Chapter

Anthocyanins: Novel Antioxidants in Diseases Prevention and Human Health

Shang Yazhen, Wang Wenju, Zhu Panpan, Ye Yuanyuan, Dai Panpan, Zhao Wusen and Wang Yanling

Abstract

Anthocyanins are a category of water-soluble natural pigments that exist widely in all kinds of vegetables, fruits, and seeds. In fact, the chemical nature of anthocyanins is a group of compounds, and possesses antioxidant capacity like flavonoids. Anthocyanins show antioxidant activity by scavenging free radicals, activating antioxidant enzyme, and chelating metal ions. Anthocyanins, therefore, are recognized as one of the most effective natural antioxidant in the human body. Anthocyanins for a variety of disease prevention and health care are closely related to their strong antioxidant activity and scavenging free radical ability. The present chapter reviewed anthocyanins eliminating free radicals for preventing neoplasm, modulating antioxidant enzyme for preventing Alzheimer's disease, losing weight for preventing diabetes, regulating lipid metabolism for preventing cardiovascular disease, and inhibiting photoreceptor apoptosis for treating xerophthalmia and for other diseases treated. In addition, some healthy food added of anthocyanins was used as precaution for some diseases, else, there are some cosmetics added with anthocyanins, including sunscreen, creams, mouthwash, and shampoo. Specific creams for characteristics of Chinese old people skin in Chinese Company were developed and achieved anti-wrinkle and moisturizing efficacy. Simultaneously, anthocyanins can also be as a food additive to lactic acid milk, cakes, and other food.

Keywords: anthocyanins, antioxidants, disease prevention, human health

1. Introduction

Anthocyanins, also known as anthocyanidins, contain acidic and alkaline groups. It belongs to flavonoid compounds with phenolic substances. They exist in various plants in the form of water-soluble natural pigments, and they are the main colorant of plants. Anthocyanins are widely found in flowering plants (angiosperms) of 27 families of 72 species and major 6 anthocyanins, such as *Pelargonium hortorum* pigment, *Centaurea cyanus* L. pigment, *Consolida ajacis* (L.) schur pigment, and other anthocyanins pigment to be found in these plants [1]. In the present, many studies have indicated that anthocyanins are the most effective antioxidants, and their antioxidant property is 50 folds higher than vitamin E and 20 times higher than vitamin C [2]. Anthocyanins, as a natural antioxidant, have

been widely used in the medical treatment, health care, cosmetology, and food supplement and especially in human health and disease prevention.

2. Type and structure of anthocyanins

Anthocyanins are kinds of water-soluble natural pigment of flavonoids, and its molecular glycosylation type, position, and hydroxyl number are the main basis for distinguishing different anthocyanins. Right now, there are more than 20 kinds of anthocyanins known in plants [3], whose basic carbon skeleton is C6-C3-C6 with cationic structure of 3,5,7-trihydroxy-2-phenyl benzopyrane (**Figure 1**). Six anthocyanins of them are the most common, including *Centaurea cyanus* L. *anthocyanin*, *Consolida ajacis* (L.) Schur *anthocyanin, Petunia hybrida* (J.D. Hooker) Vilmorin *anthocyanin, Pelargonium hortorum Anthocyanin*, *Paenonia lactiflora Pall anthocyanin*, *and Malva sinensis* Cavan *anthocyanin* (**Figure 2**). The hydroxyl group in anthocyanins exists in the form of cationic ions in the cell solution in a lower pH value and shows a strong antioxidant capacity [4, 5]. Anthocyanins are highly contained in a lot of plants and natural medicinal materials, including grapes, apples, hawthorn, tea, peanuts, purple potatoes, and ginkgo. In addition, proanthocyanidins are also found in grape juice, red wine, chocolate, and beer [6]. Proanthocyanidins can convert into the anthocyanins by heating in an acidic medium. Under natural conditions, free anthocyanins are extremely rare and often exist in combination with a single or multiple glucose, rhamnose, or galactose to form glucoside, namely, anthocyanins [7]. It is in fact that anthocyanins are the primary pigment group of plant color, which produces a wider range of colors, ranging from light yellow to violet [8]. The double bonds and polyhydroxyl structure of anthocyanins are the foundation of their antioxidant activity.

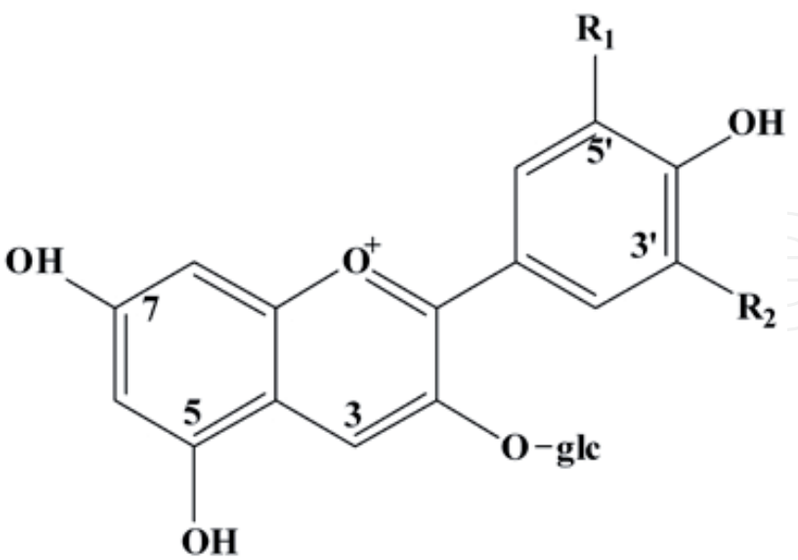

Figure 1.
The basic structure of anthocyanin.

3. Antioxidant activity of anthocyanins

Free radical is an uncoupled electron group or atoms that can independently exist, including superoxide anion radicals, hydroxyl radicals, lipoxyl radicals, nitric

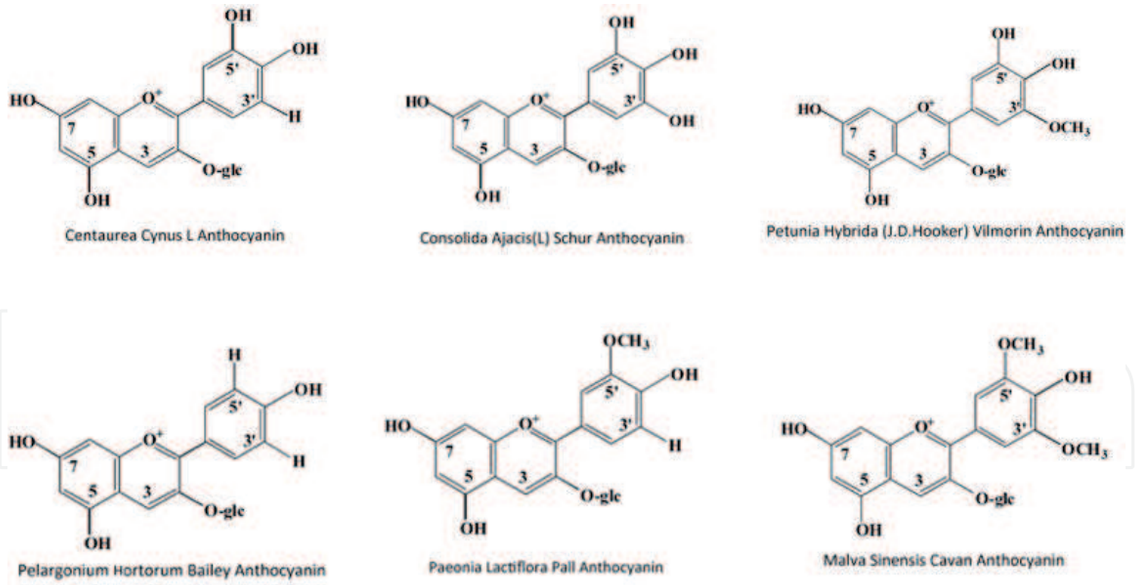

Figure 2.
The structure of anthocyanin.

oxide radicals, and other radicals. Free radicals are the normal metabolic products in an organism and also undertake the important function such as being responsible for transferring energy in the redox process of organism substance metabolism. However, the production of free radicals may be increased due to light, heat, radiation, and other factors. The excessive free radicals in the body are unstable and can capture the electron and show a strong oxidative ability and destroy the cell membrane, proteins, DNA, RNA, and other molecules, finally, which may result in aging and various diseases.

Oxygen free radicals, produced by oxidation respiratory chain, have a strong oxidation property [9]. The first way to remove oxygen free radicals is dependent on the endogenous free radical scavenging system in the body, which includes superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GSH-Px), and other antioxidants. The related reactions are as follows [10]:

- SOD catalyzes superoxide anion radicals to produce hydrogen peroxide and oxygen (**Figure 3**).
- CAT catalyzes hydrogen peroxide to produce oxygen and water (**Figure 4**).
- GSH-Px catalyzes the reduced GSH to form oxidized GSH (GSSG) and two molecular waters (**Figure 5**).

In addition, there are other antioxidants such as reduced GSH, vitamin C, and vitamin E, which can also scavenge free radicals. These antioxidant enzymes and antioxidants can effectively eliminate free radicals to form lines of defense to prevent free radicals attacked to the body and maintain the balance of free radicals and finally to ensure the health of the body.

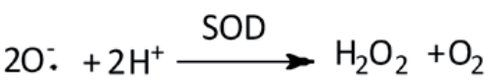

Figure 3.
Catalytic reaction of SOD.

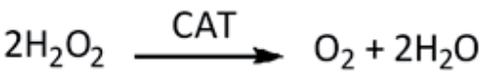

Figure 4.
Catalytic reaction of CAT.

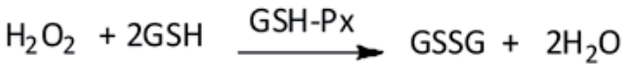

Figure 5.
Catalytic reaction of GSK-Px.

When there is an abnormal increase of free radicals in the body for some reasons, the body is unable to maintain its balance. The exogenous free radicals scavenger is needed to supplement and to help maintain the balance of free radicals to the body. The additional exogenous reduced antioxidants are oxidized by the increased free radicals and prevent the abnormal increased free radicals to attack the biomembrane and other bio-molecules. A series of studies have shown that anthocyanins exhibit its antioxidant activity from three aspects: the first is to directly scavenge free radicals, another is to regulate the activity of antioxidant enzymes, and the third is to chelate with metal ions. These three properties of anthocyanins are derived from the strong reducibility of the polyhydroxyl structure of anthocyanins. Many studies indicated that the ability of *Morus alba* L. anthocyanin, *Glycine max* (L) *Merr* anthocyanin, and *Bletilla striata (Thunb) Reichb.f.* anthocyanin for removing oxygen free radicals and hydroxyl free radicals was positively correlated with the content of anthocyanins, and their effects were higher than Vc [11–13]. Proanthocyanidins isolated from *Hippophae rhamnoides* L. and *Nelumbo nucifera* Gaertn can reduce malondialdehyde (MDA) level in serum and skin tissue of healthy rats, raise SOD and GSH-Px activities in serum and skin tissue, and significantly alleviate the liver lipid peroxidation injury by CCl4 [14]. In addition, metal ions, especially Fe^{2+}, can catalyze the transformation of oxygen radicals into hydroxyl radicals. When a substance can chelate with metal ions, the transformation from oxygen radicals to hydroxyl radicals can be blocked. Moreover, some anthocyanins have the ability to chelate with metal ions and play an antioxidant role. Procyanidins possess the "catechol" structure [10] and can strongly chelate with metal ions. The result of chelation is procyanidins can decrease free radical production from Fenton and Haber-Weiss reaction which is dependent on the necessary iron ions. Procyanidins block the free radical chain reaction and exert a strong antioxidant property. Oxygen free radical reacts with unsaturated fatty acids of the cell membrane to produce lipid peroxidation and the product to be MDA. MDA has a high toxicity and strong destructiveness to the cell membrane, which can change the cellular membrane fluidity and permeability and abnormal inside and outside ion distribution of cells and then destroy the function of various tissues and organs, which eventually leads to the cell irreversible damage and serious diseases. The polyhydroxyl structure of anthocyanins makes them have strong reducibility, which can play an important role in human health care and disease prevention by scavenging free radicals, regulating antioxidant enzyme activity and chelating metal ions in the body.

4. Effects of anthocyanins in the prevention and treatment of diseases

4.1 Antitumor effects of anthocyanins

Environmental pollution, excessive intake of junk food, irregular life, and other bad habits can lead the human body to induce certain carcinogens. The cancerogens

are metabolized and activated to produce free radicals to attack DNA to cause cancer; whereas, the carcinogenic ability of cancerogens is positively correlated to their ability of free radicals produced. At present, it has been confirmed that the increase of oxygen free radical and the change of antioxidant enzyme activity can result in the occurrence of tumors. Moreover, tumor patients usually show the imbalanced oxidoreduction state in the body and the interaction between tumors and antioxidant systems. Studies have shown that anthocyanins can exert antitumor activity by an antioxidant. The in vitro and in vivo experiments have exhibited that anthocyanins inhibit proliferation of tumor cell and development of tumor. The antitumor mechanism of anthocyanins may be related to their effective antioxidant capacity and cyclooxygenase inhibited. It is reported that *Nelumbo nucifera* Gaertn proanthocyanidins inhibited the colony formation and growth of melanoma B16 cells by a dose-dependent manner [15]. The in vitro studies by He et al. found that proanthocyanidins inhibited the proliferation of human colon cancer cell line SW620 in a concentration-dependent manner and activated the mitochondrial apoptosis pathway to promote the apoptosis of SW620 cells [16]. Many studies reported that proanthocyanidins can inhibit the proliferation and promote the apoptosis of SKOV3 cells by decreasing the expression of survival protein survivin and fight against the *Croton tiglium*-induced mouse skin papilloma formation and lessen tumor number and occurrence. Its mechanism of action is that proanthocyanidins can lower the content of NO of the skin in mice, and NO is regarded to be involved in the formation of dermal papilloma in mice [17, 18]. Studies by Zhang found that proanthocyanidins have a strong radiation sensitization action in SPC-A-1 cells of lung cancer [19]. In addition, proanthocyanidins showed good anticancer activity for liver cancer, prostate cancer, skin cancer, and other cancers. With the deepening of the research, proanthocyanidins will play a greater role in the prevention and treatment of cancer [20].

4.2 Anti-dementia effects of anthocyanins

A large number of studies have shown that the oxidative stress response is involved in the pathophysiologic process of Alzheimer's disease (AD) and a large amount of free radicals produced in AD patients' brain. If the large amount free radicals cannot be removed immediately, they will cause the lipid peroxidation of protein, nucleic acid, and other biomolecules and result in the neuronal apoptosis and aggravate the disease development of AD. *Lycium barbarum* L. anthocyanins can improve the mimic AD model rat memory impairment, increase the activity of antioxidant enzymes (SOD and CAT) and GSH content, and reduce MDA and protein carbonyl levels of serum and brain tissues [21]. Other experimental studies have confirmed that grape seed proanthocyanidins can prevent excessive production of β-amyloid protein (Aβ) in the brain and reduce cognitive decline with AD model rats and *Solanum tuberosum* anthocyanins ameliorate domoic acid-induced cognitive dysfunction, which may be used to the treatment of cognitive impairment caused by excitotoxicity and other brain diseases. *Solanum tuberosum* anthocyanins can also inhibit the nerve inflammation by blocking ERK, JNK, and NF-KB signals and show therapeutic effect on the acute encephalitis induced by lipopolysaccharide (LPS) in rats [22, 23].

4.3 Effects of anthocyanins in treatment of diabetes

Diabetes is a lifelong disease, and its incidence rate increases with the age, which seriously disturbs the quality of life to people. Studies have shown that the occurrence and development of diabetes are closely related to the abnormal metabolism

of free radicals in the body. Oxidative stress, deposition of glycosylated end products, and changes of vascular structure and function are all contributed to the increase of free radicals. Anthocyanins have antioxidant activity and can prevent and treat diabetes. Many studies showed that grape seed proanthocyanidin extract (GSPE) could significantly lower the blood glucose and glucose tolerance, increase the body quality, decrease the serum MDA level and increase the SOD activity to the mimic diabetic mice, inhibit fat deposition, and lower blood lipid to the fatty mice. Proanthocyanidins regulate fatty metabolism in mice by commonly influencing the expression of lipid metabolism-related genes, glucose, and insulin tolerance [24–26]. A series of studies by Bao et al. found that GSPE could improve renal function injury caused by diabetes and could improve the symptoms of diabetic nephropathy by antioxidative stress and inhibiting inflammation [27]. These studies suggest that GSPE have a strong hypoglycemic effect, and its hypoglycemic mechanism may be associated to its antioxidant capacity.

4.4 Effects of anthocyanins in preventing cardiovascular diseases

In recent years, cardiovascular diseases have become the common diseases that endanger human health. With the deepening of the research on oxygen free radicals in diseases, a large number of data have confirmed that the oxidative reactions mediated by free radicals and their products play an important role in the occurrence and development of cardiovascular diseases. As people age, the elastic fibers of arteries harden as they are oxidized, and the change is a major cause of cardiovascular disease in aging people. Proanthocyanidins mainly play an important role in preventing cardiovascular diseases by inhibiting the formation of artery atherosclerotic plaque and reducing the damage of free radicals induced by myocardial ischemia for protecting myocardial cell activity. Proanthocyanidins can protect blood vessels and reduce capillary permeability, and its function of preventing cardiovascular diseases is closely related to its antioxidative stress. Some results indicated that grape seed proanthocyanidins can effectively reduce the levels of LDL and cholesterol and the generation of MDA [28]. In addition, GSPE can protect vascular substances by capturing ROS and regulating enzyme activity [29]. Anthocyanins extracted from red wine can effectively remove superoxide free radicals and hydroxyl free radicals. The in vitro experiments indicated that anthocyanins can significantly inhibit the oxidation of LDL and the aggregation of platelets [30]. The animal and clinical studies have also found that proanthocyanidins can reduce blood pressure by lowering cholesterol level, reducing cholesterol deposition on blood vessel walls and improving vascular elasticity [31]. Some studies showed that *Nelumbo nucifera* Gaertn proanthocyanidins can increase the SOD activity of myocardial cells during ischemia reperfusion and reduce the production of MDA, thereby inhibiting apoptosis and protecting myocardial ischemia reperfusion [32]. Studies by Suda I et al. showed that anthocyanins from *Solanum tuberosum* can be absorbed by rats, enhance the antioxidant capacity of plasma, and play an important role in protecting cardiovascular system [33].

4.5 Protective effects of anthocyanins on liver and kidney

Studies have shown that gluttony can harm gastrointestinal tract, liver, and kidney as large amounts of free radicals are produced. Removing these deteriorated free radicals timely can protect liver cells and improve liver function. When fatty liver occurs, free fatty acids, oxidative stress, and free radicals are increased, which lead to the degeneration of proteins, DNA, and lipid in liver cells and lower the immunity. *Solanum tuberosum* anthocyanins were proven to alleviate liver injury caused by dimethylnitrosamine (DMN), protect the liver function, and resist

liver fibrosis [34]. In addition, *Solanum tuberosum* anthocyanins can also activate adenosine monophosphate to sensitize the protein kinase and inhibit liver fatty accumulation [35]. The results by Zhang et al. were also reported that anthocyanins from *Solanum tuberosum* can alleviate insulin resistance in liver caused by high-fat diet, and the effective mechanism is that anthocyanins can block oxidative and endoplasmic reticulum stress [36]. Studies showed that anthocyanins of *Solanum tuberosum* can inhibit oxidative stress in the kidney, and the molecular mechanism was to inhibit the activation of NLRP3 signaling pathway of inflammasome [37]. Studies by Sun et al. reported that *Solanum tuberosum* anthocyanins have a preventive effect on acute and subacute alcoholic liver injury and indicated that *Solanum tuberosum* anthocyanins have a certain antialcoholic effect [38].

4.6 Anti-inflammatory effects of anthocyanins

Inflammation is the body's defense against stimuli, which is usually to be regarded as beneficial but sometimes to be as harmful. The acute inflammation is a short-term self-limiting process, and the chronic systemic proinflammatory state can result in insulin resistance, atherosclerosis, type II diabetes, metabolic syndrome, cardiovascular disease, cancer, neurodegenerative disease, and other diseases [39]. When the body is in the acute inflammation, macrophages can effectively eliminate foreign materials by producing a large number of oxygen free radicals in a short time. However, when the acute inflammation changes into the chronic inflammation, the generation of reactive oxygen species (ROS) is out of control and dramatically increases, which will promote the inflammatory factors activated, aggravate the inflammatory response and gene mutations, and finally result in the occurrence of cancer [40]. Therefore, it is the important link to maintain the balance of free radicals and regulate the activity of SOD in the body against the inflammation [41]. Many studies indicated that anthocyanins showed strong anti-inflammatory activity in both in vivo and in vitro, and their effective mechanism may be the ability to remove ROS and regulate SOD activity [42]. Anthocyanins from *Ligustrum x vicaryi* Hort can inhibit the mice's auricle swelling induced by xylene, raise the serum SOD activity of mice, and then exert its anti-inflammatory and analgesic properties. Studies by Kim et al. found that anthocyanins from *Glycine max* (L) *Merr* can inhibit ROS level in human gastric epithelial cells infected by *Helicobacter pylori* and in a dose-dependent manner, and the inhibition was significant [43]. In conclusion, anthocyanins have been proven to express high antioxidant properties, and the anti-inflammatory effect is primary from its inhibiting ROS production and enhancing SOD expression [39].

4.7 Effects of anthocyanins in the male reproductive system

Smoking, drinking, staying up late, or genital tract infections, exposing to the phenols chemicals, heavy metals, and the external environmental high ionizing radiation, may significantly increase free radicals production in the male reproductive system. The high free radicals can cause many diseases to the reproductive system in the male. GSPE, as a highly effective antioxidant, plays an important role in the prevention and treatment of related male reproductive diseases. GSPE can antagonize the reproductive toxicity of male mice caused by heavy metals, fluorine, and semicarbazide, enhance the sperm survival rate, and reduce the sperm malformation rate. It is also confirmed that GSPE can increase the activity of lactate dehydrogenase X and glutamyl transpeptidase in the mice's testis of semicarbazide infected and reduce the activity of acidic phosphatase, in which it is proven that GSPE possesses a good repaired function for the testis injuries. In addition, GSPE

can elevate the SOD activity of testicular tissue induced by testicular torsion reduction, decrease the MDA level, and appear to be an obvious protection to mice reproductive function injury. Meanwhile, GSPE can also inhibit the spermatogenic cells apoptosis in experimental cryptorchidism male rats, and the effective mechanism is also derived from the antioxidant capacity of GSPE [44].

4.8 Applications of anthocyanins in ophthalmology

With the popular of various electronic devices such as mobile phones, computers, and LED lights, the blue light harm is the more and more to people. The long-term blue light irradiation to retina can cause a lot of free radicals produced. These free radicals can result in retinal pigment epithelial cell apoptosis, intraocular metabolic abnormalities, toxin trash accumulation, and hindering of the blood circulation, which cause myopia, cataracts, macular degeneration, ocular fundus diseases, vitreous opacity, floaters, retinopathy, and other eye diseases. Proanthocyanidins can effectively eliminate oxygen free radicals, which is beneficial to the treatment of ophthalmological diseases. Studies showed that anthocyanins can significantly improve visual fatigue and the early myopia and the distant vision of mild myopia [45]. This result indicated that proanthocyanidin eye drops have good effect for the treatment of xerophthalmia [46]. Muthenna et al. also provided that *Cinnamomum cassia* Presl proanthocyanidin extract B2 can improve the cataract of diabetic rats, ameliorate the optic nerve blood perfusion, and block the optic nerve cell apoptosis induced by ischemia. The possible effective mechanism of anthocyanins is that anthocyanins have a strong scavenging ability for free radical and inhibiting intracellular calcium overload and then protect the optic nerve structure and function [47]. In addition, anthocyanins also have therapeutic effects to glaucoma, in which the effective mechanism of anthocyanins is both removing free radicals and reducing intracellular calcium overload and also is related to the enhancement of SOD activity. Furthermore, anthocyanins can alleviate further injury of the optic nerve in the eye surgery, which is also associated to raising SOD activity [48, 49].

5. Functions of anthocyanins in health care and cosmetology

5.1 Enhancements of anthocyanins in the immune system

Free radicals attack the immune system or lymphocytes to damage them, which can result in the decline of cell-mediated immunity and humoral immunity. Free radicals also lead to the decline of immune recognition and the emergence of autoimmune diseases. Studies by Gabriela et al. showed that GSPE can improve the immune suppression induced by ultraviolet irradiation in mice, which may be one of the mechanisms by which GSPE inhibits the light of carcinogenesis [50]. By regulating the differentiation of inflammatory T cells, GSPE can reduce the secretion of interleukin IL-17, IL-21, IL-22, IL-26, and other cytokines and reduce the incidence of inflammation and diseases [51]. Studies showed that proanthocyanidins from *Hippophae rhamnoides* L seed could significantly increase the mice immunity, enhance the mice carbon clearance ability, raise the mice T lymphocyte activity, and promote the hemolysin formation [52]. Hao et al. added proanthocyanidins extracted from *Sorghum* to the feed of ablactation piglets. The IgG, IgM, C3, and IL-2 concentrations of piglets serum significantly increased, which was conducive to improving piglets immunity [53]. In addition, The Institute of Shanghai Nonghao Biological Technology, which studied proanthocyanidins from *Pinus tabulaeformis* Caar as a feed additive, found that proanthocyanidins have antigenic properties,

produce specific immune responses, improve the immune function, and reduce the incidence of livestock and poultry [54].

5.2 Antiaging effect of anthocyanins

Senescence is a complex physiological process. As early as 1956, Harmon proposed the free radical theory of senescence [55], which believed that the senescence was primarily caused by the attack of free radicals to cell components, and then maintaining the balance of antioxidants and free radical scavengers in the body could delay senescence. There are many studies indicated that proanthocyanidins can obviously reduce the generation of spontaneous MDA in liver and brain tissue of rats and have a significant antagonistic effect in liver lipid peroxidation induced by free radical initiators CCl_4, H_2O_2, and iron ions, lower the depletion of GSH in liver tissue, and reveal obviously anti-lipid peroxidation and free radicals' scavenging ability [56]. The result by Sato et al. reported that GSPE can promote the recovery of cardiac systolic function and decrease the area of myocardial infarction after ischemia reperfusion and the possible mechanism of this proanthocyanidins are related to directly removing peroxide free radicals, enhancing SOD activity, decreasing MDA level, and inhibiting the damage from free radical lipid peroxidation to myocardial membrane [57]. Proanthocyanidins, as natural antioxidants, can alleviate the aging of the body by adjusting the free radical oxidation system [58].

5.3 Effects of anthocyanins on cosmetology and skin care

Young people's skin is nutritious and white than aged peoples. With the increase of age, the skin will get rougher, wrinkled, and darker and gradually senile plaques form. This is the reason why the skin has some substances, like SOD, CAT, and GSH-Px, that can prevent the skin from aging. There are other antioxidants such as vitamin E and vitamin C also to assist regulating the balance of oxygen free radical for preventing skin aging and damage. With the increase of age, the enzyme activity that removes oxygen free radical drops and the antioxidant content also drops in the skin. Then, the excessive harmful oxygen free radical is able to bring about the cell damage. If the complement of a few exogenous free radical scavengers is not immediately provided, the balance of free radical of the skin is hardly maintained, and good skin is hardly possessed [10]. The present studies indicate that proanthocyanidins are good antioxidant and have free radical scavenging abilities and also can promote the covalent cross-linking of collagen molecules, inhibit the elastase production and prevent the degradation of elastin, prevent skin aging and laxity, and reduce the excessive secretion of sebaceous glands to skin. In addition, proanthocyanidins can combine with proteins by the form of hydrophobic bonds and hydrogen bonds, which can shrink skin pores and tighten skin. Proanthocyanidins can reduce the o-benzoquinone structure of the melanin to phenolic structure to fade the pigment and inhibit the key enzyme tyrosinase phthalidomide activity of melanin synthesis to achieve white skin and decrease spot efficacy. Proanthocyanidins can absorb ultraviolet light and inhibit the process of lipid peroxidation. Supplement of external grape seed proanthocyanidins can decrease Fas protein expression and increase the skin bcl-2 protein expression after the irradiation of skin and tend the skin to normal skin status, which indicates that proanthocyanidins from grape seed can reduce the sun damage to a certain extent [59–61]. In addition, proanthocyanidins also have the effects in treating skin inflammation, moisturizing and antiaging skin. In the present, proanthocyanidins, as raw materials, are added to successfully produce the night cream, skin whitener, sunscreen, mouthwash, and shampoo in France, Italy, and Japan market [62, 63]. Proanthocyanidins isolated from grape

seeds, a face cream based on the characteristics of Chinese elderly people's skin in the Chinese market was developed, which has been proven stabile to achieve anti-wrinkle and moisturizing efficacy.

5.4 Anthocyanins for food additives

Anthocyanins, as a kind of natural food pigment, have advantages of high security and abundant resources, as well as certain nutritional and dietary functions, as compared with synthetic pigments. In recent years, people pay more and more attention to food safety and health, and then anthocyanins have shown to have more and more concern for consumers and researchers. Currently, anthocyanins have been allowed to be put into production and used natural edible pigments including grape skin pigment, berry pigment, purple sweet potato pigment, perilla pigment, cabbage pigment, purple corn pigment, and other edible pigment [2]. Anthocyanins from blueberry fruits, as natural food additives, have been widely used in the lactic acid milk, cakes, and other food.

6. Conclusions

In recent years, a large number of studies have confirmed that anthocyanins have strong antioxidant properties and anthocyanins, as safe natural pigment and effective antioxidants, have been a widely used. This chapter systematically summarizes the application of anthocyanins in human disease prevention and health care based on anthocyanins' structure and species. However, at present, there is no report upon the anthocyanins as a clinical drug used. Then, the intensive research and innovation should be performed in order that anthocyanins specifically apply to the prevention of clinical diseases and health care in the future.

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Conflict of interest

The authors report no declarations of interest.

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