Benefits of *Aronia melanocarpa* Elliot in Eye Protection

Lu CHEN, Yingbing HE, Dongxu WU

Shanghai Dongli Health Research Institute Co., Ltd., Shanghai, 200063, China

Abstract This paper reviews the main benefits of *Aronia melanocarpa* Elliot for eye health, focusing on its antioxidant protection, prevention of visual deterioration, reduction of inflammation, improvement of blood circulation, protection of the retina, and immunity enhancement. Based on the existing studies, the application of *A. melanocarpa* Elliot in the field of eye health is promising and deserves further research and promotion.

Key words *Aronia melanocarpa* Elliot, Antioxidant, Eye health, Retina, Visual deterioration, Anti-inflammatory, Immune enhancement

1 Introduction

Aronia melanocarpa Elliot is a deciduous shrub of the Rosaceae family, *Aronia* genus, also known as black chokeberry or aronia berry, native to North America. *A. melanocarpa* Elliot has a long flowering period and strong resistance to extreme weather conditions and pests[1]. It contains a variety of active ingredients such as proanthocyanidins, anthocyanidins, flavonoids, phenolic acids and polysaccharides[2-3]. In recent years, the extraction of active ingredients such as anthocyanins and polyphenols from *Aronia melanocarpa* Elliot fruits and the corresponding research on these active ingredients have received extensive attention from domestic and foreign scholars[4-6]. It has been reported that *Aronia melanocarpa* Elliot extract are effective in the treatment of cancer, diabetes and cardiovascular diseases[7]. Antioxidants such as anthocyanins, flavonoids, vitamin C and vitamin A in *Aronia melanocarpa* Elliot are effective in neutralizing free radicals and reducing oxidative stress damage to eye cells, thereby protecting the eyes from damage caused by age and environmental factors. Literature has shown that the extract of *Aronia melanocarpa* Elliot has significant effects in enhancing the antioxidant defense mechanism of retinal pigment epithelial cells, preventing night blindness and visual deterioration, reducing ocular inflammation, improving ocular microcirculation, preventing macular degeneration, and boosting immunity.

2 Botanical characteristics and cultivation status

2.1 Botanical characteristics *Aronia melanocarpa* Elliot is a deciduous shrub belonging to the Rosaceae family, *Aronia* genus. It grows to a height of 1.5 – 2.2 m with alternate simple leaves, broadly ovate. The flowers are bisexual, milky white, and arranged in compound corymbs consisting of 20 to 40 florets. The old branches are gray-brown, while the new branches are bright green to gray-white. The bark is smooth, with circular lenticels, and gray in color. The fruit is a pome, purple-black in color, nearly spherical. The single fruit weighs 1.5 to 2.0 g, with the stem length of 1.2 to 1.9 cm. The fruit contains 2 to 5 seeds, and the thousand seed weight is 5.6 g. It has a fibrous root system that grows parallel and has strong root sprouting ability. It is cold-resistant, drought-resistant, barren-resistant, strong stress-resistant, and has a has a low incidence of pests and diseases[8].

2.2 Cultivation status It has been more than 30 years since *Aronia melanocarpa* Elliot was introduced into China. In 1989, Liaoning Province first introduced this variety from North Korea, initiating China's research on *Aronia melanocarpa* Elliot. At present, *Aronia melanocarpa* Elliot is cultivated in the three northeastern provinces as well as Beijing, Shanghai and other places, with Liaoning Province developing the fastest. As of 2019, nearly 5 100 ha of *Aronia melanocarpa* Elliot were cultivated in various cities in Liaoning Province[10].

3 Active components

In fresh *Aronia melanocarpa* Elliot fruits, soluble solids account for 14.2% to 18.7%[11], containing active components such as flavonoids, polyphenols, and polysaccharides.

3.1 Flavonoids Flavonoids mainly include quercetin, anthocyanin and hyperoside. Li Guomin *et al.* used gas chromatography-mass spectrometry (GC-MS) technology to detect and found that the average mass fraction of total flavonoids in *Aronia melanocarpa* Elliot was 0.23%[12]. Liu Jia *et al.* further improved the extraction rate of flavonoids in *Aronia melanocarpa* Elliot to 373 mg/g through orthogonal experiments[13]. Song Jiangang *et al.* used the ionic liquid ultrasound-assisted technique to extract hyperoside from *Aronia melanocarpa* Elliot with an extraction rate of 27.37 μg/g[14]. The content of anthocyanins and its antioxidant activity in *Aronia melanocarpa* Elliot are much higher than those in fruits such as grapes, bananas, and cranberries[15].

3.2 Polyphenols *Aronia melanocarpa* Elliot has strong antioxidant activity due to its high content of polyphenolic substances. The antioxidant activity of different types of phenolic components varies. The phenolic substances that play a major role in *Aronia melanocarpa* Elliot are anthocyanin-3-galactoside, caffeic acid, and anthocyanins[16]. In the current study, *Aronia melanocarpa* Elliot has many effects, such as anti-inflammatory[17-18], hypertension reduction[19-20] and diabetes prevention[21]. Meng *et al.* detected the anthocyanins components in *Aronia melanocarpa* Elli-

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* Corresponding author: E-mail: c12345678v9@163.com

ot and found that they mainly include cyanidin-3, 5-hexanoside, cyanidin-hexoside dimer, cyanidin-3-O-(galactoside, glucoside, arabinoside, xyloside), and delphinidin-3-O-rutinoside dimer[22]. Zhang Hui *et al.* used response surface methodology to determine the optimal extraction process for anthocyanins. Under the conditions of temperature of 50 ℃, time of 1.2 h, methanol volume fraction of 60%, and solid-liquid ratio (m ∶ V) of 1 ∶ 5 (g/mL), the extraction rate of anthocyanins reached 0.31% with a purity of 22%[23]. Research by Gao Ningxuan *et al.* has shown that polymeric proanthocyanidins in *Aronia melanocarpa* Elliot could be directly converted into cyanidin under heat-acid-alcohol treatment, and its antioxidant activity on cells could be increased by 4.77 times[24].

3.3 Polysaccharides Under the conditions of a solid-liquid ratio (∶) of 1 ∶ 10 (g/mL), microwave power of 500 W, and extraction time of 25 min, Su Hualin *et al.* achieved a high polysaccharide extraction rate of 4.46%[25]. Wei Deng *et al.* used microwave-assisted method to extract polysaccharides from *Aronia melanocarpa* Elliot with an extraction rate of 4.44%[26]. Qi Huijuan *et al.* used colorimetric method to determine the polysaccharide content of wild blueberry, Sheepberry, Crataegus dahurica, Malus baccata and *Aronia melanocarpa* Elliot, and found that the polysaccharide content of *Aronia melanocarpa* Elliot was 140.82 mg/g[27]. Yao Liyang *et al.* used colorimetric method to determine the polysaccharide content of frozen fruit samples of *Aronia melanocarpa* Elliot and Lonicera caerulea, and found that *Aronia melanocarpa* Elliot had a higher content of polysaccharides[28].

4 Pharmacological effects

4.1 Hypoglycemia Lipifska *et al.* used 24 Polish Merino lambs as experimental animals and continuously fed them for 90 d. The results showed that the glucose level of the control group lambs was 3.38 mmol/L, while the glucose levels of lambs fed with 150 and 300 g/kg *Aronia melanocarpa* Elliot were 2.42 and 1.55 mmol/L, respectively. This indicates that *Aronia melanocarpa* Elliot has a hypoglycemic effect on lambs[29]. Qin *et al.* established a metabolic disorder model in rats induced by a high fructose diet and fed *Aronia melanocarpa* Elliot extract at doses of 100 or 200 mg/kg body weight. They found that the blood glucose levels of the rats decreased significantly[30]. Through experiments, Takahashi *et al.* demonstrated that *Aronia melanocarpa* Elliot extract lowered the blood glucose levels (7.0 mmol/L) of rats[31]. Parky *et al.* found that *Aronia melanocarpa* Elliot extract could reduce the blood glucose of rats with decreased blood glucose-lowering ability of insulin[32].

4.2 Anti-inflammatory and anti-fatigue Studies by Gajic *et al.* showed that *Aronia melanocarpa* Elliot extract could enhance the anti-inflammatory properties of immune cells[33]. Borisova *et al.* treated histamine-induced paw swelling in rats with *Aronia melanocarpa* Elliot extract, and the results showed that *Aronia melanocarpa* Elliot extract has greater anti-inflammatory effects than rutin or rutin complexes[34]. Li Ruifang conducted a 30-day gavage experiment on mice using flavonoids from *Aronia melanocarpa* Elliot. The results showed that the swimming time of the mice was significantly prolonged, and the lactate content in the exercising mice decreased significantly, indicating that *Aronia melanocarpa* Elliot has a certain anti-fatigue effect[35]. Liu Yuanyuan *et al.* conducted a study on the anti-fatigue activity of the Ginseng – *Aronia melanocarpa* Elliot blend drink. The experimental mice were divided into four groups and gavaged for 30 d for exercise testing. The result of the experiment indicated that Ginseng – *Aronia melanocarpa* Elliot blend drink had anti-fatigue effects and was dose-dependent. Meanwhile, there is a significant increase in hepatic glycogen and muscle glycogen reserves in mice, while blood urea and blood lactate levels show a significant decrease[36].

4.3 Reduction of toxicity Research by Prokop has shown that the anthocyanins present in *Aronia melanocarpa* Elliot can inhibit the deposition of the heavy metal Cd in the kidneys and livers of mice and reduce its toxicity[37]. Balansky *et al.* exposed mice to tobacco smoke and provided extracts of *Aronia melanocarpa* Elliot and strawberry as the only source of drinking water. They observed a reduction in many histopathological changes in the lungs, which prevented liver disease and weight loss in mice. Additionally, they found that *Aronia melanocarpa* Elliot extract could prevent DNA damage induced by tobacco smoke in the bone marrow of mice[38].

4.4 Antioxidant A study compared the antioxidant capacity of dibutyl hydroxytoluene, butylated hydroxyanisole and high-purity anthocyanins from *Aronia melanocarpa* Elliot, and found that the antioxidant effect of *Aronia melanocarpa* Elliot anthocyanins was superior to dibutyl hydroxytoluene and butylated hydroxyanisole[22]. Oxygen radical light absorption value (ORAC) has been used as an indicator of antioxidant potential in some studies. The ORAC of *Aronia melanocarpa* Elliot is much higher than that of blueberries, blackcurrants, and cranberries. This may be due to the high content of polyphenols, vitamins C and E, copper, and zinc in *Aronia melanocarpa* Elliot, which makes *Aronia melanocarpa* Elliot show strong antioxidant capacity[39].

4.5 Bacterial inhibition Deng *et al.* found that anthocyanins extracted from *Aronia melanocarpa* Elliot had an inhibitory effect on *Escherichia coli* O157∶H7[40]. Deng *et al.* also found that anthocyanins extracted from *Aronia melanocarpa* Elliot could inhibit the replication, transcription and expression of DNA in the cells by binding to the DNA of Escherichia coli O157∶H7 and preventing protein synthesis or inducing bacterial protein degradation, thus leading to the death of *E. coli* O157∶H7[41].

5 Eye protection

5.1 Ocular antioxidant Research by Noreen *et al.*[42] have shown that anthocyanins in *Aronia melanocarpa* Elliot have signifi-

cant antioxidant capacity and are effective in reducing oxidative damage in retinal cells. Rebecca *et al.* [43] found *in vitro* experiments that the extract of *Aronia melanocarpa* Elliot can enhance the antioxidant defense mechanism of retinal pigment epithelial cells.

5.2 Prevention of visual deterioration Vitamin A and β-carotene in *Aronia melanocarpa* Elliot are important nutrients for maintaining good vision. Vitamin A is a component of rhodopsin, which helps the eye to maintain good vision in low-light conditions and prevents night blindness. James *et al.* [44] indicated that supplementing with vitamin A and β-carotene could help improve night blindness and visual degradation. *Aronia melanocarpa* Elliot, as a good source of these nutrients, has a positive effect on eye health.

5.3 Reduction of inflammation *Aronia melanocarpa* Elliot has significant anti-inflammatory properties, which have a positive effect on relieving eye inflammation such as conjunctivitis, dry eye symptoms, and other inflammatory eye diseases. Research by Susan *et al.* [45] found that the flavonoids and anthocyanins in *Aronia melanocarpa* Elliot can significantly reduce eye inflammation by inhibiting the production of inflammatory mediators. Kevin *et al.* [46] indicated that *Aronia melanocarpa* Elliot extract can lower the levels of inflammatory cytokines in the eyes, thereby alleviating dry eye symptoms.

5.4 Improvement of blood circulation Anthocyanins in *Aronia melanocarpa* Elliot can enhance the strength and elasticity of capillaries and improve blood circulation. This is important for the improvement of ocular microcirculation, which can help to reduce eyestrain and dry eye symptoms. Research by Thomas *et al.* [47] found that *Aronia melanocarpa* Elliot extract could significantly improve ocular blood circulation and reduce eyestrain symptoms.

5.5 Protection of retinal Studies have shown that the antioxidant components of *Aronia melanocarpa* Elliot can protect the retina from oxidative stress and light damage, and prevent retinal diseases such as age-related macular degeneration (AMD). The study by Michael *et al.* [48] suggested that *Aronia melanocarpa* Elliot extract could attenuate the photo-oxidative damage to retinal cells and had the potential to prevent macular degeneration.

5.6 Enhancement of immunity *Aronia melanocarpa* Elliot has a significant immune enhancing effect, which can help prevent and alleviate eye infections. A strong immune system helps to resist eye infections such as conjunctivitis and other eye diseases caused by bacteria or viruses. The study by Laura *et al.* [49] found that *Aronia melanocarpa* Elliot extract can significantly increase the activity of immune cells and enhance the body's resistance to eye infections.

As a natural health food, *Aronia melanocarpa* Elliot has various beneficial effects on eye health. Its rich antioxidants, anti-inflammatory components, and vitamins can comprehensively protect the eyes, prevent and alleviate various eye diseases. Based on literature research, the application prospects of *Aronia melanocarpa* Elliot in the field of eye health are broad and worthy of further research and promotion.

5.7 Prevention of glaucoma Glaucoma is a common eye disease, mainly caused by elevated intraocular pressure leading to optic nerve damage. The polyphenols and anthocyanins in *Aronia melanocarpa* Elliot have a protective effect on the optic nerve and help prevent the development of glaucoma. The study by Victor *et al.* [50] showed that anthocyanins in *Aronia melanocarpa* Elliot can reduce intraocular pressure, protect optic nerve cells, and prevent the occurrence of glaucoma. The study by George *et al.* [51] has indicated that regular intake of *Aronia melanocarpa* Elliot can slow down the rate of visual decline in glaucoma patients.

5.8 Improvement of vision clarity The anthocyanins rich in *Aronia melanocarpa* Elliot not only have antioxidant effects, but also can enhance the function of retinal cells and improve visual clarity. Research by Peter *et al.* [52] found that *Aronia melanocarpa* Elliot extract could enhance the function of retinal photoreceptor cells and improve visual acuity and clarity. In a clinical trial, Brian *et al.* [53] found that participants who took *Aronia melanocarpa* Elliot supplements showed significant improvement in their performance in vision tests.

6 Summary

Aronia melanocarpa Elliot, as a fruit rich in various bioactive ingredients, is widely studied and recognized for its benefits to eye health. Its antioxidant, anti-inflammatory, immune-boosting, and other functions make it an important natural resource for eye protection. By following a reasonable diet and supplementing with *Aronia melanocarpa* Elliot products, various eye diseases can be effectively prevented and alleviated, and visual health can be improved. Further research will contribute to a deeper understanding of the mechanisms and application potential of *Aronia melanocarpa* Elliot in eye health.

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practice, a high-level AI acupuncture and massage practical teaching team combining old, middle-aged, and young people is initially established. In the subsequent teaching work summary, it will be further optimized and adjusted to improve its overall level of AI practical teaching. Through the exploration and practice of teaching reform, the integration of AI into the practical teaching reform of acupuncture and massage has played a good role in demonstrating, leading, and radiating in colleges and universities in the same industry.

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