redgwell RJ, Curti D, Wang J, Dobruchowska JM, Gerwig GJ, Kamerling JP, Bucheli P. Cell wall polysaccharides of Chinese Wolfberry (*Lycium barbarum*): Part 1. Characterisation of soluble and insoluble polymer fractions. Carbohydrate Polymers 2011; 84 (4): 1344-1349.

[9] Endes Z, Uslu N, Özcan MM, Er F. Physicochemical properties, fatty acid composition and mineral contents of lycium barbarum (*Lycium barbarum L.*) fruit. Journal of Agroalimentary Processes and Technologies 2015; 21: 36-40.

[10] United States Department of Agriculture (USDA). Nutrient Database [Internet]. [cited 2016 Mar 3]. Available from: https://ndb.nal.usda.gov/ndb/foods/show/2221?format=Full&reportfmt=pdf&pdfQvs=%7B%7D.

[11] Tian M, Wang M. Studies on extraction, isolation and composition of Lycium barbarum polysaccharides. Zhongguo Zhong yao za zhi=Zhongguo zhongyao zazhi= China journal of Chinese materia medica 2006; 31 (19): 1603-1607.

[12] Wang CC, Chang SC, Inbaraj BS, Chen BH. Isolation of carotenoids, flavonoids and polysaccharides from Lycium barbarum L. and evaluation of antioxidant activity. Food Chemistry 2010; 120 (1): 184-192.

[13] Hua Ji, Hui He, Dingbo Lin. Dietary Wolfberry and Retinal Degeneration. In: Preedy VR, editor. Handbook of Nutrition, Diet and the Eye. Cambridge (England): Massachusetts Academic Press; 2014. p. 465-472.

[14] Wang Y, Chen H, Wu M, Zeng S, Liu Y, Dong J. Chemical and Genetic Diversity of Wolfberry. In: Chang RCC, So KF, editors. Lycium Barbarum and Human Health. London (England): Springer; 2015. p. 126.

[15] Yin G, Dang Y. Optimization of extraction technology of the *Lycium barbarum* polysaccharides by Box–Behnken statistical design. Carbohydrate Polymers 2008; 74 (3): 603-610.

[16] Gogoasa I, Alda L, Rada M, Negrea P, Negrea A, Bordean DM, Draghici GA, Gergen I. Goji berries (*Lycium barbarum*) as a source of trace elements in human nutrition. Journal of Agroalimentary Processes and Technologies 2014; 20 (4): 369-372.

[17] Kulczyński B, Gramza-Michałowska A. Goji berry (*Lycium barbarum*): Composition and Health Effects–a Review. Polish Journal of Food and Nutrition Sciences 2016; 66 (2): 67-75.

[18] Ahmad SR, Gokulakrishnan P, Giriprasad R, Yatoo MA. Fruitbased natural antioxidants in meat and meat products: A review. Critical reviews in food science and nutrition 2015; 55 (11): 1503-1513.

[19] Kmiecik D, Korczak J, Rudzińska M, Gramza-Michałowska A, Hęś M, Kobus-Cisowska J. Stabilisation of phytosterols by natural and synthetic antioxidants in high temperature conditions. Food chemistry 2015; 173: 966-971.

[20] Jabbar S, Abid M, Zeng X. Nutritional, Phytochemical Characterization and Antioxidant Capacity of Ningxia Wolfberry (Lycium barbarum L.). Journal of the Chemical Society of Pakistan 2014; 36 (6): 1079-1087.

[21] Yang X, Bai H, Cai W, Li J, Zhou Q, Wang Y, Han J, Zhu X, Dong M, Hu D. *Lycium barbarum* polysaccharides reduce intestinal ischemia/reperfusion injuries in rats. Chemicobiological interactions 2013; 204 (3): 166-172.

[22] Haytowitz DB, Bhagwat S. Database for the oxygen radical absorbance capacity (ORAC) of selected foods, Release 2. Washington (DC): US Department of Agriculture; 2010.

[23] Amagase H, Sun B, Borek C. *Lycium barbarum* (goji) juice improves in vivo antioxidant biomarkers in serum of healthy adults. Nutrition Research 2009; 29 (1): 19-25.

[24] Li XM. Protective effect of *Lycium barbarum* polysaccharides on streptozotocininduced oxidative stress in rats. International journal of biological macromolecules 2007; 40 (5): 461-465.

[25] Wu HT, He XJ, Hong YK, Ma T, Xu YP, Li HH. Chemical characterization of lycium barbarum polysaccharides and its inhibition against liver oxidative injury of highfat mice. International journal of biological macromolecules 2010; 46 (5): 540-543.

[26] Ming M, Guanhua L, Zhanhai Y, Guang C, Xuan Z. Effect of the *Lycium barbarum* polysaccharides administration on blood lipid metabolism and oxidative stress of mice fed highfat diet in vivo. Food Chemistry 2009; 113 (4): 872-877.

[27] Tang WM, Chan E, Kwok CY, Lee YK, Wu JH, Wan CW, Chan RYK, Yu PHF, Chan SW. A review of the anticancer and immunomodulatory effects of *Lycium barbarum* fruit. Inflammopharmacology 2012; 20 (6): 307-314.

[28] Chao JC, Chiang SW, Wang CC, Tsai YH, Wu MS. Hot waterextracted *Lycium barbarum* and *Rehmannia glutinosa* inhibit proliferation and induce apoptosis of hepatocellular carcinoma cells. World Journal of Gastroenterol 2006; 12 (28)*:* 447-884.

[29] Zhu CP, Zhang SH. *Lycium barbarum* polysaccharide inhibits the proliferation of HeLa cells by inducing apoptosis, Journal of the Science of Food and Agriculture 2013; 93 (1): 149-156.

[30] Mao F, Xiao B, Jiang Z, Zhao J, Huang X, Guo J. Anticancer effect of *Lycium barbarum* polysaccharides on colon cancer cells involves G0/G1 phase arrest. Medical Oncology 2011; 28 (1): 121-126.

[31] Vidal K, Bucheli P, Gao Q, Moulin J, Shen LS, Wang J, Blum S, Benyacoub J. Immunomodulatory effects of dietary supplementation with a milkbased wolfberry formulation in healthy elderly: a randomized, doubleblind, placebocontrolled trial. Rejuvenation research 2012; 15 (1): 89-97.

[32] Amagase H, Sun B, Nance DM. Immunomodulatory effects of a standardized *Lycium barbarum* fruit juice in Chinese older healthy human subjects. Journal of medicinal food 2009; 12 (5): 1159-1165.

[33] Zhou J, Pang H, Li W, Liu Q, Xu L, Liu Q, Liu Y. Effects of *Lycium barbarum* Polysaccharides on Apoptosis, Cellular Adhesion, and Oxidative Damage in Bone Marrow Mononuclear Cells of Mice Exposed to Ionizing Radiation Injury. BioMed Research International 2016; 2016: 18.

[34] Jin M, Huang Q, Zhao K, Shang P. Biological activities and potential health benefit effects of polysaccharides isolated from *Lycium barbarum* L. International journal of biological macromolecules 2013; 54: 16-23.

[35] Luo Q, Cai, Y, Yan J, Sun M, Corke H. Hypoglycemic and hypolipidemic effects and antioxidant activity of fruit extracts from Lycium barbarum. Life Sciences 2004; 76 (2): 137-149.

[36] Zhao R, Jin R, Chen Y, Han FM. Hypoglycemic and Hypolipidemic Effects of *Lycium barbarum* Polysaccharide in Diabetic Rats. Chinese Herbal Medicines 2015; 7: 310-315.

[37] Cui B, Liu S, Lin X, Wang J, Li S, Wang Q, Li S. Effects of *Lycium barbarum* aqueous and ethanol extracts on highfatdiet induced oxidative stress in rat liver tissue. Molecules 2011; 16 (11): 9116-9128.

[38] Cai H, Liu F, Zuo P, Huang G, Song Z, Wang T, Lu H, Guo F, Han C, Sun G. Practical Application of Antidiabetic Efficacy of Lycium barbarum Polysaccharide in Patients with Type 2 Diabetes. Medicinal Chemistry (Shariqah (United Arab Emirates) 2015; 11 (4): 383-390.

[39] Du M, Hu X, Kou L, Zhang B, Zhang C. *Lycium barbarum* Polysaccharide Mediated the Antidiabetic and Antinephritic Effects in DietStreptozotocinInduced Diabetic Sprague Dawley Rats via Regulation of NFκB. BioMed Research International 2016; 2016: 19.

[40] Ni T, Wei G, Yin X, Liu X, Liu D. Neuroprotective effect of *Lycium barbarum* on retina of Royal College of Surgeons (RCS) rats: a preliminary study. Folia Neuropathologica 2013; 51 (2): 158-163.

[41] Amagase H, Hsu CHP. Metaanalysis of the general effects of a standardized Lycium barbarum fruit juice shown in randomized, doubleblind, placebocontrolled human clinical studies. The FASEB Journal 2009; 23 (1 Supplement): 71-61.

[42] Amagase H, Nance DM. Improvement of sleep quality by a standardized Lycium barbarum fruit juice shown in a randomized, doubleblind, placebocontrolled human clinical study, Planta Medica 2008a; 74 (9)*:* PH18.

[43] Amagase H, Nance DM. A randomized, doubleblind, placebocontrolled, clinical study of the general effects of a standardized *Lycium barbarum* (goji) juice, GoChi™. The Journal of Alternative and Complementary Medicine 2008b; 14 (4): 403-412.

[44] Amagase H, Farnsworth NR. A review of botanical characteristics, phytochemistry, clinical relevance in efficacy and safety of *Lycium barbarum* fruit (Goji). Food Research International 2011; 44 (7): 1702-1717.

[45] Chang RCC, So KF. Use of antiaging herbal medicine, *Lycium barbarum*, against agingassociated diseases. What do we know so far?, Cellular and Molecular Neurobiology 2008; 28 (5)*:* 643-652.

[46] Amagase H, Nance DM. *Lycium barbarum* increases caloric expenditure and decreases waist circumference in healthy overweight men and women: pilot study. Journal of the American College of Nutrition 2011; 30 (5): 304-309.

[47] Hsu CH, Nance DM, Amagase H. A metaanalysis of clinical improvements of general wellbeing by a standardized *Lycium barbarum*. Journal of medicinal food 2012; 15 (11): 1006-1014.

[48] Mocan A, Vlase L, Vodnar DC, Bischin C, Hanganu D, Gheldiu AM, Oprean R, Silaghi-Dumitrescu R, Crişan G. Polyphenolic content, antioxidant and antimicrobial activities of *Lycium barbarum* L. and *Lycium chinense* Mill. Leaves. Molecules 2014; 19 (7): 10056-10073.

[49] Carnés J, de Larramendi CH, Ferrer A, Huertas AJ, López-Matas MA, Pagán JA, Navarro LA, García-Abujeta JL, Vicario S, Peña M. Recently introduced foods as new allergenic sources: sensitisation to Goji berries (*Lycium barbarum*), Food chemistry 2013; 137 (1): 130-135.

[50] Ballarín SM, Lopez-Matas MA, Abad DS, Pérez-Cinto N, Carnés J. Anaphylaxis associated with the ingestion of Goji berries (*Lycium barbarum*). Journal of Investigational Allergology and Clinical Immunology 2011; 21: 567-570.

[51] Chua YT, Ang XL, Zhong XM, Khoo KS. Interaction between warfarin and Chinese herbal medicines. Singapore medical journal 2015; 56: 11-18.

[52] Rivera CA, Ferro CL, Bursua AJ, Gerber BS. Probable interaction between *Lycium barbarum* (goji) and warfarin. Pharmacotherapy: The Journal of Human Pharmacology and Drug Therapy 2012; 32: e50-e53.

[53] Ulbricht C, Bryan JK, Costa D, Culwell S, Giese N, Isaac R, Nummy K, Pham T, Papp C, Rusie E. An evidencebased systematic review of Goji (*Lycium* spp.) by the Natural Standard Research Collaboration. Journal of dietary supplements 2015; 12: 184-240.