Volume 3, Issue 12, December - 2025 ISSN (E): 2938-3811

THE ROLE OF ANTHOCYANINS IN LIVING ORGANISMS

Tursunov Yakhyo Bokhadirovich
Associate Professor, Department of Ecology and Sustainable Development, Andijan State University
tursunovyaxyobek029@gmail.com,

Sadiqova Zilola Shuhratbek kizi
2-nd Year Student Biology, Andijan State University
drzilolasodiqova@gmail.com

Abstract
This article highlights the chemical structure, synthesis, and specific properties of anthocyanins in color formation. In addition, the article provides information about the use of anthocyanins in the food industry and the field of medicine. The research results contribute to a deeper understanding of the practical importance of anthocyanins in plant ecology and human activity.

Keywords: Anthocyanins, pH level, Liver, Biosynthesis, Cyanide.

Introduction

Anthocyanins – are water-soluble pigments belonging to the group of flavonoids, producing various dark red, purple, and blue colors in plants. They are mainly found in flowers, fruits, leaves, stems, and in some cases, in root tissues. The ecological, physiological, and adaptive functions of anthocyanins in plant life are extremely important. **Chemical nature and classification of anthocyanins.** Anthocyanins are one of the main components of the flavonoid family, and their main structure consists of anthocyanidins. Anthocyanins are formed as a result of the glycosylation of anthocyanidins. The main types of anthocyanins: **Delphinidin** – responsible for blue-purple colors. **Cyanidin** – a red-purple pigment, found in most fruits [1].

Introductions "Anthocyanins" (from Greek *"ánthos"* – color and *"kýanos"* – attractive) are natural coloring substances. Plant substances from the flavonoid group are classified as glycosides. The term "anthocyanin" was used for the first time by Marquart in 1835. The structure of anthocyanins was created in 1913 by the German biochemist R. Willstätter. Anthocyanins regulate excessive light intensity. They absorb light in the blue and ultraviolet spectrum, preventing photooxidative stress in photosynthetic tissues. Anthocyanin pigments are now being used more and more widely. The reason for this is that anthocyanin pigments obtained from plant materials, along with serving as a coloring agent, also contain other valuable, biologically active components [11]. These include vitamins, glycosides, organic acids, aromatic substances, microelements, and others. Their use not only improves the appearance and provides an attractive, natural color, but also increases the biological value of food products containing these pigments. In this article, the anthocyanin pigment obtained from cornelian cherry by freeze-drying is examined. Its properties and changes during storage are studied. Plants are consumed by phytophages. The bright, juicy color of flowers helps plants attract insects [8]. Anthocyanins are found in large quantities in delphiniums, phlox, dark red roses, irises, and may be present in purple and blue hosta flowers [9].

The Main Part

Color changes in anthocyanins

Anthocyanins (also called anthosyanins; from Greek *ánthos* – flower and Greek *khánsos* – blue, magic) are colored plant glycosides that contain anthocyanidins as aglycone substitutes related to flavonoids in the form of 2-phenylchromes. In 1835, the German pharmacist Ludwig Clamor Marquart, in his treatise "The Colors of Flowers," for the first time gave the name anthocyanin to the chemical compound that gives flowers their blue color. They occur in plants and produce the red, purple, and blue colors of fruits and leaves. Anthocyanins belong to the parent class of molecules called flavonoids, synthesized via the phenylpropanoid pathway. They are located in all tissues of higher plants, including leaves, stems, roots, flowers, and fruits. Anthocyanins are obtained from anthocyanidins by adding sugars. They are odorless and moderately astringent [1].

Anthocyanins, which are pyrilium salts, dissolve easily in water and polar solvents, slightly in alcohol, and do not dissolve in non-polar solvents.

The formation of complexes with metal cations also affects the color; monovalent cation K^+ forms purple-colored complexes, divalent Mg^{2+} and Ca^{2+} form blue complexes, and adsorption to polysaccharides may also influence color. Anthocyanins are hydrolyzed to anthocyanidins in 10% hydrochloric acid; anthocyanidins themselves are stable at low pH values and decompose at high pH values. Anthocyanins often determine the color of flower petals, fruits, and autumn leaves. They usually provide purple, blue, pink, brown, and red colors. This coloration depends on the pH level of the cell contents. The solution of anthocyanins in an acidic medium is red, in a neutral medium is blue-purple, and in an alkaline medium is yellow-green. The color of anthocyanins may change during fruit ripening and flower fading – processes accompanied by pH changes in the cell contents. For example, lungwort buds have a pink color, while its flowers are blue-purple [3].

The effect of anthocyanins on liver cells

The liver is the "biochemical laboratory" of the body, controlling important processes such as detoxification (neutralization of harmful substances), metabolism, and bile formation. Liver function can be impaired by various factors — improper nutrition, alcoholic beverages, drugs, toxins, viruses (for example, hepatitis), or oxidative stress. Anthocyanins and their metabolites have also been identified in the liver, kidneys, lungs, eyes, and central nervous system. Anthocyanins have a protective effect on the liver, which is associated with their anti-inflammatory and antioxidant properties [6]. They protect against liver damage by reducing inflammation and oxidative stress and may help improve conditions such as non-alcoholic fatty

Volume 3, Issue 12, December - 2025 ISSN (E): 2938-3811

liver disease — particularly by reducing fat accumulation and improving liver enzyme activity. However, more scientific research is required in this area. Studies conducted on animals show that anthocyanins reduce liver fibrosis and improve signs of aging in liver cells [2].

Mechanisms of liver protection by anthocyanins

1. Antioxidant and anti- inflammatory effect:

Anthocyanins neutralize free radicals and block inflammatory pathways, which protects liver cells (hepatocytes) from damage.

2. Protection against liver injury:

Studies have shown that anthocyanins protect against acute liver injury caused by substances such as carbon tetrachloride (CCl_4). This is associated with their ability to inhibit inflammatory mediators and the excessive proliferation of Kupffer cells (immune cells in the liver).

3. Management of NAFLD (non-alcoholic fatty liver disease):

Anthocyanins reduce fat accumulation in liver tissue, improve lipid profiles, but their effects on liver enzymes are still being fully studied. Some studies have found that anthocyanins significantly reduce liver enzymes such as ALT and AST, especially when used as a primary therapeutic agent. However, further studies are needed to confirm these results.

4. Effect on liver fibrosis:

Animal studies have shown that anthocyanins reduce liver fibrosis, which occurs through the inhibition of activation and proliferation of hepatic stellate cells (HSCs).

Anthocyanins that enter the bloodstream quickly reach the liver via the portal vein. Hepatocytes convert anthocyanins into hydroxylated, glucuronidated, sulfated, and methylated derivatives. A portion of them is excreted into the intestinal lumen with bile. Then, anthocyanins and their metabolites are reabsorbed. This process is called enterohepatic circulation.

Some anthocyanins reach the large intestine, where most of the intestinal bacteria are present. Further metabolism of anthocyanins is carried out by the bacterial microflora, leading to the formation of aldehydes and phenolic acids, such as protocatechuic, vanillic, and gallic acids. In general, the amount of anthocyanin metabolites continuously increases throughout the gastrointestinal tract. Enterohepatic circulation itself contributes to this and prolongs the residence time of anthocyanins in the body. In conclusion, anthocyanins are natural compounds that protect the liver, reduce inflammation, provide antioxidant protection, and support the healthy functioning of liver tissues. However, more extensive scientific studies are required to confirm their precise clinical effects [11].

The effect of anthocyanins in food on the body.

Anthocyanins, which are biologically active compounds, belong to the class of flavonoids. They are found in various plants and give them red, blue, or purple colors. There are a very large number of different anthocyanins in nature. The most common ones are listed below:

- **Cyanidin** – responsible for the bright colors of black and red grapes, chokeberry (ejovika), cherry (vishnya), currant (boyarishnik), as well as apple, apricot, red cabbage, and red onion;
- **Nasunin** – the main anthocyanin in eggplant;
- **Peonidin** – found in purple-fleshed sweet potatoes (batat), black rice, and black bananas;
- **Petunidin** – present in blue fruits, blackcurrants, blueberries, vigna, and red grapes;
- **Pelargonidin** – gives color to raspberries, chokeberries (aronia), strawberries, as well as apricot and pomegranate fruits.

In the human body, anthocyanins act as antioxidants — they neutralize free radicals, thereby slowing the aging process and reducing cell damage that can lead to cardiovascular diseases and cancer. Additionally, they have anti-inflammatory, blood glucose-regulating (hypoglycemic), neuroprotective, and immune-enhancing effects. According to research, regularly consuming foods rich in anthocyanins — such as blueberries, black grapes, blackcurrants, raspberries, cherries, purple cabbage, eggplant, and black rice — helps maintain normal blood pressure, improves visual acuity, and supports heart function. An important point is that many scientific studies investigate not the effect of individual anthocyanins, but the overall effect of anthocyanin-rich food sources. This is because natural food sources simultaneously contain various types of anthocyanins, and the method of preparation or cooking significantly affects the composition and activity of anthocyanins. For example, Prior and co-authors studied the composition of low-growing blueberries (Vaccinium myrtillus) and identified 19 different types of anthocyanins. Their content in the fruit ranged from 1.1% to 14.4%. In addition, the harvest season and plant genotype also influence the anthocyanin profile. Therefore, it is very complex to isolate the precise effect of each individual anthocyanin on health. For this reason, further scientific research is necessary to explore the potential of anthocyanin-rich foods in maintaining the health of the aging population [2]. According to existing data, anthocyanin-rich products may be beneficial in four main areas — preventing or mitigating issues related to cardiovascular diseases, cancer, neurodegenerative diseases, and loss of bone mass [9].

In scientific sources, the table shows the main anthocyanin-rich food sources, the primary types of anthocyanins present in them, and their proven biological roles in disease prevention.

Food Source	Major Anthocyanin Types	Proposed Health Benefits
Blueberry	Malvidin, Petunidin	Increases high-density cholesterol levels, reduces total triglycerides and adiponectin levels, lowers blood pressure, inhibits tumor cell growth
Black bean	Cyanidin	Inhibits cancer cell growth, lowers cholesterol, reduces pro-inflammatory cytokine secretion
Black currant	Cyanidin, Delphinidin	Increases HDL cholesterol, improves cognitive function, increases bone mass
Red raspberry	Cyanidin, Pelargonidin	Reduces fat accumulation, inhibits cancer cell growth
Strawberry	Cyanidin	Improves blood lipid profile, suppresses cancer cell growth

Conclusion

For a long time, the biological activity of anthocyanins was considered low because their absorption and bioavailability in the body were thought to be relatively limited. However, recent studies have changed this view. Anthocyanins undergo rapid metabolic transformations, and their metabolite forms (i.e., breakdown products) exhibit active effects in the body. Therefore, their actual bioavailability is significantly higher than previously thought — exceeding 12%. After consumption, anthocyanins are primarily absorbed through the gastrointestinal tract. A portion enters the bloodstream directly, but the majority is converted by gut microbiota into phenolic acids and other biologically active compounds. It is these metabolites that exert the main physiological effects in the body.

References

1. Karimov A. Plant Physiology. – Tashkent: Uzbekistan, 2016.
2. Qosimov M. Fundamentals of Agrochemistry. – Tashkent: O‘qituvchi, 2011.
3. Tursunov Ya. Inheritance of anthocyanin color and chlorophyll content in gooseberry. – Andijan, 2022.
4. Photosynthesis and Chloroplast Selection. – Dushanbe, 2011.
5. Rakhimov S. Botany. – Tashkent: Fan va Texnologiya, 2015.
6. Islomov A. Plant Hormones. – Tashkent: Fan, 2014.
7. Tursunov A. Energy Metabolism in Plants. – Andijan, 2020.
8. Ahmad Shah Ahmadzai, Chunmei Hu, Changwei Zhang, Ying Li, Mechanisms of anthocyanin-mediated salt stress alleviation and cellular homeostasis in plants, Plant Growth Regulation, 10.1007/s10725-025-01298-3, (2025).
9. Zhang YJ, Yang QY, Lee DW, Goldstein G, Cao KF. Extended leaf senescence promotes carbon gain and nutrient resorption: importance of maintaining winter photosynthesis in subtropical forests. Oecologia. 2013 Nov;173(3):721–730. doi: 10.1007/s00442-013-2672-1. Epub 2013 May 1. PMID: 23636462.
10. Xo’jayev J.X. Plant Physiology Textbook. – Tashkent: Mehnat, 2004.
11. Gould, K. S. (2004). Nature’s Swiss Army Knife: The diverse protective roles of anthocyanins in leaves. Journal of Biomedicine and Biotechnology, 2004(5), 314–320.