Antioxidant rosehips complex of different growing conditions for food purposes

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Abstract. The article presents the results of ecological and biochemical studies of wild rosehips, May rose and Prickly rose (R. majalis Herrm, R. acicularis L., respectively), selected according to the growing principle in different climatic zones. Three types of zones in the Krasnoyarsk Territory (subtaiga, forest-steppe, and south-taiga) were taken as the selected plant ranges. The studied plants are considered as a potential source of a biologically active complex of the antioxidant action. The chemical structure of plants was analyzed taking into account climatic conditions during the search period. Studies show that with the deterioration of the growing conditions, the antioxidant complex is enriched with ascorbic acid. The studies of the biochemical structure of the rosehips of the studied plants showed a difference in the ratio and quantitative accumulation of substances related to the antioxidant complex, depending on the geographical location of the selected distribution areas, as well as on the climatic parameters of the crop year. A comparative analysis of the two types of rosehips made it possible to identify more productive for introducing into the culture and prospects for introducing plant fruits into the formulations of fortified foods.

1. Introduction
A human’s quality of life is determined by his state of health, activity, life expectancy, and resistance to adverse environmental factors, which in turn depends on the organism’s resources and its adaptability, including oxidation processes associated with cell aging [1, 2, 3].

In living systems regulators of free radical processes are substances, so called antioxidants. The chemical characteristics of antioxidants are associated with the ability to both donor and acceptor interactions with the reducing elements of the redox chain.

Plants can have antioxidant properties in the case of such compounds accumulation as vitamins C, P, E, provitamin A, some mineral elements and some other substances to which these properties can be inherent in pure water or as an element of compounds, such as antioxidant enzymes [4, 5].

Rosehips have long been known as a source of a complex of substances useful for a human health, including antioxidant ones. That is why they can be applied in various industries that provide consumers with useful products.

The purpose of this paper is to evaluate the accumulation of the active principle with antioxidant properties in two species of rosehips growing in three different zones of the Krasnoyarsk Territory in comparison with the climatic conditions of two consecutive years, which differ in the degree of favorable conditions, and the possibility of their use in creating food products for healthy local nutrition population.
2. Materials and methods

The object of the study is two wild species of wild rose: R. majalis Herrm. and R. acicularis L. (May rose and Prickly rose, respectively). The paper presents the results of studies for two consecutive years. They differ in the degree of favorable climatic conditions. Plants were taken from three different areas located in the Krasnoyarsk Territory. Zones differ in climatic conditions and type of vegetation, due to the latitude and topography [6, 7].

The territory of the Ermakovsky district located in the foothills of the Western Sayan, defined by the classification as subtaiga, was chosen as the first distribution area. The climatic regime in this region is characterized by typical warm continental conditions (an average temperature in July is +19.4-20.2 °C). Winters are with moderately cold weather (an average temperature in January is -18.0-19.4 °C). Along with this, a large number of sunny days provide dry air with humidification up to 0.77 and a sum of temperatures which above 10°C is 2000°C under rainfall conditions up to 350 mm per year. All these factors form the conditions for a sufficient vegetation period (up to 140 days).

The second distribution area belongs to the forest-steppe zone. Geographically, the distribution area located in Yemelyanovsky district was chosen. The climate features in this area are colder winters (an average temperature in January is -20.0-21.0°C) and less warm summers (an average temperature in July is +18.7°C). The sum of positive temperatures above 10°C is 1400-1800°C. In general, 350-400 mm of rain falls per year does not provide sufficient air humidification due to values close to the rate of evaporation. Thereby the evaporation coefficient is determined in the range from 0.77 to 1.00. In the specified area, there may be from 100 to 120 days for the growing season.

The territory of the Yenisei region, classified by the subzone of the southern taiga, was selected as the third distribution area of comparison. This region is characterized by windy, cold winter (an average temperature in January is -22.0°C), longer in time, with a short summer (an average temperature in July is +18.4°C), therefore plants have a period of 90 days during vegetation under such conditions. Among other important differences, one can mention a sufficient degree of hydration. It is 1.00-1.33 with a total precipitation of 350-500 mm per year. A cool summer is caused by a low sum of temperatures (1640°C above 10°C) [6, 7, 8, 9].

Soils in the first of the selected regions (Ermakovsky district; subtaiga) and in the second (Emelyanovsky district; forest-steppe) are leached, podzolized chernozems, gray forest. The main differences between them is that in the conditions of sub-taiga, soils freeze in depth and duration moderately, in the conditions of the forest-steppes they freeze deep. Moreover, forest dark gray soils are also typical for Emelyanovsky district. Soils of the third range (Yenisei district; southern taiga) differ significantly from them: sod-podzolic, well-drained soils with a second humus horizon.

The biologically active substances with antioxidant properties were determined: carbohydrates [10], organic acids [11], ascorbic acid (vitamin C) [10], rutin (vitamin P) [12], tocopherol (vitamin E) [13], carotene (provitamin A) [14], trace elements [15, 16, 17]. A random error was estimated using standard error, with a confidence level of 0.95 for biological investigations. The assessment of reliability was estimated in laboratory experiments using a two-sample student with unequal variances (heteroscedastic) Student's test included in the MS Excel analysis package. As a result, it returns the probability of a “null hypothesis”, i.e., two samples belong to general populations with the same average. A 5% probability value of the “null hypothesis” was chosen as the confidence interval with a probability value of more than 5%, the “null hypothesis” cannot be discarded [18]. The sample representativeness was determined by generally accepted methods [19].

3. Results and discussion

The dependence of the biochemical structure of the studied plants on environmental factors in their ranges has been shown [20].

The average value of organic acids (malic, citric) in rosehips was found to be 3.81% and 3.14% for May rose and Prickly rose, respectively. Moreover, in the first year of the study, the largest amount of precipitation was recorded in the Yenisei region, where in the same period a high acid content (3.19-3.91%) was noted in rosehips.
The average value of organic acids (malic, citric) in fruits was found to be 3.81% and 3.14% for May rose and sparkling, respectively. Moreover, in the first year of the study, the largest amount of precipitation was recorded in the Yenisei region, where in the same period a high acid content (3.19-3.91%) was noted in rosehips of this territory. The average value of organic acids (malic, citric) in fruits was found to be 3.81% and 3.14% for May rose and Prickly rose, respectively. Moreover, in the first year of the study, the largest amount of precipitation was recorded in the Yenisei region, where in the same period a high acid content (3.19-3.91%) was noted in the fruits of this territory. In general, during the growing season of the initial year of research, when the conditions for the plants growing and development can be considered more favorable, the accumulation of organic was inferior to the values of the less favorable subsequent year as it was wetter and cooler. This tendency can be explained by the rate of biochemical reactions, which in warm conditions consume the formed acids more intensively, while the possibility of their accumulation appears in the metabolic processes slow down in cool conditions.

In comparing the two types of roses, a difference was noted that can be used as an identifying attribute to determine the species. So the organic acidity is up to 1.5 times higher in rosehips of May rose.

There exists a great number of works on the dependences of the accumulation of ascorbic acid and on biotic and abiotic environmental factors on the content of ascorbic acid. However, scientists have some different point of view in this problem [21, 22]. According to the results of studies [6, 7], it is possible to conclude that the synthesis of ascorbic acid is more intense in more unfavorable conditions in the growing period and development. The revealed differences according to the results of statistical processing are recognized as reliable by the types of wild rose, and by the areas of growth, and by the years of collection. On average, the obtained values were in the ranges of 1510-1755 mg% for May rose and 1814-2345 mg% for Prickly rose, with the maximum values in a less favorable year in the forest-steppe (Emelyanovsk region) of 1755 mg% and 2345 mg%, respectively. The values range was determined by climatic and geographical conditions.

In the second year of the study the accumulation of ascorbic acid was observed on average by 35-70 mg% as an adaptation reaction to lower temperatures and an increase in the amount of precipitation during accumulation of ascorbic acid accumulation can suggest a finer pulp in rosehips of May rose where the main accumulation of vitamins occurs.

A difference by species in ascorbic acid accumulation by 1.3 times in favor of Prickly rose is noted. It suggests this species as more resistant to non-optimal environmental conditions. At the morphological level, a factor that ensured the difference between the species in terms of the ascorbic acid accumulation can suggest a finer pulp in rosehips of May rose where the main accumulation of vitamins occurs.

Data analysis on the of vitamin P accumulation showed significant differences between the studied species. So in May rose hips, the variability in vitamin P presence is greater (13.5-32.7 mg%), and in average 1.5 times it is higher (variability in Prickly rose hips forms a range of 12.2-20.7 mg %). The conditions of a more favorable first year of the study contributed to a more intensive rutin accumulation in the rosehips than in the following year due to warm, with moderate humidity, sunny weather during the growing season. A common trend for species was a more noticeable rutin accumulation in rosehips towards the north and south of Emelyanovsk forest-steppe. The maximum levels of values were observed for the May rose species in a favorable year in rosehips in the distribution areas of the southern taiga (32.7 mg%) and subtaiga (24.1 mg%). The minimum level for all species averaged 14.4 mg% and it was observed in the rosehips in the distribution area of the forest-steppe zone.

Such a distribution of values can be explained by the adaptation properties described above and the ability of phenolic compounds, to which rutin belongs, to absorb a part of the light spectrum with short waves in the range of 280-320 that is detrimental to plants [23, 24]. The data obtained during the analysis indicate that vitamin P in this case has an anti-stress function, preventing oxidative overloads.
of the plant caused by ultraviolet (UV) rays. In other words, we can talk about the formative influence of the spectral composition of light on the accumulation of rutin, and in particular its UV spectrum.

The range of accumulated carotene values turned out to be quite wide of 5.5-47.7 mg%, but the values obtained during the experiments have significant differences.

Having compared the first year of the study typical for these regions, when the climatic parameters are favorable, an increase in of carotene accumulation towards the south is noted. It does not occur with a change of year and a decrease in the level of favorable climatic parameters. It may be connected with the antioxidant properties of carotene. They have photoprotective properties with respect to chlorophyll. In the presence of excessive light exposure, carotene prevents oxidative stress [22; 24]. In general, it was noted that a degree of carotene accumulation was observed in rosehips of Prickly rose on average in 2 times higher.

Among the main trends in the accumulation of tocopherol, the following are noted. The total range of values obtained with significant differences was 22.7-39.5 mg%. The maximum values were observed for rosehips from the southern taiga distribution area is 36.3 and 39.5% (May rose and Prickly rose, respectively). The worsening climatic conditions with a northward movement in both species contributed to an increase in vitamin E. Being one of the most intense natural antioxidants, tocopherol under adverse conditions also plays an adaptive role as protection against stress factors, in particular with respect to polyunsaturated fatty acids, preventing their oxidative reactions. Moreover, the tocopherol accumulation can also be attributed to species identification parameters due to the greater ability of Prickly rose to accumulate.

In more detail, the mineral structure and its dependence on the places and conditions of growth was highlighted earlier in [6; 7]. Summing up the results presented in this article with respect to the antioxidant complex, it can be concluded that the biochemical structure of rosehips growing in the sub-taiga environment is distinguished by a large accumulation of carotene; the conditions of the forest-steppe zone contribute to a more intensive accumulation of ascorbic acid, manganese; climate and growing conditions in the southern taiga gives the most significant effect on the accumulation of an antioxidant complex of substances, i.e., ascorbic acid, tocopherol, rutin, iron and manganese [6; 7].

4. Conclusions

The analysis of the accumulation of the active start with antioxidant properties in rosehip species growing in three different zones of the Krasnoyarsk Territory with different climatic conditions showed that the rosehip raw materials from the Yenisei region have enough time to form a richer structure during the growing season.

It is shown that the accumulation degree of the considered components of the biochemical structure can serve as indicators of resistance to negative natural environmental factors and the ability to adapt. In terms of the sum of these indicators and for each separate indicator, Prickly rose surpasses May rose. It is regarded to be more stable for conditions in all considered regions.

The presented results of the study, as well as the analyzes conducted in the framework of [6] for compliance with safety requirements, allow both of the considered varieties to be used as a raw material base for pharmaceutical and food purposes. In particular, it can be used as a prescription component for the enrichment of drinks and food [6; 7; 25-28] and giving them the functional properties of an antioxidant nature for the human health.

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