A review of Goji berry (*Lycium barbarum*) in Traditional Chinese medicine as a promising organic superfood and superfruit in modern industry

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ABSTRACT

Traditional Chinese Medicine (TCM) has been used for thousands of years by different generations in China and other Asian countries as foods to promote good health and as drugs to treat disease. Goji berry (*Lycium barbarum*), as a Chinese traditional herb and food supplement, contains many nutrients and phytochemicals, such as polysaccharides, scopoletin, the glucosylated precursor, amino acids, flavonoids, carotenoids, vitamins and minerals. It has positive effects on anticancer, antioxidant activities, retinal function preservation, anti-diabetes, immune function and anti-fatigue. Widely used in traditional Chinese medicine, Goji berries can be sold as a dietary supplement or classified as nutraceutical food due to their long and safe traditional use. Modern Goji pharmacological actions improve function and enhance the body's ability to adapt to a variety of noxious stimuli; it significantly inhibits the generation and spread of cancer cells and can improve eyesight and increase reserves of muscle and liver glycogens which may increase human energy and has anti-fatigue effect. Goji berries may improve brain function and enhance learning and memory. It may boost the body's adaptive defences, and significantly reduce the levels of serum cholesterol and triglyceride, it may help weight loss and obesity and treats chronic hepatitis and cirrhosis. At present, they are considered functional food with many beneficial effects, which is why they have become more popular recently, especially in Europe, North America and Australia, as they are considered as superfood with highly nutritive and antioxidant properties. Geographical origin of Goji berries is one of the most important quality parameters in TCM since the differences in climate, soil, and cultivation methods cause differences in the chemical composition of the plants. Goji berry has huge health benefits that attract good international markets. It is as known as the super fruit and super food in TCM for the claimed health benefits and it should be part of daily diet.

Key words: Goji berry, TCM, superfood, superfruit.

INTRODUCTION

Goji berry and its cultivation in China and other parts of the world

Goji, which is also called wolfberry has been used as traditional medicinal foods in China and other Asian countries for centuries (Potterat, 2010). They are very hard, spiny, shrubby vines in the tomato-nightshade family Solanaceae. Goji berry has different vernacular names; the most common name, wolfberry, comes from the character “gou” as it is related to the one that means wolf. The name goji is an extrapolation of a number of native words, and it was originally coined in 1973 by researchers at the Tanaduk Botanical Research Institute (TBRI) (Amagase and Farnsworth, 2011). Goji plants are native to China, where
they are grown from the subtropics in the south to the cold, dry climate on Inner Mongolia. Commercial fruit production is concentrated near Inner Mongolia. The fruit are red like a tomato, with a green calyx near the stem. Seeds are small and edible, similar to tomato seeds. The flowers open a purple colour which fades to yellow (CPC, 2010; Amagase and Farnsworth, 2011; Amagase, 2014). It has been observed that geographical origin is one of the most important quality parameters for many foods, since the differences in climate, soil and cultivation methods cause differences in the chemical composition of the plants (Bondia-Pons et al., 2014). Cao and Wu (2015) reported that while Ningxia is recognized as the daodi region of Goji, increasing market demands pushed the cultivation into new regions in China and Goji fields now stretch over different geographical and climatic environments between 82°E and 115°E, 30°N and 45°N. These include temperate monsoon climate (Hebei), temperate continental semi-arid climate (Ningxia, Gansu and Inner Mongolia), plateau continental climate (Qinghai), and continental arid climate (Xinjiang) (Li et al., 2017). These different environmental conditions influence both the appearance and the metabolite profile of Goji (e.g., amount of polysaccharides, flavonoids, betaine, and carotenoids) (Zhang et al., 2012; Shen et al., 2016; Dermesonlouoglou et al., 2018). Moreover, different species and cultivars (e.g., Ningqi series) are widely cultivated while L. chinese is only cultivated in Hebei (Cao and Wu, 2015). Traditionally, a good Goji quality was defined as: Large berries with red colour; mild texture, few seeds, and sweet taste (Chinese Pharmacopoeia Commission, 1963). Goji berry belongs to the division of Magnoliophyta, class of Magnoliopsida, order of Solanales, family of Solanaceae and Genus of Lycium. Goji berry or wolf berry is the common name of the fruits Lycium barbarum or Lycium chinese, which are two closely related species (Chang et al., 2010; Redgwell et al., 2011). The genus Lycium (Solanaceae) consists of about 80 species found worldwide in arid to semi-arid environmental condition (Chen et al., 2013; Huang et al., 2015). The main centers of diversity for this genus are distributed between Argentina and Chile, Southern Africa and Southwestern North America (Miller and Venable, 2003; Miller et al., 2008). L. barbarum and L. chinese have been domesticated and widely cultivated in Northwest China for more than 600 years. Lycium ruthenicum is endemic to northwestern China and is regarded as a potential plant to control erosion because of its high salt-tolerance (Chen et al., 2013). Some common species of wolfberry in Arizona, California and Mexico are Wolfberry or Frutilla (Lycium brevipes), Wolfberry or Manzanita (Lycium andersonii), Wolfberry or Barchata (Lycium berlandieri), Wolfberry or Frutilla (Lycium californicum), Wolfberry or Frutilla (Lycium exsertum), and wolfberry or Frutilla (Lycium fremontii). In recent years, there has been a growing trend in introducing Goji cultivation to different pedoclimates in Europe (Italy, Romania, Bulgaria, Portugal), or even developing new cultivars (Donno et al., 2015; Mocan et al., 2017; Protti et al., 2017). Currently, Romania has the biggest cultivated area of L. barbarum plants in the European Union (Mocan et al., 2018). Goji plant can handle a wide range of conditions (Patsilinakos et al., 2018). They prefer a moderately moist, well-drained soil, but they are also fairly drought tolerant. The berries will produce and ripen the best in full sun. Goji berry shrubs have long, arching branches that hold up better with some structural support. The famers can also train Gojis onto a trellis, fence or any other solid structure. Due to their vigorous growth habit, Gojis can be pruned anytime to control their height and shape. Yao et al. (2018) reported that it does not justify superiority of a specific production area over other areas. Instead, it will be essential to distinguish Goji from different regions based on the specific morphological and chemical traits with the aim to understand what its intended uses are. Liu et al. (2017) postulated that environmental temperature play one of the most and important factor influencing on the phenolic compositions and contents in the leaves and stems. From an agronomical point of view, each region produces specific cultivars that may differ in chemical composition and biological properties (Wojdylo et al., 2018). For example, the differences between Goji berries growing in China and Italy were previously evaluated by Rocchetti et al. (2018) or in different localization in China (Dong et al., 2012).

Some important facts about Goji berry in China are:

1) The Goji berry is commonly used as a natural form of erosion control in China.
2) L. barbarum is being researched for Alzheimer’s and other neurodegenerative diseases.
3) L. chinese has shown evidence of growth-inducing effects on probiotic cells.
4) Goji berries are celebrated each August in Ningxia during an annual festival coinciding with the yearly berry harvest.
5) Theory of how L. barbarum came to bear so many nutrients, due to Yellow River silty, mineral-rich loess leftover from the last glaciations period.

Recently, numerous phytotoxic and pharmacological studies focus on its health benefits, and support its use as functional food (often sold under the marketing concept of an alleged “superfood) (Yao et al., 2011; Chang and So, 2015; Jatoi et al., 2017; Qian et al, 2017; Pedro et al., 2018). It is also called “superfruit” in Europe and North America due to their potentially health-promoting constituents (Potterat, 2010; Hempel et al., 2017). Some problems, identification and control treatment of Goji berries are shown in Table 1.

**Goji berry and traditional Chinese medicine (TCM)**

Some of the first healers to recognize the power of the Goji Berry were the Himalayan people, who utilized the berries...
of the Goji vine which flourished in the valleys of the Himalayas for thousands of years. Some sources state that wolfberries have been used in traditional Chinese medicine for at least 2000 years (Williamson et al., 2013). Their undocumented legend, however, is considerably older, as wolf berries are often linked in Chinese lore to Shen Nung (Shennong), China’s legendary First Emperor, mythical father of agriculture, and herbalist who lived circa 2800 BC. The book was named Shennong Ben Cao Jing and was supposed to contain all of the emperor’s knowledge on the subject of agriculture. There is another important Chinese book written by Li Shi-Zhen in the 16th century that also included important information on the subject of the Goji berry. From a TCM point of view, the nature of Goji berry is calm, and its flavour is sweet. According to TCM theory and practice, Goji berry can act on both the liver channel and the kidney channel, and the major health benefits of Goji berry are its ability to nourish and tonify liver and kidney (Chinese Pharmacopoeia, 2005; Cieslik and Gebusia, 2012). It should be noted that Goji berry is used not only as a drug in TCM prescriptions to treat diseases but also as a popular food by Chinese people in their daily life for promotion of general health. According to the regulations of the China State Food and Drug Administration, it is one of the 87 TCM ingredients that can be used as both normal food and functional food (Bucheli et al., 2011; Fiorito et al., 2019). Goji berry translates to wolfberry. One theory as to the origin of the wolfberry name stems from speculation that Chinese farmers saw wolves sheltering among the dense Goji berry vines. Most of the world’s Goji berry production centers around areas in Northwestern China, where there are 200,000 acres of farmland dedicated to Goji berry cultivation. Goji berry plantations can also be found in Inner Mongolia and Shaanxi (Zhu et al., 2016). Wu et al. (2018) also reported that northwest regions of China are the main producing area of *L. barbarum*, including Xinjiang, Tibet, Ningxia, Inner Mongolia, Qinghai and Gansu. Goji berries provide 8 essential amino acids that the body cannot synthesize. One of the most important reason for the popularity of Goji berries is the fact that they contain a high concentration of an antioxidant called Zeaxanthin. According to various studies, a diet that contains Goji berries can increase a person’s Zeaxanthin levels by as much as 26%. Goji berry is frequently added to soups, hot pots, and herbal teas, and is also popularly soaked in wines alone or together with other TCM ingredients to make functional wines (Bucheli et al., 2011; Zhang et al., 2015). Red Goji (*L. barbarum L.*) is a perennial, deciduous shrub growing northwest China and the Mediterranean region (Zhao et al., 2015). Black Goji is a black colour small berry fruit from (*L. ruthenicum Murr.*) natively growing in northwest part of China (Xin et al., 2017). Tang and Giusti (2018) reported that the fruit, known as black Goji, is popular in traditional Chinese medicine. On the basis of TCM view, Goji berry is mainly used in treating yin deficiency in liver and kidney. The dried fruit (Figure 1) is commonly used in TCM preparations at a dose of 6-15 g, taken twice or thrice daily (Liu and Tseng, 2005). Goji berry can also be a part of a mix of Chinese herbs that is ground to a fine powder and used in honey pills (a traditional TCM formulation in which honey is used as main excipient to make pills) of 15 g each. One of these pills is taken with bland soup in the morning and another at night on an empty stomach (Liu and Tseng, 2005; Wang et al., 2018). Goji berry is one of the most popular TCM herbs regulated as a foodstuff that is used in nutricosmetic products in China. Nutricosmetics are used for the promotion of skin and hair health. Only angelica and pearl powder are more frequently found in nutricosmetic products in China (Bucheli et al., 2011). Wojcieszek et al. (2017) reported that compounds identified in Goji berries are most likely to be responsible for better bioaccessibility of elements such as copper and zinc to the human organism. The berries are also used in traditional Korean medicine, traditional

<table>
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<th>Problem</th>
<th>Identification</th>
<th>Control</th>
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<tr>
<td>Goji gall mite <em>(Aceria kuko)</em></td>
<td>Extremely small, difficult to see with naked eye. Pale salmon and wormlike mites with six to seven generations per year. Small bead-like galls from on leaves. They are yellow/green on the bottom and reddish on top. Each gall holds large numbers of mites.</td>
<td>Sulfur, insecticidal soap, or horticultural oil (0.5% solution) can be used to control. A spray application of 2% horticultural oil, either in the fall (just before leaves drop) or in the spring (just as leaves emerge) will be most effective. Keep alternative hosts such as pepper, eggplant and black nightshade, clear from the area.</td>
</tr>
<tr>
<td>Powdery mildew <em>(Sphaerotheca spp.)</em></td>
<td>Fungal disease that forms white patches of powder on leaves and stems.</td>
<td>Prune to improve air circulation and minimize wet foliage. Horticultural oils can help prevent further spreading once present in field.</td>
</tr>
<tr>
<td>Blossom end rot</td>
<td>Calcium deficiency related abiotic disorder resulting in a water-soaked spot on the end of fruit.</td>
<td>Control by careful irrigation to minimize extreme fluctuations in soil moisture (particularly during bloom and fruit sizing).</td>
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Figure 1: Fresh and dried Goji berries. It appears red in colour with white seed inside.

Japanese medicine, and traditional Tibetan medicine (Wang et al., 2010; Yao et al., 2011; Cho et al., 2016). Goji Berry root bark is used for treating inflammation and certain skin diseases. Song et al. (2011) concluded that the traditional Chinese medicine, *L. barbarum* and its taurine component is valuable medicinal herb for the prevention of diabetic retinopathy.

**Composition, health beneficial and clinical aspects of Goji berries**

Goji berries can provide almost twice vitamin A that a person needs in a day (Liu et al., 2018). It has almost a third of the daily recommended vitamin C. Moreover, Goji berries are rich in some important and essential minerals including iron and potassium. Potterat (2010) and Endes et al. (2015) reported that this crop includes essential oils, vitamins (A, A, and C), amino acids, mineral elements (K, P, Ca, Mg, Fe, and Na), and betaine. A diet that contains Goji berries can help in the treatment and prevention of various health issues, but the most important ones are:

**High blood sugar:** Goji berries are said to be able to lower blood sugar in addition to helping to relieve insulin resistance which can be able to reduce risk of developing diabetes. Goji berries contain high levels of fibre and protein, which means that they can help to provide a feeling of fullness without the need to take in an inordinate amount of calories. Regular consumption of Goji berries can enhance lymphocytes, which are the red blood cells that protect the body from harmful bacteria. The nutritional and functional properties of Goji berries are provided by a rich variety of components, including amino acids, polyphenols, carotenoids, polysaccharides, organic acids and their derivatives (Zhao et al., 2015; Ducruet et al., 2017; Zhou et al., 2017; Bertoldi et al., 2019; Zhao et al., 2019). Mocan et al. (2018) reported that Goji berries are a rich source of bioactive compounds with functional properties that need further risk/benefit evaluation when used in foods or health promoting formulations. There are many varieties of Goji Berry grown in many parts of the world. As the popularity of the berry continues to grow, more and more varieties will likely appear as the vine is cultivated for commercial purposes. But it is said that the most powerful and nutrient rich Goji Berries in China still come from the vines of Himalayan valleys.

Goji is a good source of fiber, protein, carotenoids (Liu et al., 2014), and polysaccharides (He et al., 2012). It also has a lot of biological activities, including antidiabetes (Lin et al., 2012), antiproliferative activity (He et al., 2012), preserving retinal function (Chu et al., 2013), and antioxidant activity (Luo et al., 2004; Amagase and Farnsworth, 2011; Song and Xu, 2013; Magiera and Zareba, 2015; Zhang et al., 2016). Donno et al. (2015) mentioned that Goji berry is identified as a rich source of antioxidant compounds, with health promoting properties as compared with other common fruit species. Recent studies have shown that antioxidant activities of some natural products are correlated with defence against oxidative stress and different human diseases including cancer, arteriosclerosis and aging process (Willcox et al., 2004). Compounds of nutritional value of Goji are very diverse, including polysaccharides, carotenoids, polyphenols, essential oils, betaine, vitamins, amino acids and oligo elements (Forino et al., 2016). Goji berries are rich in sugars (Montesano et al., 2016) and lipids (Blasi et al., 2016). Wojdylo et al. (2018) indicated that apart from being natural, nontoxic colorants in drinks and cosmetics, Goji carotenoids show biological activity, e.g. they act as antioxidants or precursors of vitamin A. Xie et al. (2016) reported that *L. barbarum* can be utilized as pharmaceutical for treatment and also as an ingredient in Chinese cooking. Cheng et al. (2015) reported that Goji berries have long been used to promote fertility and as potent anti-aging and antioxidant agent. They are rich in ascorbic acid (approx. 42 mg/100g) (Llorent-Martinez et al., 2013), thiamine, riboflavin and vitamins E, B1, B2 and
B6 (Wojdylo et al., 2018). Further, they contain carbohydrates (arabinose, rhamnose, xylose, galactose, mannose and glucose) (Montesano et al., 2016), organic acids (malic acid, citric acid, shikmic acid and fumaric acid) (Mikulic-Petkovsek et al., 2012), and many minerals (potassium, sodium, phosphorus, magnesium, iron, calcium, zinc, and selenium) (Gieslik and Gebusia, 2012; Llorente-Martinez et al., 2013; Nile and Park, 2014). Goji berries comprise also fatty acids (hexadecanoic acid, linoleic acid and myristic acid) (Blasi et al., 2017), and amino acids (proline, betaine and taurine) (Potterat, 2010). Xin et al. (2017) reported that the pulp of the Goji had the highest concentration of phytochemicals [TPC (Total phenolic content, TFC (Total flavonoid content, MAC (Monomeric anthocyanin content, and CTC (Condensed tannin content)] as compared with the seeds and whole fruits. They have also found that the antioxidant activities order is like pulp>seeds>whole fruits.

Yan et al. (2014) in their experiment indicated that the contents of nutritional components in the different tissues were significantly different. The ratios of essential amino acids/total amino acids and ratios of essential amino acids/non-essential amino acids for the leaf, pollen, and flower were all higher than the criteria provided by FAO/WHO. The pollen and the fruit contained highly unsaturated fatty acids. All the tissues were good sources of mineral elements, polysaccharides and phenolic compounds. Furthermore, they have found that Ningxia wolfberry pollen, leaf and flower can be a potential resource of nutrients for humans and animals. It has also effectiveness in aging, increased metabolism, immune system, liver function and glycemic control (Silva et al., 2017). However, their benefits are attributed to the bioactive component polysaccharide-protein complex 4 (LBP4), which is composed of six monosaccharides (galactose, glucose, rhamnose, arabino, mannoseandxylose) (Amagase and Nance, 2008; Ming et al., 2009; Amagase et al., 2009; Lu and Zhao, 2010; Carnes et al., 2013). Soares deSousa et al. (2016) noted that Goji has a complex rich vitamins and minerals that protect the central nervous system, reduces the risk of glaucoma and has antitumor activity, prevents chronic diseases such as hypercholesterolemia, diabetes, hepatitis, and also helps in reducing fatigue and greater resistance in exercise, being a strong ally in the prevention of aging. It has been found that the flavonoids from wolf berries protect the blood cells and mitochondria against oxidative damages (Luo et al., 2004). Jin et al. (2013) demonstrated that L. barbarum polysaccharides has various important biological activities, such as antioxidant, immunomodulation, antitumor, neuroprotection, radioprotection, anti-diabetes, hepatoprotection, anti-osteoporosis and antifatigue. Gao et al. (2008) also mentioned that Goji berries have a long history of use for the treatment of eye problems, skin rashes, psoriasis, allergies, insomnia, chronic liver disease, diabetes, tuberculosis, and kidney disorders. Masci et al. (2018) also concluded that the purified components of the Goji berry may be potentially useful as adjuvants in the treatment of diabetes and its correlated illnesses. Wolfberry polysaccharides were reported to have shown antioxidant activity in vitro. A glucopyranoside and phenolic amides isolated from wolfberry root bark have also been found to have an inhibitory activity in vitro against human pathogenic bacteria and fungi. A human supplementation trial showed that daily intake of wolfberries increased plasma levels of zeaxanthin (Karioti et al., 2014; Hempel et al., 2017). On the contrary, it is also reported in some literature that in the west, none of this research has been scientifically verified, confirmed in clinical studies, and accepted by regulatory authorities. Some health benefits of Goji berry are boosted immune system and flu protection, potential weight loss aid, antioxidants for eyes and skin, maintenance of blood sugar, increased testosterone, restoration of body homeostasis and strengthening of body energy (Chang et al., 2010; Chu et al., 2013; Protti et al., 2017). The findings of Pehlivan Karakas et al. (2016) study showed the methanol extract of L. barbarum on low levels of anxiety and depression like behaviours. Their results also indicating that females seem to benefit from the methanol extract of L. barbarum more than males in terms of anxiety and depression like behaviours, as well as spatial learning behaviour (Pehlivan Karakas et al., 2016). Some researchers reported that the carotenoid profile of Goji berries is the subject of different reports, where zeaxanthin-dipalmitate was confirmed as the major carotenoid of Goji berries (Peng et al., 2005; Inbaraj et al., 2008; Hempel et al., 2017; Fratianni et al., 2018). Fratianni et al. (2018) mentioned that the dried samples of Goji berries could be used as a dietary source of carotenoid and be worthy of development and utilization.

Dried fruits can be eaten raw and used in confectionary goods or in bakery products, added to trail mix, cereals, muffins, energy bars or soups (Gao et al., 2008; Rosa et al., 2017). According to the findings, the dried fruits are red-orange, seeded, rich in vitamins of group B, C, E, contain 21 microelement including anticancer germanium (Llorente-Martinez et al., 2013), 18 amino acids, 8 of which the human body does not produce, and 4 irreplaceable polysaccharides which do not exist in products of food. Goji berries contain not only high amounts of antioxidants, carotenoids, vitamin A and zeaxanthin, but also rich in vitamins B and C polysaccharides (Ionica et al., 2012; Senica et al., 2018; Skenderidis et al., 2018). In addition, flavonoids such as rutin, gentisic acid and quercetin are the main active compounds present in the leaves of L. barbarum (Dong et al., 2009; Duan et al., 2010; Chen et al., 2013; Dermesonluoglu et al., 2018). Lopatriello et al. (2017) found L. barbarum flowers and pruned stems as sources of beneficial compounds. The most important health benefits of Goji berry are shown in Table 2.

L. barbarum extracts were proven to possess prosperity biological activities, e.g. anti-ageing effects, increased...
**Table 2:** The most important health benefits of Goji berry.

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<tr>
<td>Helps to slow down the growth of cancer cells</td>
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<tr>
<td>Helps to improve gastrointestinal functions</td>
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<tr>
<td>Aids in improving eyesight and protects skin against UV rays</td>
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<tr>
<td>Effective in increasing semen quantity and improving sperm quality</td>
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<tr>
<td>Beneficial in reducing stress and fatigue</td>
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<tr>
<td>Reduces risk of cardiovascular diseases</td>
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<tr>
<td>Contains high level of anti-oxidant</td>
</tr>
<tr>
<td>Helps to protect liver against infections</td>
</tr>
<tr>
<td>Helps to reduce high cholesterol</td>
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<tr>
<td>Aids in controlling diabetes</td>
</tr>
<tr>
<td>Protects brain cells from damage</td>
</tr>
<tr>
<td>Help lower blood sugar level</td>
</tr>
<tr>
<td>Boosts immune system</td>
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<tr>
<td>Promote restorative sleep</td>
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metabolism, antioxidant properties, anti-diabetes and glucose control, immunomodulation, anti-glaucoma, neuroprotection, anti-fatigue/endurance, cytoprotection and antitumour activity (Potterat, 2010). Numerous studies indicated the powerful antioxidant potentials achieved from *L. barbarum* molecules, to act as promotions for various health protective effects (Wu et al., 2004; Abdenacer et al., 2015). It is well documented that several traditional herb and plant extracts have antioxidant properties and are potential candidates for the prevention and treatment of ROS-induced diseases (reactive oxygen species) (Li et al., 2007; Leontopoulos et al., 2017). Dried Goji fruits (*L. Chinese*) has the highest content of total polyphenols and vitamin C based on the cellular juice concentration due to fruits dehydration. Extraction with alcohol 80% as well as with hydrochloric acid 2% have resulted in the highest values of the polyphenols content while the highest antioxidant activity was found by using as solvent the hydrochloric acid 2% normally used for vitamin C determination. The DPPH method was affected by the content of vitamin C (Ionica et al., 2012; Rocchetti et al., 2018). Yu et al. (2006) mentioned that the pharmacological activities associated with *L. barbarum* include hypoglycemic, immunomodulation, anti-hypertension, lipotropic, protecting hepatic function, anti-aging, anti-fatigue, antioxidant and so on. Some Researches indicated that components of berry fruits especially Goji berry may inhibit replication of the virus both directly and indirectly, e.g. by blocking surface flycoproteins of influenza virus and stimulating immune system of the organism; in consequence to its properties, Goji berry are raw materials of potential use in the prevention and treatment of influenza (Gramza-Michalowska et al., 2017).

Macronutrients include carbohydrates, protein, fat, and dietary fiber. 68% of the mass of dried wolf berries exists as carbohydrate, 12% as protein, and 10% each as fiber and fat, giving a total caloric value in a 100 g serving of 370 (kilo) calories, of which 272 come from carbohydrates and 90 of which come from fat.

Micronutrients include the following:

1). 11 essential and 22 trace dietary minerals
2). 18 amino acids
3). 6 essential vitamins
4). 5 unsaturated fatty acids, including the essential fatty acids, linoleic acid, and alpha-linolenic acid
5). Beta-sitosterol and other phytosterols
6). 5 carotenoids, including beta-carotene and zeaxanthin (below), lutein, lycopene and cryptoxanthin, a xanthophyll
7). Numerous phenolic pigments (phenols) associated with antioxidant properties.

It is also reported that 100 grams of dried contain the following minerals:

1). **Calcium:** Wolfberries contain 112 mg/100 g serving, providing about 8-10% of the Dietary Reference Intake (DRI).
2). **Potassium:** Wolfberries contain 1132 mg/100 g dried fruit, giving about 24% of the DRI.
3). **Iron:** Wolfberries have 9 mg iron/100 g (100% DRI).
4). **Zinc:** 2 mg per 100 g dried fruit (18% DRI)
5). **Selenium:** 100 g of dried wolfberries contain 50 micrograms (91% DRI).
6). **Riboflavin (Vitamin B2):** At 1.3 mg, 100 g of dried wolfberries provide 100% of DRI.
7). **Vitamin C:** Vitamin C content in dried wolfberries has a wide range (from different sources) from 29 mg/100 g to as high as 148 mg/100 g (respectively, 32 and 163% DRI).

Wolfberries also contain numerous phytochemicals, such as:

1). **Beta-carotene:** 7 mg/100 g dried fruit.
2). **Zeaxanthin:** Reported values for zeaxanthin content in dried wolfberries vary considerably, from 25 to 200 mg/100 g. The higher values would make wolfberry one of the richest edible plant sources known for zeaxanthin content. Up to 77% of total carotenoids present in wolfberry exist as zeaxanthin (Fratianni et al., 2018).
CONCLUSION

Known in Asia as an extremely nutritious food, Goji berry fruits have been extensively eaten raw, consumed as juice or wine, brewed into herbal tea or prepared as a tincture, eaten as salads and used widely in other culinary preparations. Its leaves are made into tea. Besides its uses in food and culinary, wolfberries have long played important roles in traditional Chinese medicine (TCM), where they are believed to enhance immune system function, improve eyesight, protect liver, boost sperm production and improve circulation, among other effects. It has been widely used in Asian countries such as China, Japan, Korea, Vietnam, and Thailand for many years. Goji berry is widely distributed in the arid and semi-arid regions of China, Japan, Korea, Europe, North America and the Mediterranean. The northwest regions of China are the main producing areas of L. barbarum, including Xinjiang, Tibet, Ningxia, Inner Mongolia, Qinghai and Gansu. Currently, China is the major supplier of L. barbarum products in the world. TCM calls for Goji berries to be prepared as a decoction or ground into a powder and mixed with other herbs. Goji berry is being widely used as a functional food, mainly for their antioxidant action due to a high content of vitamin C. Anti-aging, antioxidant, immunomodulating, hypotensive, antimicrobial, antifungal, antiviral, anti-diabetic, neuroprotective, and anticancer properties have been associated with L. barbarum. In TCM science, it has been reported that this crop is also good to improve eyesight and to strengthen the liver and kidney. L. barbarum contains polysaccharides, carotenoids, including zeaxanthin, vitamins, and flavonoids. The roots contain alkaloids, flavonoids, betaine, and vitamins E, B1, B2 and B6. Additionally, Goji berries are rich in ascorbic acid, thiamine and riboflavin. Moreover, they contain carbohydrates (arabinose, rhamnose, xylose, galactose, mannose and glucose), organic acids (malic acid, citric acid, shikimic acid, and fumaric acid), and so many minerals such as potassium, sodium, phosphorus, magnesium, iron, calcium, zinc and selenium. At present, the Goji is enjoying the enormous popularity worldwide by being made into Goji berry tea, bars, beer, cookies, cuttings, dessert, drinks, eye cream, extract, powder, essential oil, facial cream, face mask, jelly, smoothie, jam, muffin, supplement, tablets and etc. Although, TCM in China is partly integrating with western medicine science, researchers should learn more from TCM and carry out more studies. This review article allowed verifying that Goji berries are sources of compounds with valuable nutritional and bioactive properties and, therefore, they could be useful for incorporation into foods with functional properties. They can also provide industrial sustainability and could be considered as organic superfood and superfruit in not only Asian countries but also western countries.

REFERENCES


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