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Review

Berberis lycium Royle: A review of its traditional uses, phytochemistry and pharmacology

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***Berberis lycium* Royle (family: Berberidaceae), a native to Pakistan, India and whole region to Himalyas is widely used like food and in folk medicine. A wide range of medicinally and nutritionally important phytochemical constituents have been isolated from plant such as alkaloids, cardioactive glycosides, saponins, tannins, anthocyanins, vitamins, carbohydrates, proteins, lipids, fiber content, β carotein, cellulose, phytic acid and phytate phosphorous. Plant possesses minerals such as Sodium, Calcium, Sulphur, Iron, Zinc, Copper, Lead, Manganese, Potassium and Phosphorus, which contribute to broad variety of biological processes and are valuable in the treatment of various disorders. Traditionally, the plant has been used against diarrhea, intestinal colic, piles, jaundice, internal wounds, rheumatism, diabetes, ophthalmia, gingivitis, throat pain, backache, scabies, bone fractures, sun blindness, pustules, manorrhagia, fever and as diuretic, expectorant and diaphoretic. *B. lycium* is known to possess antidiabetic, antihyperlipidemic, hepatoprotective, antibacterial, antifungal, anticoccidial, pesticidal, antimutagenic and wound healing properties, supporting its traditional uses. In this review, a comprehensive account of phytochemical constituents and pharmacological activities is presented along with traditional uses in a view of many recent findings and its potential for future research. To what extent, the findings about pharmacological activities are of potential clinical relevance and are unclear due to lack of clinical data.**

Key words: Antidiabetic, antihyperlipidemic, antimicrobial, antimutagenic, *Berberis lycium,* hepatoprotective.

INTRODUCTION

Nowadays, food is not only considered as the source of nutrients but also a powerful medicine. Information about the new food sources and exploitation of large number of less familiar plant resources which are present in nature is present in today's necessity (Kaur et al., 2001). *Berberis lycium* Royle (family: Berberidaceae), a lesser-known plant is named in English as barberry (Anwar et al., 1979), whereas, its fruit is called as "kashmal" (Usmanghani et al., 1997; Baquar, 1989) and roots are known as "Darhald" (Nadkarni, 1980). It is native to the whole region of Himalyas Mountains and is widely distributed in temperature and semi temperature areas of Pakistan, India, Afghanistan, Nepal and Bangladesh. In Pakistan, it grows in Baluchistan, NWFP, Punjab and Azad Kashmir at elevation of 900 to 2900 m (Fluck, 1971; Ali and Khan, 1978). According to International Union for Conservation of Nature (IUCN), categories *B. lycium* species are vulnerable (Waseem et al., 2006; Hamayun et al, 2006). Fruits (Kashmal) have been used by

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primitive societies living in Himalyan range of Jammu and Kashmir and Himachal Pradesh since ancient times as a food source (Kaur et al., 2001), and also made into sauce (Tiwari et al., 2010).

B. lycium contains alkaloids like berberine (Ali and Khan, 1978; Chandra and Purohit, 1980; Gosh et al., 1990; Gulfraz et al., 2004), plamitine (Gosh et al., 1990; Gulfraz et al., 2004), berbamine (Khare, 2004), baluchistanamine, karakoramine, gilgitine, jhelumine, punjabine, sindamine, chinabine (Manske, 1998) and umbellatine (Baquar, 1989). Plant is documented to posses proteins, carbohydrates, lipids, vitamin C (Gulfraz et al, 2004; Sood et al., 2010), hydrolysable tannins, cardioactive glycosides and saponins (Ahmad et al., 2009). Especially, fruits have moisture, vitamin A, fibre content, cellulose, hemicelluloses, β carotein, anthocyanins, phytic acid and phytate phosphorous (Sood et al., 2010). A wide variety of minerals are also documented such as Sodium, Calcium, Sulphur, Iron, Zinc (Gulfraz et al., 2004), copper, lead, manganese (Srivastava et al., 2006), Potassium and Phosphorus (Sood et al., 2010).

Plant is reported to possess antibacterial, antifungal (Singh et al., 2007), anticoccidial, immunostimulant (Nidaullah et al., 2010), pesticidal (Tewary et al., 2005), antimutagenic (Khan et al., 2010), hypoglycemic (Gulfraz et al., 2007; Gulfraz et al., 2008; Ahmad et al., 2009a), antihyperlipidemic (Chand et al., 2007; Ahmed et al., 2009b), hepatoprotective (Khan et al., 2008) and wound healing properties (Asif et al., 2007). Berberine, an alkaloid from *B. lycium* is also known to posses antidiarrheal (Zhang and Shang, 1989), antinocioceptive, antipyretic (Küpeli et al., 2002), anti inflammatory (Kuo et al., 2004), anti hypercholesterolemia (Doggrell, 2005), antitumor (Issat et al., 2006) and antidiabetic properties (Steriti, 2010). It also reduces brain ischemic-hypoxic injury (Benaissa et al., 2009) and can ameliorate spatial memory impairment (Zhu and Qian, 2006).

In this review, a comprehensive description of its traditional uses, pharmacological activities and phytochemical constituents is presented in a view of various recent findings and its potential for future research. Information on *B. lycium* Royle was gathered via the internet (using Sciencedirect, PubMed, Google Scholar, Google patent, and Endnote software) and libraries.

BOTANICAL ASPECTS

Plant is a semi deciduous shrub, 2 to 3 m high; twigs yellowish, glabrous or minutely pubescent; leaves 2.5 to 7.5 by 8.18 mm, sessile lanceolate or narrowly obovate-oblong, cariaceous, entire or with a few large spinous teeth, dull green above; racemes shortly stalked, drooping, longer than leaves, often with a few long-stalked, flowers at the base; pedicles slender, 1 to 3 cm long. Berries are globose ovoid, 8 mm long, blue, covered with a bloom (Baquar, 1989). The cork is 5 to 10 cell thick, cambium, xylem with spiral, pitted and reticulate tracheae (Mahmood et al., 2005). Investigation on pollen morphology was carried out through light and scanning electron microscope. Pollen diameter in pollen type *Berberis kunawurensis* in µm is 38.71 (41.5 ± 0.57) 45.5 and exine thickness in µm is 2.25 (2.42 ± 0.34) 2.59 (Perveen and Qaiser, 2010). It is also visited by honey bees for nector (Zabihullah et al., 2006).

USE IN TRADITIONAL MEDICINE

B. lycium Royle has also been used in folk medicine against diarrhea (Zaman and Khan, 1970; Baquar, 1989; Usmanghani et al., 1997; Kaur et al., 2001; Hamayun et al., 2005; Hamayun et al., 2006; Afzal et al., 2009), intestinal colic (Kaur et al., 2001; Hamayun et al., 2006), jaundice (Baquar, 1989; Hamayun et al., 2005; Zabihullah et al., 2006; Hamayun et al., 2006), internal wounds (Ahmed et al., 2004; Hamayun et al., 2005; Hamayun et al., 2006), piles (Zaman and Khan, 1970; Baquar, 1989; Gosh et al., 1990; Hamayun et al., 2006; Afzal et al., 2009), ophthalmia (Zaman and Khan, 1970; Khan et al., 1979; Baquar, 1989; Kaur et al., 2001; Uniyal et al., 2006), diabetes (Ahmed et al., 2004; Waseem et al., 2006; Tiwari et al., 2010), rheumatism (Kaur et al., 2001; Zabihullah et al., 2006), backache (Zabihullah et al., 2006), gingivitis (Hamayun et al., 2005), throat pain, scabies, pustules, bone fractures (Ahmed et al., 2004), sun blindness, intermittent fever, remittent fever (Kaur et al., 2001) and manorrhagia (Baquar, 1989). Plant is also expectorant, diuretic (Hamayun et al., 2006), diaphoretic (Kaur et al., 2001) and febrifuge (Baquar, 1989; Gosh et al., 1990; Shamsa et al., 1999; Mahmood et al., 2005).

Different parts of plant have been used in different preparations traditionally. Dried powdered plant bark is used for dysentery, internal wounds and throat pain. Root bark water extract is used against diabetes, pustules and scabies while root powder paste has been used in bone fracture (Ahmed et al., 2004). A decoction is prepared by drying root in shade and then boiling in water. This decoction is then concentrated and finally dried at low temperature. The end product is called “Rasaunt” and is used to cure eye infections. New vegetable atypical shoots are crushed and sap is also used for the same purpose (Uniyal et al., 2006). Decoction of rhizome is also utilized for jaundice by traditional practitioners (Zabihullah et al., 2006).

Traditional systems of medicine have produced many beneficial leads in the development of medications for various diseases. Several studies have proposed that plants and their constituents mediate their effects by modulating several of these recently recognized therapeutic targets. However, traditional medicine needs rediscovery in light of our existing understanding of allopathic (modern) medicine (Aggarwal et al., 2006). *B. lycium* Royle has been reported by various studies for its use in traditional system of medicine to treat diabetes. Pharmacological studies in recent years showed that plant reduces hyperglycemia, and insulin like effect is suggested as possible mechanism of antidiabetic activity of plant. Similarly, this plant is well documented for its folkric use to treat rheumatism, and gingivitis. Berberine, a major constituent of this plant is now well known to possess anti-inflammatory property. Traditional practitioners have also used this plant to treat wounds. Recent experiments revealed that plant causes healing of wound by increasing the area of epithelialization and collagen deposition. Useful leads which are provided by practitioners of traditional system of medicine continue to help us in development of modern medicine and novel therapeutic targets.

PHYTOCHEMISTRY

There are more than 20 chemical elements (often called minerals) necessary for humans. Deficiency in such essential nutrients leads to a wide range of symptoms depending upon the deficient mineral (Campbell, 1996). Roots and fruits were analyzed for mineral contents through chemical analysis. Roots contain 0.2% Sulphur and 0.2% Zinc, while in fruits, amount of Sulphur and Zinc present is 0.1 and 0.8%, respectively (Gulfraz et al., 2004). Analysis of roots and stem for mineral contents was done by using Atomic absorption spectrophotmeter. Copper (Cu) detected in the roots and stem of *B. lycium* were 4.360 ± 0.176 and 5.031 ± 0.176 ppm, respectively. Amount of Lead (Pb) found in the roots and stem of plant was 4.360 ± 0.176 and 7.992 ± 0.106 ppm, respectively. Manganese (Mn) present in the roots and stem of plant is 15.500 ± 0.212 and 18.272 ± 0.212 ppm, respectively (Srivastava et al., 2006). Atomic absorption spectrophotometer was used to analyze Sodium, Potassium and Iron, while Calcium by flame photometer. Calcium (18.272 ± 0.212 mg/100 g), Sodium (14.5± 0.11 mg/100 g), Potassium (161.42 ± 0.41 mg/100 g), Phosphorus (38.0 ± 0.24 mg/100 g) and Iron (2.61 ± 0.06 mg/100 g) content of the fruit are in appreciable amount (Sood et al., 2010). Leaves are abundant in Zinc (37.71 ± 0.02 μgg^{-1}), Mn (136.12 ± 0.01μgg^{-1}), Iron (528.47 ± 0.02 μgg^{-1}), Cu (53.41 ± 0.09 μgg^{-1}), Phosphorous (1315.00 ± 0.01 μgg^{-1}), Potassium (4077.00 ± 0.58 μgg^{-1}), Sodium (79.00 ± 0.01 μgg^{-1}) and Calcium (2389.00 ± 0.04 μgg^{-1}). It was revealed that Zinc, Cu and Sodium were maximum in root, while Mn, Phosphorous, Calcium in leaves, whereas, Potassium in shoot (Shah et al., 2003).

There is hardly a food, beverage, pharmaceutical, or cosmetic preparation which does not contain essential oils, glycosides, enzymes, resins, mucilages, tannins, gums, fibers and other botanical ingredients (Said, 1996). Roots of *B. lycium* possess dry matter (61.2%), moisture (20.5%), protein (4.5%), fat (2.6%), sugar (3.5%), fiber (2.5%) and vitamin C (0.3%). Fruits also contain dry matter (62.5%), moisture (12.5%), protein (2.5%), fat (1.8%), sugar (4.5%), fiber (1.5%) and vitamin C (0.8%) in considerable amount (Gulfraz et al., 2004). It was revealed that leaves have maximum amount of moisture followed by shoot and root, respectively. Maximum amount of fat and fiber was observed in roots, while highest amount of crude proteins was found in leaves (Shah et al., 2003). Alkaloids, saponins, cardioactive glycosides and hydrolysable tannins were found to be present in water extract of plant (Ahmad et al., 2009). β-Carotene (343.0 ± 0.89 µg/100 g), vitamin A (85.65 ± 0.17 µg/100 g), tannins (8.9 ± 0.15 mg/100g), phytic acid (2.5 ± 0.04 mg/100 g), phytate phosphorus (0.78 ± 0.06 mg/100 g), anthocyanin (82.47 ± 0.29 mg/100 ml juice), cellulose (7.94 ± 0.60 %) and hemicellulose (6.01 ± 0.41 %) were detected in fruits. Diameter, weight and length were detected as 1.5 cm, 17.15 g/100 fruits and 0.80 cm, respectively in physiochemical evaluation (Sood et al., 2010). Berberine and palmitine are found in roots of *B. lycium* in a concentration of 4.5 and 3.1%, respectively, while 2.9% berberine is present in fruits (Gulfraz et al., 2004). Berbamine (Khare, 2004), baluchistanamine, karakoramine, gilgitine, jhelumine, punjabine, sindamine, chinabine (Manske, 1998) and umbellatine (Baquar, 1989) are also documented to be present in plant. Structures of the major constituents of *B. lycium* Royle are showb in Figure 1.

PHARMACOLOGICAL PROPERTIES

Antidiabetic activity

Effect of *B. lycium* Royle was evaluated in alloxan-induced diabetic rabbits and plant was collected by native author Alamgeer from Gilgit district, Pakistan. Crude powder of *B. lycium* reduced the blood glucose levels of both diabetic and normal rabbits. Water, methanolic, aqueous methanolic, n-hexane and chloroform extracts of plant were prepared for screening their antidiabetic activity in alloxanized rabbits. Results indicated that among the extracts, orally administered 500 mg/kg of water extract produced maximum hypoglycemic activity for up to 6 h. Same doses of methanolic, aqueous methanolic and n-hexane extracts decreased blood glucose level up to 4 h. Chloroform extract did not show any significant antidiabetic activity. Water extract was further compared in combination with insulin. The results of 500 mg/kg of water extract with 2 units of insulin were comparable with 6 units of insulin (Ahmad et al., 2009a). Ethanolic and aqueous extracts of plant roots were

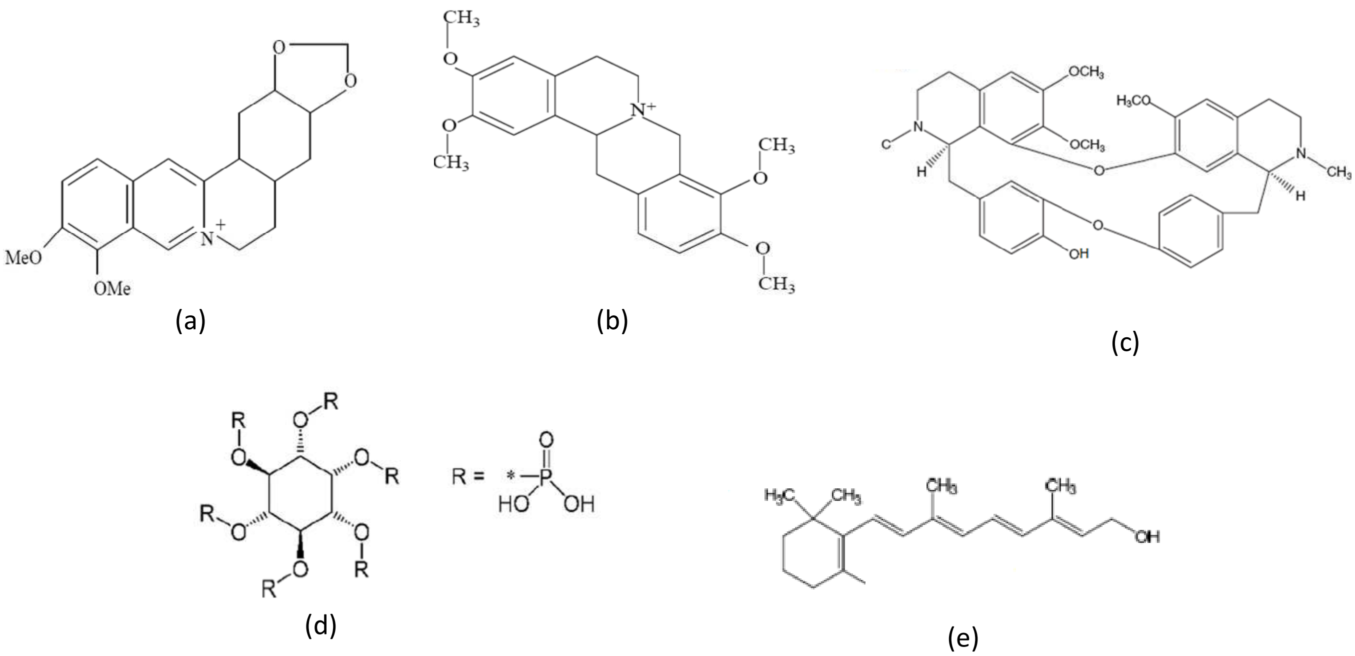

Figure 1. Structures of the major constituents of *B. lycium* Royle. a) Berberine (Singh et al., 2010); b) Palmitine (Singh et al., 2010); c) Berbamine (Wen-Ying et al., 2006); d) Phytic acid (Ali et al., 2010); and e) Vitamin A (Huang et al., 2009).

administered in normal and alloxanized rats and 20 mg/kg glibenclamide was used as reference drug. Serum was utilized to evaluate blood glucose level by the glucose oxidase method. The doses of 50 and 100 mg/kg decreased hyperglycemia after 3 to 5 h of treatment but the effect of later dose was more pronounced. Oral glucose tolerance test showed that plant extracts reduced serum glucose level in a dose-dependent manner. The observed mechanism involved in hypoglycemia is insulin-like effect, possibly through the peripheral glucose consumption. The applied doses were devoid of any behavioural changes or acute toxicity in experimental animals (Gulfraz et al., 2007). Antidiabetic activity of pure berberine was compared with ethanolic root extract of *B. lycium* in normal and alloxan-induced diabetic rats using similar doses (50 mg/kg) of each. Plant extract and berberine reduced blood glucose level significantly and demonstrated significant effects on glycosylated haemoglobin, glucose tolerance, serum lipid profiles and body weight. Plant extract was comparable in efficacy with berberine (Gulfraz et al., 2008).

Antihyperlipidemic property

Antihyperlipidemic property was investigated and roots of *B. lycium* Royle were collected for this purpose. Results indicated that oral administration of 250 and 500 mg/kg crude powder for 4 weeks resulted in significant decline in triglyceride, low density lipids (LDLs) and total cholesterol levels in male albino rabbits, while high density lipids (HDLs) were enhanced. Furthermore, same doses stabilized the weight of diabetic rabbits (Ahmad et al., 2009b). In another study, *B. lycium* root bark powder was studied for hypolipidemic effect in broilers. The powder was added to commercial broiler feed at the rate of 2.0%. *B. lycium* crude powder significantly decreased the total cholesterol, triglycerides and LDL, while HDL was significantly increased dose dependently (Chand et al., 2007).

Hepatoprotective property

To evaluate hepatoprotective effect, crude powder and methanolic extract of *B. lycium* Royle was used. Paracetamol was used to induce hepatotoxicity in rabbits. Results showed that plant significantly reduced the raised levels of alkaline phosphatase, serum glutamic pyruvic transaminase and serum glutamic oxaloacetic transaminase enzymes in treated hepatotoxic rabbits (ahmad et al., 2008). In another study, six poly herbal formulations including Livokin (Herbo-med, Kolkata) which also contains *B. lycium* were studied in mice. This formulation was found to have hepatoprotective effect in paracetamol induced hepatotoxic mice (Girish et al., 2009). Powder of *B. lycium* bark along with *Pistacia integerrima* and *Gallium aparine* were mixed in distilled water (2, 1 and 1 mg/ml, respectively) and shaken vigorously. Carbon tetrachloride was used to induce hepatotoxicity in male Sprague-Dawley rats. Study indicated that these medicinal plants have more effect as curative agents rather than preventive agents (Khan et al., 2008).

Antimicrobial property

Hydroalcoholic (50%) extract of air dried root and stem of *B. lycium* were used to determine antibacterial activity through microdilution method. Plant extract demonstrated antibacterial activity against *Micrococcus luteum, Bacillus subtilis, Bacillus cereus, Enterobactor aerogenus, Escherichia coli, Klebsiella pneumonia, Proteus mirabilis, Pseudomonas aeruginosa, Staphylococcus aureus, Salmonella typhimurium* and *Streptococcus pneumonia.* Minimum inhibitory concentration (MIC) showed by root extract against each test organism was 1.25, 0.62, 2.50, 2.50, 0.31, 1.25, 1.25, 0.62, 0.62, 2.5 and 0.62 µg/ml, respectively, while values for stem extract were; 0.31, 0.31, 2.50, 1.25, 0.62, 0.31, 0.31, 0.31, 0.62, 0.62, and 1.25 µg/ml, respectively. Root and stem extracts also inhibited fungal strains of *Aspergillus terreus* at MIC 0.31 and 0.62 µg/ml respectively. Root extract was also found active against *Aspergillus spinulosus* and *Aspergillus flavus* at MIC 0.62 and 1.25 µg/ml, respectively (Singh et al., 2007). The hydroalcoholic extract exhibited stronger and broader spectrum against bacterial strains as compared to fungal strains (Singh et al., 2009). *B. lycium* was mixed in drinking water of broilers along with other medicinal plants. It showed better immune performance against newcastle disease, infectious bursal disease and infectious bronchitis. A significant reduction in coccidial oocysts per gram of feces was also noticed (Nidaullah et al., 2010).

Pesticidal property

Petroleum ether and aqueous methanol extracts of *B. lycium* root was prepared using Soxhlet apparatus and dried under vaccum. The activity of plant extracts were tested at two higher doses (5000 and 10000 ppm) against pests. Petroleum ether extract showed 25% mortality rate against *Helicoverpa armigera* Hub and 92% mortatlity rate against *Aphis craccivora* Koch at the dose of 5000 ppm. Extract also exhibited 26% mortality rate against *Tetranychus urticae* Koch, 98% mortality rate against *A. craccivora* Koch, while 28% mortality rate against *H. armigera* Hub and *Plutella xylostella* L. each at the dose of 10,000 ppm. Petroleum ether extract inhibited *A. craccivora* Koch at 458.65 ppm lethal concentration at 50% (LC_{50}) after 24 h contact time and 57.79 ppm LC_{50} after 48 h contact time. The LC_{50} at 48 h exposure was nearly comparable with that of Dimethoate (a chemical insecticide) at 24 h exposure. Aqueous methanolic extract demonstrated 26% mortality rate against *A. craccivora* Koch at the dose of 5000 ppm. Extract also showed 44% mortality rate against *H. armigera* Hub, 41% against *P. xylostella* L., 43% against *T. urticae* Koch and 68% against *A. craccivora* Koch (Tewary et al., 2005).

Antimutagenic property

Anti-neoplastic activities of *B. lycium* root extracts were evaluated using p53 deficient HL-60 cells along with berberine and palmatine. The n-butanol extract demonstrated highest toxicity against HL-60 cells (IC_{50} 2.3 µg extract / ml medium after 48 h of treatment), followed by the ethanol extract (23.5 µg/ml) and the water extract (110 µg/ml). Berberine showed IC_{50} 1.2 µg/ml after 48 h of treatment, while palmatine did not exhibit inhibitory effect on cell growth. HL-60 cells were exposed to 5.5 µg butanol extract/ml and 0.6 µg berberine/ml for 48 h to evaluate the cell cycle distribution which resulted in reduction of G1 cells and accumulation of cells in the S-phase by both plant extract and berberine. All three types of extracts induced apoptosis and the butanol extract was found to be superior in activity followed by the ethyl acetate and the water extracts. Berberine produced a similar pro-apoptotic effect as the extract in a comparable concentration as contained in the butanol extract. Both induced apoptosis in HL-60 cells without concomitant induction of γH2AX, which shows that the anti-neoplastic effects have not been stimulated by berberine-caused genotoxicity. Comet assay revealed that both plant extract and the pure compound cause no DNA damage. Both demonstrated ~2-fold transient phosphorylation of p38-MAPK compared to untreated control. Chk2 also became activated and pattern was found correlated with the accumulation of cells in S-phase. Cdc25A proto-oncogene inactivation was the earliest event exhibited by the berberine and butanol extract, followed by the acetylation of α-tubulin, activation of Chk2 and p38, and the down-regulation of cyclin (Khan et al., 2010).

Wound healing property

Root extracts of *B. lycium* was studied in Swiss Wistar rats for wound healing activity**.** Aqueous and methanol extracts of the plant root were examined using, excision, incision and dead wound space models of wound repair. Both extracts increased the area of epithelialization and also showed increase in breaking strength. In aqueous extract treated group moderate collagen deposition, macrophages and fibroblasts were found, whereas a significant rise in collagen deposition with lesser macrophages and fibroblasts were observed in methanol extract treated group. A noteworthy increase in dry weight and hydroxyproline content of granulation tissue was also noticed. It was revealed that methanolic extract was more efficient than the aqueous extract (Asif et al., 2007).

CONCLUSION

Over the years, scientists have investigated and verified many of the traditional uses of *B. lycium* that continue to be an important natural remedy for various diseases. From medicinal point of view this rare plant possesses important pharmacological properties such as antidiabetic, antihyperlipidemic, hepatoprotective, antibacterial, antifungal, anticoccidial, pesticidal, antimutagenic and wound healing properties. From nutritional point of view, fruits have been used by primitive societies living in Himalayan range since centuries when in winter temperature falls down to -40℃ and the intensity of ultraviolet radiations are high. Plant possesses Sodium, Calcium, Sulphur, Iron, Zinc, Cu, Lead, Mn, Potassium, Phosphorus, Vitamin A and Vitamin C. Human and animal, studies originally demonstrated that optimal intakes of minerals such as, Potassium, Cu, Zinc, Calcium and Mn could decrease individual risk factors, including those associated with cardiovascular disorders (Mertz, 1982; Brody, 1994; Sanchez-Castillo et al., 1998). Calcium is helpful in teeth growth and is considered as major element present in bone (Anke et al., 1984). Sodium and Potassium are involved in membrane functions and are principal cations of extracellular and intracellular fluids, respectively (Bender and Mayes, 2003a). Iron plays important role in oxygen and electron transfer and is useful in the formation of hemoglobin (Dalziel, 1936; Kaya and Incekara, 2006). Zinc and Cu are required in our diet because they perform a broad range of biological functions such as parts of enzymatic and redox systems (McLaughlin et al., 1999). Dietary Vitamin A has important role in vision, its deficiency can lead to night blindness and xerophthalmia, Vitamin A and Provitamin A (β-carotene) are also antioxidants and have possible role in atherosclerosis and cancer prevention. Vitamin C functions as enzyme cofactor and its deficiency leads to scurvy (Bender and Mayes, 2003b).

A few patents have been granted by United States Patent and Trademark Office (USPTO). A herbal formulation for the treatment of diabetes and associated complications (Krishnan: 8163312), and a process for the preparation of herbal wines from ripe Himalayan berries (Singh et al: 6793957) are present in USPTO gazette.

B. lycium has considerable potential for future research. Plant is known to possess tannins and anthocyanins. Both have antioxidant property (Okamura et al., 1993; Yang and Zhai, 2010), but fewer research works have been done in this direction. So future research should be undertaken using plant extracts and different antioxidant models. Plant has been used traditionally in diarrhea and in intestinal colic since centuries. Berberine, a plant constituent is documented to possess antidiarrheal property but the exact mechanism is still uncertain. Therefore, *in vitro* spasmolytic activities and *in vivo* antidiarrheal activities of different plant extracts should be evaluated in a view to find the mechanism. Some other *Berberis* species have also been evaluated for various potential pharmacological properties. *Berberis aristata* has been examined for anti-inflammatory and cardiotonic properties (Potdar et al., 2012). *Berberis vulgaris* is known to possess antioxidant (Zovko Končić et al, 2010), anti-histaminic, anti-cholinergic (Shamsa et al., 1999), and anti-inflammatory property (Ivanovska and Philipov, 1996). These results indicate that *B. lycium* Royle might also possess similar activities. Therefore, research should be directed to evaluate *B. lycium* Royle for these pharmacological properties in future. Critical evaluation revealed that pharmacological studies are deficient in the identification of active constituents responsible for pharmacological activities, therefore, more emphasis towards identification and isolation of active constituents in future studies is suggested. A serious limitation in our knowledge is the lack of clinical data and it is not yet apparent to what extent the findings about pharmacological activities are of potential clinical relevance.

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