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RESEARCH OF PHENOLIC COMPOUNDS CONTENT IN YOSHTA BERRIES FOR THE PERSPECTIVE OF CULTIVATION AND USE IN HEALTHY NUTRITION IN THE STEPPE ZONE OF UKRAINE

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Abstract

Unfavourable socio-economic conditions and unbalanced nutrition, expressed in the deficiency of biologically active substances, determine the need to use fruit crops as a source of biologically active substances. In world practice, priority is given to fruit plants that have biological activity useful for the human body. The relevance of the concept of balanced natural nutrition is increasing with the growth of the global population. Products containing pesticides, preservatives, artificial colors and flavors or other chemicals are included in the "black" list of all natural food advocates.

Jošta fruits is a low-calorie berry, 100 g of berries contain only 45–48 calories. Nutritional value of yoshta (per 100 g of product): carbohydrates – 9.1 g; fats – 0.2 g; proteins – 0.7 g; water – 80 g. Jošta fruits contains vitamin C (ascorbic acid) in large quantities, vitamin P (rutin), pectin substances, phytoncides, organic acids, sugar, anthocyanins, potassium, iron, iodine, copper, etc. And the anthocyanins included in its composition accelerate metabolic processes and are capable of breaking down fats. Pectins improve and normalize intestinal microflora, which in turn contributes to cleansing. The aim of the work was the study of Jošta plant as a promising species for further possible ecological diversity of the territory of the right bank of the Dnieper in Ukraine.

The rare currant-gooseberry hybrid Jošta plant can be recommended for growing and using fruit products in functional human nutrition. The Jošta can be recommended for the cultivation and use of fruit products in functional human nutrition and, in particular, in the restaurant business namely locavores for the presentation of the author's intellectual interpretation of local products.

Keywords: Jošta berries, phenolic compounds, antioxidant capacity, locavores, balanced nutrition, ecological diversity.

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1. Introduction

A healthy lifestyle is an important marker of the health of the population. Rational human nutrition is one of the conditions for ensuring working capacity and longevity. Ignoring the rules of healthy eating became the reason for the spread of the so-called "diseases of civilization" (diabetes, coronary heart disease, atherosclerosis, hypertension, etc.). Due to the ability to biosynthesize and accumulate components with antioxidant properties, the use of fruit plants can prevent the development of many diseases caused by oxidative stress. Antioxidants can protect cells through a variety of mechanisms, including the conversion of ROS into non-radical forms (which depend on the involved antioxidant), breaking the autooxidative chain reaction initiated by ROS, and reducing the localized oxygen concentration. Intake of exogenous antioxidants, such as ascorbic acid (vitamin C), α-tocopherol (vitamin E), carotenoids, and polyphenols found in common fruits, vegetables, beverages, cereals, and other foods, can support antioxidant defense [1]. For example, anti-carcinogenic, anti-mutagenic and anti-inflammatory effects are associated with the antioxidant capacity of phenolic compounds contained in plants, as well as the effect on the signaling pathways of the metabolism of carcinogens [2].

In recent years, due to the unfavorable environmental situation and unbalanced diet (expressed by a deficiency of biologically active substances), the need to use fruit crops as a source of biologically active compounds has increased significantly. Fruit plants have always been one of the most important nutrition sources for humans. The nutritional benefits of products determine their consumer value and competitiveness. In the modern world, there is a trend towards the elimination of synthetic compounds from food and the use of natural plant extracts. In the food market, plant extracts have won a leading position due to the fact that they have the highest antioxidant potentials. In this regard, the introduction and selection of fruit plants, the technology of their cultivation, methods of extracting a complex of biologically active substances and the creation of a new generation of food additives on its basis are promising scientific and practical directions. Natural products, including plant extracts, open up wide opportunities for creating a huge range of new medicines, which have higher efficiency and fewer side effects than their synthetic counterparts.

Steppe of Prydniprovya belongs to the territories of Ukraine, in which plant organisms are subjected to a double negative impact: aridity of the climate and pollution of the environment. As a result, the growth of plants is significantly suppressed, they age prematurely and significantly reduce their phytoremediation efficiency, which negatively affects the life of the animal world and the health of the population. There is now evidence that environmental changes in recent decades have been favorable for some adventitious species and have allowed them to spread into regions where they previously had no chance of survival and reproduction. Long-term studies conducted simultaneously in different countries have confirmed that the mild winter conditions of the last few decades are consistent with the trend of expansion from south to north of the potential ranges of introduced plants, the likely consequence of which will be a significant change in the composition and structure of natural and artificial plantations in various parts of Europe. Modern economic relations and the level of development of plant introduction open up new prospects for various countries, including Ukraine. Thus, the scientific data available today indicate a rich phytochemical composition and a high antioxidant capacity of different plants, including those that were introduced in the steppe zone of Ukraine. However, even the successful acclimatization of alien plants species and varieties does not guarantee a consistently high yield, as well as the nutritional and biological value of fruit plant products. One of the reasons lies in the natural variability of the plant chemical composition, reflecting the degree of realization of the genetic potential of plant species under certain environmental conditions.

Currently, locavores, as eating according to the geographical principle, is becoming widespread. Locavoring is eating "local" products grown nearby. This applies to vegetables, fruits, berries, and eggs, as well as dairy and meat products. Some adherents of the theory even use firewood for grilling from the nearest territories, and kitchen utensils are chosen considering the regional principle. The main differences in providing nutrition to the population with local products are regional availability, seasonal origin, ecological methods of processing, natural specificity of cultivation, and preservation of cultivation traditions.

Conservative locavores believe that "local" products can be called grown or produced no further than 100 miles from the dwelling. It's about 160 km. At the very least – 200 km. But this is the

maximum. The main advantage of local products is fast transportation. Local delivery means shorter distances and lower fuel costs. Accordingly, it is more environmentally friendly than exporting. Since the availability of certain food products in a particular area depends on the season, export products come to the aid of local markets. But then, when there is an outflow of local products, the first principle of Locavore comes to nothing. After all, vegetables, fruits, and berries come from abroad either chemically treated or unripe.

Products containing pesticides, preservatives, artificial dyes and flavours, or other chemicals are included in the "black" list of all locavores. In this case, for such consumers, the choice falls either on food products of their own production (gardens), or on food products of local proven farmers and agricultural markets. The same applies to the country's traditional cuisine. The environmental friendliness of local products can be checked. Therefore, products are often purchased directly from the manufacturer. At farmers' markets, buyers interact more often with sellers, which allows them to learn more about a particular farm and its products. Farmer's markets can become popular tourist attractions. To expand the assortment of fruit and berry products, let's suggest introducing Jošta plants as a source of biologically active substances into the home and individual gardening [3, 4].

The controlled use of introduced low-growing fruit plants in functional nutrition for the sake of economic health and ecological attractiveness of consumers plays an important role in enriching the local flora of the right bank of the Dnipro River in Ukraine. Jošta is one of the representatives of low-growing fruit plants.

The aim of the work was to study the accumulation and composition of phenolic compounds with antioxidant capacity in the fruits of Jošta plants growing in the steppe zone to determine the prospects for cultivation and locavores use in the region.

2. Methods of research

Ripe fruits of the Jošta currant-gooseberry hybrid (family Grossulariaceae DC) were used as the material for the research. The ripe Jošta fruits were harvested in the second decade of July 2021 at two distant plots with different growing conditions. The first plot is located on the territory of the Botanical Garden of the Dnipro National University (48° 26'7 "N, 35° 2'34" E, Dnipro city, Ukraine; plot 1). The second plot is located in a private subsidiary farm (48° 24′45″ N, 33° 42′12″ E, Dnipropetrovsk region; plot 2). In plot 2, unfavourable regional climatic conditions (low air temperatures in winter and high in summer, insufficient moisture in the soil, frequent hot dry winds) have a significant impact on the growth and development of plants [5, 6].

Plant extracts for the secondary metabolites content and antioxidant activity determination were prepared using 80 % isopropanol. Briefly, a 2.0 g weighed portion of fresh fruit (peel and pulp as the separated samples) was triturated with 20 ml of isopropanol and kept for 24 hours at room temperature in dark with occasional shaking. Then, extracts were filtered through the paper filters, and the total volume was divided into two parts intended for different studies. Total polyphenols content (TPC), Total flavonoids content (TFC), Free Phenolic acids content (FPAC), Total antioxidant capacity (TAC), and ferric-reducing power (FRP) were determined in the crude extracts obtained [7–10].

The study results obtained in triplicate were statistically processed by calculating the mean of TPC, TFC, FPAC, FRP, and TAC and standard deviation (mean±SD). The criterion of significant difference of group means (Tukey's test) was used to compare the mean values of the indicators. The difference in means was considered statistically significant at $P<0.05$. The relationship between the parameters determined for the peel and pulp of the fruit was assessed by Pearson's correlation coefficient. The relationship between the two sets of variables was determined using the canonical correlation methods.

3. Results and discussion

The Jošta hybrid combines the phytochemical characteristics of two fruit species with high antioxidant capacity, namely black currant and gooseberry. This hybrid is among the rare fruit crops. Moreover, the study of the secondary metabolites' chemical composition and antioxidant capacity of fruits and other parts of plants has practically not been carried out [11–14].

Jošta fruits have absorbed all the useful properties of gooseberries and currants. The calorie content of 100 g of berries is 45 kcal (**Table 1**). The pulp contains fats, proteins and carbohydrates.

Jošta is a very useful berry for health and well-being. It has a beneficial effect on increasing the body's resistance to adverse environmental factors, as it strengthens immunity. Eating berries is an excellent prevention of many viral and cold diseases. Regular consumption of berries saturates the body with vitamins, minerals and other useful substances necessary for normal functioning. Jošta contains: vitamins A 3.7 %, B1 0.7 %, B2 1.1 %, B5 5.7 %, B6 1.5 %, B9 1.3 %, B12~, C 33 %. D~, E 3.3 %, b-car 4 %, PP 2 %, Choline 8.4 %. The following mineral substances are available: H 10 %, K 6.5 %, Potassium 10 %, Ca 2.2 %, Si 40 %, Mg 2.3 %, Na 1.8 %, P 3.5 %, Cl~, Fe 4.4 %, I 0.7 %, Co 9 %, Mn 23 %, Cu 13 %, Mo 17 %, Se 1.1 %, F 0.3 %, Cr 2 %, Zn 0.8 %.

Table 1

Nutritional value per 100 grams

Calories	Proteins	Fats	Carbohydrates	Alimentary fiber	Water	Others
45 kcal	0.7 g	0.2 g	9.1 g	3.4 g	85 g	1,6 g
100 %	0.76 %	0.28 %	9.15 %	3,42 %	85.13 %	1.6 %

Considerable attention is paid to the study of the antioxidant system, which is a powerful mechanism that prevents the development of avalanche-like free radical and peroxide reactions in living organisms. Antioxidants are among the most important food additives, which are natural or identical compositions natural biologically active substances intended for direct ingestion with food or introduction into the composition of food products, with the aim of enriching the diet with individual food or biologically active substances and their complexes. The introduction of antioxidants into raw materials and finished products ensures the prevention of their spoilage, reduction of losses, extension of shelf life and the production of high-quality products that retain the characteristic features of fresh, full-fledged products for a long time. The antioxidant system is represented by enzymatic antioxidants and low-molecular components, among the latter a significant place is given to secondary metabolites, in particular, phenolic compounds. The study results showed significant differences in the phenolic compounds accumulation and the antioxidant activity in both the fruits from two different plots, and in the fruit peel and pulp (**Fig. 1, 2**).

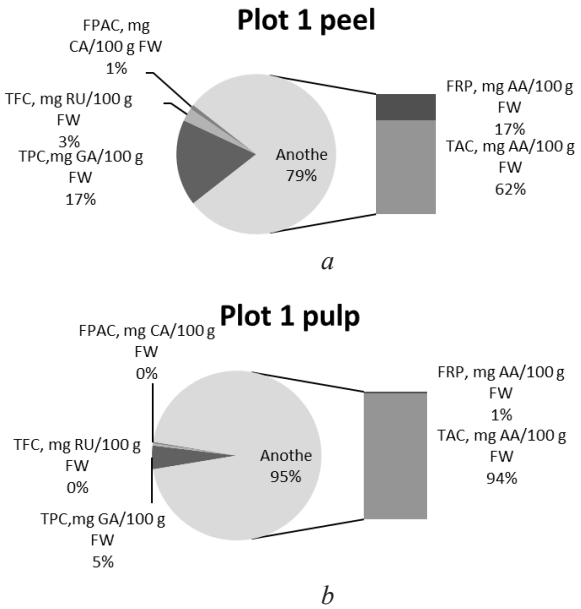

Fig. 1. Statistical evaluation of the content of phytochemicals and antioxidant capacity (by Tukey's test, $X \pm SE$, $n=3$, $P<0.05$) of ripe Yost fruits collected from plot 1: *a* – peel; *b* – pulp
Note: Plot 1 – Botanical Garden. The different letters in line indicate statistically significant differences in the means of the compared pair according to the Tukey criterion (HSD)

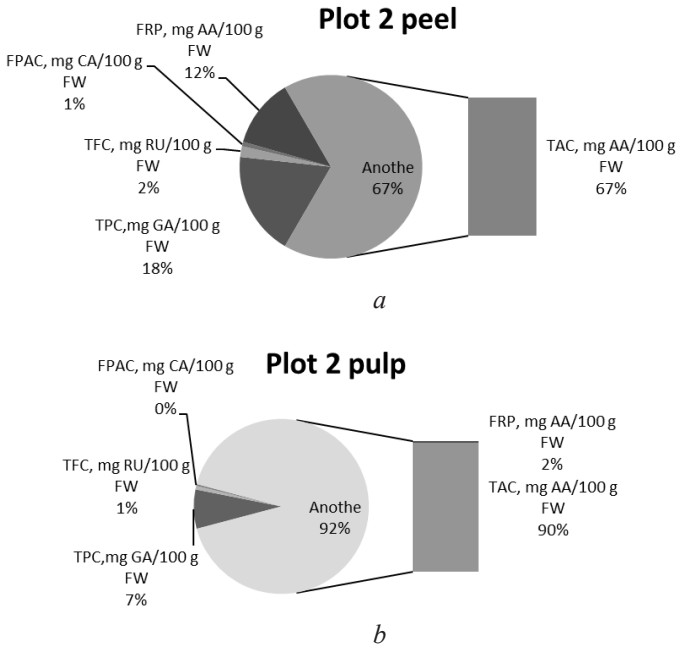

Fig. 2. Statistical evaluation of the content of phytochemicals and antioxidant capacity (by Tukey's test, $X \pm SE$, $n=3$, $P<0.05$) of ripe Yost fruits collected from plot 2: *a* – peel; *b* – pulp

Note: Plot 2 – private subsidiary farm. The different letters in line indicate statistically significant differences in the means of the compared pair according to the Tukey criterion (HSD)

In the next step of the analysis of the results, let's combine the parameters of phytochemical accumulation (TPC, TFC and FPA) into one block of indicators Phenolic compounds (Y1), while the antioxidant parameters (TAC and FRP) were combined into the block Antioxidant capacity (Y2) to reveal the ratio of the combined variables between yourself. Statistical canonical analysis made it possible to find out the relationship between two sets of variables (**Table 2**).

The canonical correlation coefficient between the Y1 block (Phenolic compounds) and the Y2 block (Antioxidant capacity) for skins and whole fruits was statistically significant and amounted to 0.999. In contrast, the canonical correlation coefficient for pulp (0.914) was not statistically significant. Thus, the indicators in the Phenolic compounds group and in the Antioxidant capacity group are closely related. These findings concerning the fresh Jošta fruit confirm earlier data that phenolic compounds are largely responsible for the antioxidant properties of *Berberis* fruits [15] and *Chaenomeles* plants [16, 17]. Consequently, functional foods fortified with Jošta fruit peels are able to have a significantly greater positive effect on the antioxidant capacity of potential nutritional supplements than fruit pulp diets.

Table 2

Results of canonical correlation analysis of the Jošta fruit phytochemical parameters

Sample	Correlation coefficient (*r*) and its significance level	Canonical variables
Peel	r=0.999 (P=0.009)	*Y*1=–0.128*TPC+1.061*TFC+0.067*FPAC *Y*2=–0.210*FRP+1.209*TAC
Pulp	r=0.914 (P=0.194)	*Y*1=0,750*TPC+0,029*TFC–0,437*FPAC *Y*2=1,816*FRP+0,879*TAC
Whole fruit	r=0.999 (P=0.048)	*Y*1=–0.945*TPC+1.308*TFC+0.639*FPAC *Y*2=–0.915*FRP+ 1.911*TAC

The successful introduction of promising plant species producing fruits with high biological value and good commercial characteristics, an example of which is Jošta, is limited by the unfavorable conditions of the steppe climate. Therefore, one of the directions of further research is the

improvement of technologies for growing introducers in arid conditions. In our opinion, further in-depth research of the Jošta hybrid on the content of physiologically active substances with the aim of including it in the composition of functional products is important.

4. Conclusions

The introduction of fruit crops enriches the diversity of the floral composition of the regional vegetation and at the same time creates the possibility of expanding the raw material base to meet the needs of human nutrition and health. Today, more than 400 species of fruit and berry plants have been introduced in different regions of Ukraine, however, the number of species introduced into the industrial horticulture of the Steppe Dnieper region is insufficient. Thus, among the fruit plants of the Dnipropetrovsk region, every year, more and more attention should be paid to introduced, uncommon non-traditional fruit species, in which fruits, leaves, stems and other parts have high biological value and are a source of physiologically active compounds that can contribute to the prevention and treatment of many diseases, be raw materials for the food industry.

The Jošta currant-gooseberry hybrid can be cultivated in unfavourable regional climatic conditions such as low air temperatures in winter and high in summer, insufficient moisture in the soil, frequent hot dry winds, ordinary low-humus chernozems, significant anthropogenical transformation of the zonal soil cover.

As a result of the conducted research, let's determine a high total content of phenolic compounds, flavonoids, free phenolic acids, general antioxidant capacity and iron-reducing activity in the peel and flesh of the Jošta fruits.

The antioxidant system of plants is one of the important nonspecific mechanisms of resistance, which significantly contribute to the drought resistance of plants. Obviously, in an arid steppe climate, the advantage will be on the side of plants with a high level of functioning of the antioxidant system. Comparative analysis of the total (peel and pulp) characteristics of the fruits of the studied rowan species allows to select the Joshta as the most promising for distribution in the region, since the fruits of this species have the maximum levels of phytochemical indicators.

Thus, the rare currant-gooseberry hybrid Jošta plant can be recommended for the cultivation and use of fruit products in "healthy" nutrition and, in particular, in the restaurant business namely locavores for the presentation of the author's intellectual interpretation of local products.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this study, including financial, personal, authorship, or any other, that could affect the study and its results presented in this article.

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The study was conducted without financial support.

Data availability

The manuscript has associated data in the data repository.

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