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RESEARCH ON ACID-ALKALINE TRANSFORMATIONS OF ROWANBERRY (SORBUS AUCUPARIA)

ДОСЛІДЖЕННЯ КИСЛОТНО-ЛУЖНИХ ПЕРЕТВОРЕНЬ ГОРОБИНІ ЗВИЧАЙНОЇ (SORBUS AUCUPARIA)

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Abstract. *Chemical analysis showed that rowanberries (Sorbus aucuparia) contain 1950 mg/100 g total phenolics, ranking them among the highest in flavonoid content. Only chokeberries sometimes have more, with up to 5000 mg/100 g of flavonoid compounds. This study details how the sum of phenolic substances (bioflavonoids) in rowanberries changes in response to acidic and basic reagents, as measured by spectrophotometry. The findings reveal distinct spectral changes in rowan berry extracts depending on pH, indicating structural insights into the berries' bioflavonoids. The results suggest that preparations from rowan berries are particularly promising for use in functional foods, as the phenolic derivatives identified demonstrate strong antioxidant properties. Their abundance in phenolic hydroxyls suggests significant potential to enhance the antioxidant capacity and health-promoting applications of food products.*

Keywords: *rowanberry, phenolic substances, flavonoids, bioflavonoids, flavones, flavonols, antioxidants, functional foods, spectrophotometry.*

Introduction.

Rowanberries have been widely used as a medicinal remedy in both traditional and folk medicine in European countries [1]. In Poland, rowan berries were used for kidney, urinary, and gallbladder ailments, as well as diabetes. In Hungary, they were used for dysentery. In Norway, they aided wound healing. Common rowan berries have a rich, well-studied chemical composition. The main focus is on the berries' vitamin C and carotenoid content. These levels exceed those of these substances found in many fruits and vegetables. In terms of vitamin C content, the plant successfully competes with currants, tomatoes, and apples. For carotenoid content, it matches carrots and the best pumpkin varieties [2]. However, the literature lacks information on the presence of certain substances in rowan berries. These substances are now attracting attention due to their biological activity, making this raw material highly valuable in the production of functional foods. These are phenolic substances. They are found in every part of the plant – in every cell, root, leaf, berrie, and bark. Several thousand phenols are released from plants. Naturally, such common substances must perform important, vital functions. One key function is their strong capillary-strengthening effect. This is why plant phenolic substances can stop hemorrhagic bleeding and improve vascular tone, including coronary arteries.

The study of phenolic substances in plants, which makes raw materials very valuable for producing functional food products, is a pressing issue that has been studied by a number of domestic and foreign scientists [3, 4].

Flavonoids, also called bioflavonoids, are the most common group of phenolic compounds in plants. Their structure has two aromatic rings joined by a carbon-carbon bridge. The main aromatic ring is an oxygen-containing pyran heterocycle. Each part of the molecule has many hydroxyl groups as side substituents, classifying them as polyphenols [5]. Bioflavonoids have several forms with different oxidation states, which can convert into each other when exposed to oxidative or reductive reagents. A diagram shows the main bioflavonoid structures and how they transition (Figure 1).

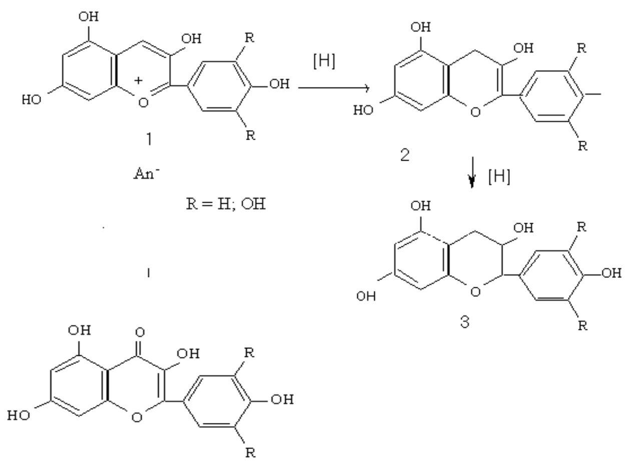

Figure 1 – Main groups of plant bioflavonoids

Source: [1]

The results of the research.

A chemical analysis found that rowanberries (Sorbus aucuparia) contain 1950 mg of phenolics per 100 g, making them among the richest in flavonoid content. Their flavonoid content is second only to chokeberry, which can reach 5000 mg/100 g. However, this value only indicates the total phenolic content, not the specific structure. To study the structure of rowan bioflavonoids, we performed spectrophotometric analyses of aqueous berry extracts at various pH levels. Bioflavonoids, with many conjugated double bonds and hydroxyl groups containing mobile hydrogen atoms, are highly sensitive to pH changes.

Spectrophotometric studies show that rowan berry bioflavonoids have two distinct absorption maxima, as is typical for these molecules [6]. As pH increases, these maxima undergo a marked bathochromic shift: at acidic pH, the maxima are at 340 and 380 nm; near neutral pH, they shift to 400 and 40 nm. Such a significant bathochromic shift occurs only with a long chain of conjugated bonds, as found in structure 1 (Figure 1), the anthocyanidin molecule. In this molecule, mutual transitions with changing pH are possible, as shown in Figure 2.

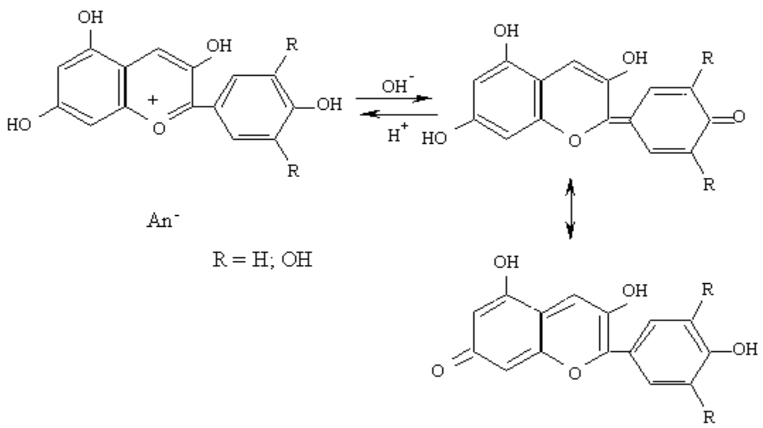

Figure 2 – Structural changes of the anthocyanidin molecule in alkaline conditions

Author's development

The detachment of a proton from one of the phenolic hydroxyls by the hydroxyl anion of an alkali forms an anhydrous base structure. This base exists in two resonant forms, which determine its stability. Anhydrous base molecules typically absorb at longer wavelengths than the corresponding salt-like structures to which anthocyanidins belong. This is even noticeable visually. When exposed to alkaline reagents, the aqueous extract from rowan berries acquires a deeper color. This confirms the presence of anthocyanidins in the bioflavonoids of rowanberries. However, anthocyanidins are known to be extremely vibrant in color compared to other bioflavonoids and are responsible for the wide range of colors in flowers and fruits. Rowanberries, on the other hand, are not very colorful compared to other fruits and berries. Their aqueous extract is also not vibrant at all. This suggests that anthocyanidins are not the main bioflavonoids in rowanberries, although they are what give rowanberries their red color.

Consider the possible presence of reduced and oxidized forms of bioflavonoids in rowanberries. The reduced forms are leucoanthocyanidins (2) and catechins (3). To confirm whether these structures are present, we conducted several chemical studies. It is known that leucoanthocyanidins are converted to anthocyanidins when boiled in the solutions of mineral acids, particularly hydrochloric acid, and the reaction mixture should then acquire a brighter color. However, boiling an aqueous extract from the berries with 10 % hydrochloric acid did not cause any color change. Instead, the mixture became paler, consistent with spectrophotometric studies. This test allows us to exclude leucoanthocyanidins from the bioflavonoid complex in rowanberries with high certainty.

The next reduced structure is catechins. Among bioflavonoids, they are the most reduced form. As strong reducing agents, they reduce oxidizing agents during reactions. One well-known mild oxidizing agent in plant research is methylene blue. When reduced, methylene blue turns into its leuco form and becomes colorless.

When we studied the reaction mixture of an aqueous extract of rowanberries and methylene blue spectrophotometrically, we observed no discoloration of the medium; the optical density did not decrease and in fact increased slightly. This observation suggests that the rowan bioflavonoid complex does not contain catechins. The increased optical density points to the presence of oxidized forms – flavones and flavonols – among the rowan bioflavonoids (4). This conclusion is further supported by IR spectra of crushed dried rowanberries, where a distinct and highly intense band at 1712 cm-1 corresponds to stretching vibrations of carbonyl groups (C=O) in the flavone ring.

Thus, all experimental studies show that oxidized bioflavonoids – anthocyanidins and flavones or flavonols – predominate in rowanberries. This indicates the berries have diverse functional properties. For example, they likely interact actively with metal cations, especially transition metals, by chelating them via reactive groups. Carbonyl and hydroxyl groups in flavones, and the positively charged heterocyclic pyran ring in anthocyanidins, enable complex formation with metals. This offers significant potential for detoxifying toxic heavy metals from water, air, and food under conditions of high anthropogenic load [7].

Conclusions.

Preparations from rowanberries (Sorbus aucuparia) show promise for functional foods. Phenolic derivatives, among the most powerful free radical inhibitors, act as antioxidants. The abundance of phenolic hydroxyls in bioflavonoids makes them promising natural antioxidants. Adding these antioxidants to foods can enhance their functional properties, providing therapeutic and prophylactic benefits.

References:

1. Research work in agronomy: teaching manual: in 2 books. Book. 1. Theoretical aspects of research work. A. O. Rozhkov, V. K. Puzik, S. M. Kalenska et al.; ed. A. O. Rozhkova. Kharkiv: Maidan, 2016. P. 167–169.

2. Kutsenko N. I. Prospects for breeding research on medicinal and essential oil plants in Ukraine. Agroecological Journal. 2016. No. 2. P. 85–92.

3. State Register of Plant Varieties Suitable for Distribution in Ukraine. Ministry of Agrarian Policy and Food of Ukraine – Official List of Varieties Suitable for Distribution in Ukraine. 2024. https://data.gov.ua/dataset/ccf95f4a-8238-4b18-a4d3-002444876325.

4. Levenspiel, O. (2016). Inzheneriya khimichnykh reaktsiy [Chemical reaction

engineering]. New York: USA. 450 p.

5. Simakova, O., Korenets, Yu., Yudina, T., Nazarenko, I., Goriainova, Iu. (2018). Examining a possibility of using purple amaranth in the technology for products made of yeast dough. Eastern European Jornal of Enterprise technologies: Technology and equipment of food production. Vol. 2, no. 11 (92). P. 57–64. doi: 10.15587/1729-4061.2018.127173.

6. Simakova, O.O., Nykyforov, R.P. (2018). Rozrobka novitnikh tekhnolohii vyrobiv z boroshna s zadanymy vlastyvostiamy [Development of the newest technologies of products from flour with the set properties]. Kryvyi Rih, DonNUET Publ., 146 p.

7. Mykhaylov, V., Samokhvalova, O., Kucheruk, Z., Kasabova, K., Simakova, O., Goriainova, Iu., Rogovaya, A., Choni, I. (2019). Influence of microbial polysaccharides on the formation of structure of protein-free and gluten-free flour-based products. Eastern European Jornal of Enterprise technologies: Technology and equipment of food production. Vol. 6, no. 11 (102). P. 23–32. doi: 10.15587/1729-4061.2019.184464.

Анотація. *Хімічний аналіз показав, що ягоди горобини звичайної (Sorbus aucuparia) містять 1950 мг фенольних сполук на 100 г, що робить їх одними з найвищих за вмістом флавоноїдів. Тільки в чорноплідній горобині іноді міститься більше флавоноїдних сполук – до 5000 мг/100 г. У цьому дослідженні докладно описується, як змінюється сума фенольних речовин (біофлавоноїдів) в ягодах горобини у відповідь на кислотні і лужні реагенти, виміряна за допомогою спектрофотометрії. Результати дослідження виявили чіткі спектральні зміни в екстрактах ягід горобини в залежності від pH, що вказує на структурне розуміння біофлавоноїдів в ягодах. Результати показують, що препарати з ягід горобини особливо перспективні для використання в функціональних продуктах харчування, оскільки виявлені фенольні похідні володіють сильними антиоксидантними властивостями. Їх велика кількість у фенольних гідроксилах свідчить про значний потенціал підвищення антиоксидантної здатності харчових продуктів і їх корисності для зміцнення здоров'я.*

Ключові слова: *горобина, фенольні речовини, флавоноїди, біофлавоноїди, флавони, флавононоли, антиоксиданти, функціональні харчові продукти, спектрофотометрія.*

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