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RESEARCH ARTICLE

# Comparative assessment of the content of vitamin C and carbohydrates in the fruits of *Ribes* L. species

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## Abstract

The features of the biochemical composition (i.e., content of ascorbic acid and carbohydrates) have been determined in ripe fruits of five *Ribes* species (i.e., *R. aureum, R. nigrum, R. alpinum, R. tenue*, and *R. rubrum*). The plants were grown for many years in the collection of the "Olexandria" State Dendrological Park of the NAS of Ukraine. Among the studied species, the highest content of ascorbic acid (vitamin C) was recorded in *R. nigrum* fruits (185.4 ± 19.0 mg/100 g), while the lowest was in *R. tenue* fruits (8.8 ± 1.4 mg/100 g). The highest content of carbohydrates was recorded in *R. aureum* fruits (9.7 ± 0.6 %), while the lowest was in *R. rubrum* fruits (1.8 ± 0.1 %). Over 60 % of the total sugar content was represented by invert sugars – fructose prevails, and glucose was much less present. The obtained results have practical value and can be applied in plant breeding to obtain adapted interspecific hybrids and new promising varieties of the genus *Ribes*.

**Keywords:** *Ribes*, "Olexandria" State Dendrological Park, biochemical composition, carbohydrates, vitamin C

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## Introduction

The introduction and cultivation of plants of various species of the genus *Ribes* L. (Grossulariaceae) using new varieties to create cultivars with a complex of valuable economic and biological characteristics adapted to local conditions is an urgent task. Considering that, organic acids and tannins contained in the fruits of various species of the genus *Ribes* contribute to reducing the effects of radiation exposure on the human body, kill pathogenic flora. *Ribes* fruits contain a complex of essential biologically active substances (BAS), including vitamins B1, B2, B3 (PP), B5, B6, B9, B12, C (ascorbic acid), E (tocopherol), flavonoids, trace elements, organic acids, sugars (sucrose, fructose, glucose), pectin substances (Nour et al., 2011).

The biochemical composition of *Ribes* species has been the focus of much research for the last two decades (Mattila et al., 2011; Petrisor et al., 2013; Mackėla et al., 2015; Çolak & Alan, 2017; Islam, 2019; Sun et al., 2021; Karaklajic-Stajic et al., 2023). However, it was briefly investigated in Ukraine only

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recently (Yezhov & Grynyk, 2020a, 2020b). The biochemical composition of fruits in *Ribes* species is mostly a hereditary feature, but it can vary in different soil and climatic conditions (Petrisor et al., 2013; Islam, 2019; Karaklajic-Stajic et al., 2023). Therefore, accumulation of the biologically active substances in the *Ribes* fruits is a crucial topic investigated and represented here for the "Olexandria" State Dendrological Park of the NAS of Ukraine.

Among all the studied species, *R. nigrum* L. serves as one of the most important natural sources of vitamin C. The berries of *R. nigrum* have a high content of this vitamin (on average 200–300 mg per 100 g of fresh fruit), which significantly exceeds the content in citrus fruits (oranges and lemons). In particular, the content of ascorbic acid (vitamin C) in the most popular fruits consumed in Ukraine and Europe is following: orange or lemon (40 mg/100 g), raspberry (30 mg/100 g), apple (7 mg/100 g), pear (4 mg/100 g), grape (3 mg/100 g) (Dasgupta & Klein, 2014).

The uniqueness of currants lies in their diverse action – they are both a source of vitamins and minerals, as well as an antiseptic and a detoxifying agent (Rizwana et al., 2022; WebMD, 2024). Unpretentiousness to soil and climatic conditions, winter and drought resistance, resistance to pests and diseases make currants a desirable crop for cultivation in the Right-Bank Forest-Steppe of Ukraine.

Valuable economic characteristics of various species of the genus *Ribes* are their high yield, early fruiting, and annual abundant fruiting. Currant bushes have a long generation period and, provided that the proper agricultural techniques are used, can bear fruit for up to 20–35 years (Kokhno, 2002). The fruits of *R. aureum* Pursh, *R. nigrum*, and *R. rubrum* L. are suitable for consumption fresh, frozen, dried, and are also used to make jams, marmalades, pastilles, juices, jellies, fillings for sweets, etc. (Wynia, 2011; Bashta & Ivchuk, 2020; Osokina et al., 2024).

The research was aimed at conducting a comparative analysis of the biochemical composition (i.e., content of vitamin C and carbohydrates) of ripe fruits of *Ribes* species in the "Olexandria" State Dendrological Park of the NAS of Ukraine (Right-Bank Forest-Steppe of Ukraine) and comparing the obtained results with published data from different natural climatic conditions.

## Material and methods

Five *Ribes* species from the collection of the "Olexandria" State Dendrological Park of the NAS of Ukraine, representing different genotypes (i.e., *R. aureum*, *R. nigrum*, *R. alpinum* L., *R. tenue* Janczewski, and *R. rubrum*) were investigated in the 2024 vegetation season.

Biochemical studies covered the content of vitamin C and carbohydrates in ripe fruits and were conducted in the laboratory of the Service and Analytical Center "Institute of Plant Health" (Cherkasy, Ukraine) following the Testing Protocol (2022).

The "Olexandria" State Dendrological Park of the NAS of Ukraine is located within the nature zone of the Right-Bank Forest-Steppe of Ukraine. The climate of the study area is temperate continental. Gray forest soils (podzolized alfisols) prevail in the territory of the "Olexandria" State Dendrological Park of the NAS of Ukraine. Although the humus horizon in these soils is thick (50–60 cm in some places), it contains only 1.2–2.8 % humus (Deriy & Semczekov, 1958).

## Results and discussion

For the first time, the genus *Ribes* in the "Olexandria" State Dendrological Park of the NAS of Ukraine was presented in 1958 by the *R. alpinum*. Planting material was obtained from the Central Republican Botanical Garden in Kyiv (currently M.M. Gryshko National Botanical Garden of the NAS of Ukraine). *Ribes alpinum* seedlings were planted in curtains in the landscapes of the "Olexandria" State Dendrological Park of the NAS of Ukraine. Later, seedlings and seeds were obtained from the Chisinau Botanical Garden of the Republic of Moldova and the O.V. Fomin Botanical Garden of the Taras Shevchenko National University of Kyiv.

Today, in the "Olexandria" State Dendrological Park of the NAS of Ukraine, the collection of currants includes eight Ribes species (Galkin, 2013), which grow in the collection areas Fruticetum and Sad Mur (Table 1). The plants have undergone a successful multi-year introduction trial, demonstrating high winter hardiness and drought tolerance (Mezhenskyj et al., 2007),

**Table 1.** Inventory of the genus *Ribes* in the "Olexandria" State Dendrological Park of the NAS of Ukraine.

| Nr | Species | Introduction to the park, year | Growing location, quarters | Life form | Exist in 2024 | Winter hardiness group | Drought tolerance group | Fruiting |
|---|---|---|---|---|---|---|---|---|
| 1 | *R. alpinum* L. | 1956 | 9, 15, 25, 27, F | bush | + | VIII | VII | + |
| 2 | *R. aureum* Pursh | 1969 | 28 | bush | + | VII | VIII | + |
| 3 | *R. komarovii* Pojark. | 1964 | F | bush | + | VII | V | – |
| 4 | *R. mandschuricum* (Maxim.) Kom. | 1956 | 27 | bush | + | VII | V | – |
| 5 | *R. nigrum* L. | 1959 | F, M | bush | + | VIII | VI | + |
| 6 | *R. spicatum* Robson | 1964 | F | bush | + | VII | VI | + |
| 7 | *R. tenue* Jancz. | 1964 | F, 27 | bush | + | VII | V | + |
| 8 | *R. rubrum* L. | 1959 | M | bush | + | VIII | VI | + |

**Notes. Collection areas: F** – Fruticetum; **M** – Sad Mur. **Winter hardiness** (Mezhenskyj, 2007): **VII** – high: all flowers have frozen out or fruits have fallen off due to winter damage but one-year sprouts are not frozen out; **VIII** – very high: only up to 50% of flower buds frozen out. **Drought tolerance** (Mezhenskyj, 2007): **V** – medium: only up to 50 % of the leaves are damaged or fallen; **VI** – from medium to high: only individual leaves have local damage; **VII** – high: leaves lose turgor, but quickly restore it; **VIII** – very high: plants have special adaptation mechanisms, i.e., react by folding or changing the orientation of the leaf blades.

but not all bear fruit. In *R. spicatum*, the number of produced fruits was small, so this species was not included in the current study.

The natural and climatic conditions of the Right-Bank Forest-Steppe are characterized by a temperate continental, relatively warm climate, with an unstable moisture regime over the past decades. Due to climate change caused by global warming, with a change in the average annual temperature, according to Kalashnikova (2021), the boundary of climatic zones is significantly shifting, and the "Olexandria" State Dendrological Park of the NAS of Ukraine can already be characterized as belonging to the more arid Northern Steppe zone. For the last decade, the average annual temperature here has increased from +7.5 °C to +10.4 °C. The number of days with high temperatures (so called 'heat waves'), when the daytime temperature exceeds 30–35 °C, has significantly increased too (Ivaniuta, 2020; Kalashnikova, 2021; Kalashnikova et al., 2024). According to the results of long-term observations of the Bila Tserkva weather station (BSCGO, 2024), 562 mm of precipitation fell yearly, most of which fell in the spring and summer period. The average annual relative humidity is 76 %. The annual amount of moisture that arrives with atmospheric precipitation approximately equals the evaporation. A characteristic feature of the winter period is the alternation of frosts with thaws, which in some years provoked premature vegetation of plants and caused damage by subsequent frosts (Kalashnikova, 2021).

The vitamin C in currant fruits is more actively synthesized in cooler summers, and the carbohydrate content, on the contrary, increases in years with dry, hot summers (Woznicki et al., 2015).

We compared the biochemical composition of ripe fruits of the genus *Ribes* based on literary sources and the results of our laboratory investigations (Table 2). The plants we used for comparison were grown in the same (Yezhov & Grynyk, 2020a, 2020b) or similar climatic conditions with brown soils (IzV, 2025). We also used data on *R. aureum* from China (Sun et al., 2021), where the climate is characterized as cold semi-desert, with grey-cinnamon (chestnut) and brown forest soils. For two species, *R. alpinum* and *R. tenue*, we measured the content of vitamin C for the first time and did not find respective published data. We also measured the content of carbohydrates in the fruits of *R. alpinum* and *R. tenue* for the first time.

It was shown that the investigated parameters of ripe fruits of the genus *Ribes*

**Table 2.** Comparative analysis of biochemical composition of the fruits in the studied *Ribes* species.

| Species | Average weight of one fruit, g | | Vitamin C, mg/100 g | | Carbohydrates, % | |
|---|---|---|---|---|---|---|
| | Current study | Published data * | Current study | Published data * | Current study | Published data * |
| *R. nigrum* L. | 2.3±0.2 | 0.6–2.5 | 185.4±19.1 | 87.1–373 | **8.5±0.5** | 14.5 |
| *R. aureum* Pursh | 1.9±0.3 | 0.9–2 | **19.3±2.8** | 28–40.1 | **9.7±0.6** | 12.3 |
| *R. alpinum* L. | 1.4±0.1 | 0.3–1.5 | 9.0±1.5 | – | 6.5±0.4 | – |
| *R. rubrum* L. | **1.6±0.2** | 0.5–0.9 | 22.4±3.2 | 14.9–96.3 | 1.8±0.1 | 2.0 |
| *R. tenue* Jancz. | 0.9±0.1 | 0.3–0.9 | 6.4±0.4 | – | 8.8±1.4 | – |

**Notes.** * – Published data includes the feature values gathered and combined from several sources (i.e., Kaijalainen et al., 2009; Sun et al., 2013; Yezhov et al., 2020a, 2020b; Karaklajic-Stajic et al., 2023). The **bold font** indicates the values that are out of the ranges reported before.

in the "Olexandria" State Dendrological Park of the NAS of Ukraine mostly lay within the reported (Kaijalainen et al., 2009; Sun et al., 2013; Yezhov & Grynyk, 2020a, 2020b; Karaklajic-Stajic et al., 2023) diapasons. However, some values for *R. nigrum*, *R. aureum*, and *R. rubrum* significantly differ from those reported before.

The biochemical composition of fruits is a hereditary species trait, but may vary depending on weather conditions. For example, the vitamin C in currant fruits is more actively synthesized in cooler summers, and the carbohydrate content, on the contrary, increases in years with arid, hot summers (Zheng et al., 2009).

We have established that the largest mass of one fruit (berry) is possessed by the fruits of *R. nigrum* (Table 2) – this explains the great popularity of varieties of this species and their excellent use for consumption. According to Yezhov et al. (2020a), *R. nigrum* also has the largest mass (up to 2.5 g). *Ribes nigrum* takes first place in terms of ascorbic acid (vitamin C) content, both according to literary data (up to 373 mg/100 g) and according to the results of our research (185.4±19.1 mg/100 g). The highest content of ascorbic acid (vitamin C) in the fruits of *R. nigrum*, which we found, is due to the wet and cool weather during fruit ripening in the year of research (Zheng, 2013).

In general, the content of carbohydrates (sugars) in the fruits of the five investigated *Ribes* species varied from 1.8% to 9.7%. These figures are slightly lower than the reported data (from 2 to 14.5%).

It was found that the fruits of the North American species, *R. aureum*, as well as the fruits of *R. nigrum* (Kaijalainen et al., 2009; Yezhov et al., 2020a), accumulate the most carbohydrates. In contrast, the fruits of *R. rubrum* accumulate the least carbohydrates. It was especially valuable to find that over 90% of the total sugar content is represented by invert sugars, with fructose predominating compared to glucose (Mezhenskyj et al., 2007).

## Conclusions

We summarize that the ripe fruits of various *Ribes* species have a complex chemical composition and contain a valuable complex of biologically active substances. It is known that the main acids in currants are citric, malic, and ascorbic (vitamin C). The highest content of ascorbic acid, both according to literature data (up to 373 mg/100 g) and according to the results of our research (185.4 mg/100 g), was recorded in the fruits of *R. nigrum*. The highest content of carbohydrates was recorded in fruits of *R. aureum* (9.7±0.6%), which is characterized by the highest drought tolerance (IV group according to Mezhensky's scale) and is a promising species in modern conditions of increasing xerophytization of the climate in the study area. For two species, *R. alpinum* and *R. tenue*, we measured the content of vitamin C and carbohydrates for the first time.

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## Порівняльна оцінка вмісту вітаміну С та карбогідратів у плодах видів роду *Ribes* L.

Вікторія Солошенко

Державний дендрологічний парк “Олександрія” НАН України, Біла Церква-13, Київська обл., 09113, Україна; miss456@ukr.net

Було встановлено особливості біохімічного складу (а саме, вмісту аскорбінової кислоти та вуглеводів) стиглих плодів п’яти видів родини *Ribes* (*R. aureum, R. nigrum, R. alpinum, R. tenue* та *R. rubrum*). Рослини вирощувалися протягом багатьох років у колекції Державного дендрологічного парку “Олександрія” НАН України. Серед досліджуваних видів найвищий вміст аскорбінової кислоти (вітаміну С) було зафіксовано у плодах *R. nigrum* (185,4 ± 19,0 мг/100 г), найнижчий – у плодах *R. tenue* (8,8 ± 1,4 мг/100 г). Найвищий вміст вуглеводів було зафіксовано у плодах *R. aureum* (9,7 ± 0,6 %), а найнижчий – у плодах *R. rubrum* (1,8 ± 0,1 %). Понад 60 % загального вмісту цукру було представлено інвертованим цукром, у якому переважала фруктоза, а глюкози було значно менше. Отримані результати мають практичну цінність і можуть бути застосовані в селекції рослин для отримання адаптованих міжвидових гібридів та нових перспективних сортів роду *Ribes*.

**Ключові слова:** *Ribes*, Державний дендрологічний парк “Олександрія”, біохімічний склад, карбогідрати, вітамін С