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Ecological Aspects of the Comparative Study of *Cornus mas* L. Genotypes According to Morphological Characteristics of the Fruits, the Content of Functional Groups of Biochemical Substances and Suitability for Healthy Food Production

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ABSTRACT

The relevance of the research lies in constant desire to increase the possibilities of using dogwood, in the system of fruit horticulture. The methodological basis for conducting research include the method of carrying out an examination of suitability of fruit and berry group varieties for spreading in Ukraine, the method of assessing the quality of fruit and berry products as well as the state standards of Ukraine for determining the quality of fruits. The original data on the morphology plants and biochemical properties of the fruits of different dogwood varieties selected by Ukrainian scientists have been presented. Attention was focused on the content of dry soluble substances, sugars, pectin substances, organic acids, and polyphenolic substances as a source of antioxidants. It was found that the content of dry soluble substances in the fruits of the Stoyan form is at the level of the Olena and Radist varieties, about 18.5%. The Hrafskyi dogwood fruits are characterized by a low content of titrated acids, which results in a balanced taste considering the sugar-acid index (SAI, 5.5). The Hrafskyi form is distinguished by the increased content of pectin substances in the fruits. It has been studied that the form of Stoyan (F-32-5-18) contains the highest amount of polyphenolic substances (944 mg/100 g), while Vydubytskyi contains 274, Vyshgorodskyi – 327, Radist – 375 mg/100 g. The content of polyphenolic substances in the fruits of the Hrafskyi form is 483 mg/100 g, which is almost on a par with the Volodymyrskyi and Lukyanivskyi varieties. The Stoyan and Hrafskyi forms have the highest content of flavonoids - 107.5±4.4 and 102.5±2.0 mg/100 g. It was found that the fruits of the Hrafskyi form have an above average content of anthocyanins (52.83±1.92 mg/100 g), compared to other varieties. The originality of the study lies in the fact that the knowledge about the morphological characteristics of plants and the biochemical characteristics of the common dogwood fruits, developed by Ukrainian scientists, was expanded. On the basis of the research results, the best varieties were selected, the fruits of which are suitable for developing technologies for the production of blended syrups for a healthy diet.

Keywords: Cornelian Cherry, ecological characteristics, biochemistry of fruits, ready-made health products.

INTRODUCTION

The problems of poor provision of the population with fruits and berries rich in biologically active substances, the role of which, according to FAO (2021), is important in the system of life support, are current issues in the world. According to Kalmpourtzidou et al. (2020), this is the case for low- and middle-income countries. Therefore, fruit and berry plants are of fundamental

importance for food security (Migicovsky et al., 2022). As noted by J. Harris et al. (2022) the efficient use of these plants must be consistent with a wide range of political, economic, social, cultural and environmental factors.

In this aspect, the horticultural products of less common fruits and berries are beginning to rise to superfood status in the world, with a clear belief in their health benefits, including their role in reducing the risk of cancer and heart diseases. As Brooks (2020) notes, these fruits are important because they contain the nutrients that are not found in other foods. However, according to nutritionist Taylor Wolfram, who runs a private practice in Chicago, Illinois (United States of America), it is not the superfoods themselves that are valuable, but the healthiest diverse and balanced diets based on them. Therefore, McMullin et al. (2019) claim that although sufficient fruit consumption can alleviate the deficiency of micronutrients and reduce the risk of a number of associated diseases, for better assimilation of nutrients, a scientifically based technology of processing and manufacturing quality products for healthy nutrition is needed (Lytovchenko et al., 2022). According to experts (Moskalets, T.Z., et al., 2019), within the framework of Ukraine food security, it is possible to double the gross production of fruit and berry products, due to the expansion of areas for domestic varieties of less common fruit and berry crops – blackberry, viburnum, honeysuckle, dogwood, chequer tree, serviceberry, chokeberry, cranberry, rowan, quince, sea buckthorn, medlar, and blackthorn – as well as intensification and modernization of processing fruit and berry raw materials, in addition to manufacturing finished products.

According to Czerwińska and Melzig (2018), it is known that the genus *Cornus L.,* 1753 belongs to the *Cornaceae* family (Bercht & Presl), *Cornales ordo* Link, 1829, *Angiosperms* or *Magnoliophyta* clade (Cronq., Takht. & Zimm., 1966). Among the 65 species of the genus *Cornus (Cornaceae*), only 2 have a long tradition of use in the food and medical industries. Dogwood (*Cornus mas L.,* 1753) is a shrub or small tree native to southern Europe and southwestern Asia, while *Cornus officinalis* Siebold & Zucc., 1839 (Asian dogwood, Japanese 74 dogwood) is a deciduous tree common in East Asia, mainly in China, as well as in Korea and Japan. It can be stated that dogwood has long been used as a fruit, medicinal, technical and decorative plant, the fruits of which are useful for both healthy people and patients with diabetes, angina, flu, diseases of the gastrointestinal tract. Dogwood is effective in treatment of stomatitis in the form of rins with an infusion of fresh or dried fruits. It should be noted that the importance of dogwood fruits in processing and manufacturing healthy nutrition products is determined by the proper provision of the fruit and berry market with a wide range of fruits having a high content of indispensable micronutrients.

Therefore, the dogwood is popular among plant breeders, manufactures of planting material and garden fruit products as well as among food processing and manufacturing technologists in most economically and socially developed countries of Europe, the USA, and Japan, ensuring the consumption of fresh and processed vitaminized products.

As Postolenko, Ye (2018) points out, dogwood is very popular in many countries of the world, such as Serbia (Aratinskirani, Bačka), Bulgaria (Pancharevskiy, Shumenskiy), Poland (Dublany, Florianka, Kresowiak, Raciborski, Podolski, Paczoski), Slovakia (Devin, Titus, Ovidius), the Czech Republic (Tišnovský, Ruzyňský), Austria (Joliko, Schonbrunner), Germany (Cormas), Greece (Vermio), Sakartvelo (Adreula, Tshenturi, Aromatnyi, Lagodehskiy ranniy), etc. At the same time, it is worth noting that owing to the hard work and numerous expeditions of Ukrainian breeders Klymenko and others (National Botanical Garden of National Academy of Sciences of Ukraine), it has become possible to describe more than 350 forms of dogwood. More than 100 forms have been selected and propagated, constituting the initial genetic material for selection by various traits. The most interesting forms of dogwood have been found in the Crimea – in the Bakhchisarai (villages of Sokolyne, Tankov, Kyzylivka, Zavitne), Belogorsk, Simferopol districts, in the Kyiv region (on the outskirts of Kyiv - in the Podol, Kurenivka, Korchuvaty districts, in particular on the territory of the National Botanical Garden named after M.M. Hryshko of the National Academy of Sciences of Ukraine 100–150 year old plants have been found), Cherkasy and Kirovohrad (in the triangle between the cities of Chygyryn-Smila Znamyanka), Vinnytsia (Murovani Kurylivtsi village), Ternopil, Khmelnytsky (Lavrynivtsi village), Lviv, Ivano-Frankivsk, Kirovohrad, Dnipropetrovsk, Zhytomyr, Poltava and Transcarpathian regions. It is worth noting that Transcarpathia has unique dogwood plantations, in particular in the Vynohrady region, in the

Botar tract, between the villages of Cherna and Novoselytsia, the largest natural dogwood plantation in Europe has been formed for more than 300 years. Its area is about 12 hectares. The appearance of these dogwood plantations is associated with the name of scientist Benedikt Komyati, who suggested that dogwood drinks be used to fight the plague, which was devastating the population throughout Europe at that time (Nazarova, 2018). Komyati suggested planting dogwood to counteract the epidemic and to produce a medicinal balm from the fruits. The locals called it "derenka". It should also be noted that at that time dogwood plantations were also established in other places of Transcarpathia, notably in Tarna Mare (near Romania), in Rokosov (Khust district) and the town of Vynohradov on Black Mountain. Modern scientists have counted about 10 varieties of dogwood there. They vary in the size of berries, color and taste and are not subject to diseases. By law, these plantations are on the balance sheet of the local Vynohradiv forestry enterprise, and have the status of a botanical reserve of local importance "Cherniansky Derenkovach". Kogutych (2021) reports that Doctor of Biological Sciences Svitlana Klymenko has taken an interest in the Chernyansk dogwood plantation, and wants to take it under her care, because according to her, there are zoned varieties in this area, where it is possible to continue selection and spread dogwood culture in the future.

Therefore, the above mentioned scientists have succeeded in reviving the culture of dogwood in Ukraine. As a result of the long-term selection work of the National Botanical Garden named after M.M. Hryshko of the National Academy of Sciences of Ukraine, promising varieties for Ukrainian horticulture with oval, spherical, pear-shaped, bottle-shaped fruits with red, cherry, 5 dark red, almost black, yellow and pink fruits have been created. The taste of the fruits was characterized as sweet-sour with a pleasant specific aroma. Moreover, the weight of the fruits of the new forms range from 4 to 10 g, length - 22-36 mm, width - 11–19 mm, while in wild dogwood these indicators are 1.6–2.5 g, 13.0–18, 0 mm, 6.9-11.0 mm, respectively (SontseSad, 2021).

According to the authors (Klymenko&Ilyinska, 2023), more than 30 varieties have been created. Early ripening varieties include Mykolka, Grenader, Elegant, etc. Among the mid-ripening ones, the Lukyanivskyi variety, which has large and tasty fruits, as well as the Exotic, Vydubytskyi, Volodymyrivskyi, Evgenia, etc., deserve attention. The selection results of the Mliivsk Research Station of Horticulture Institute of the National Academy of Sciences of Ukraine, in particular, the Mykhailivsky variety should be noted (Postolenko, 2020).

Until recently, in view of the increased demand for fruits, the crop of dogwood has not been properly spread. According to Tripoli (2023), "Variant" Farm (Donetsk region), Research Station of Pomology named after L.P. Symyrenko of the Institute of Horticulture of the National 139 Academy of Agrarian Sciences of Ukraine (Cherkasy Region) and Agricultural Company with Limited Liability "Yenogray" (Kherson Region) are the official producers of dogwood fruits on the territory of Ukraine. However, recently dogwood gardens have been gradually taking their place in Ukrainian gardening. Serhii Malyavkin, a farmer and director of the peasant farm, notes (Agronews (2020) that planting 1–2 hectares of dogwood is a risk. When planting up to 5 hectares, the farmer will work only for the domestic market and will not be able to form an export batch (Agronews (2020).

According to the reports of Agravery (2018), the breeder Svitlana Klymenko and the manager of the dogwood farm Serhii Olshanskyi note that larger areas are needed for this crop in order to reach the level of intensive processing of fruits and production of food products. Other gardeners noted that dogwood, being a valuable fruit crop will have prospects in Ukraine. In particular, Oleksandr Hubar notes that each part of the dogwood is useful: fruits, pits, leaves, bark, and roots. The latter is used in Israel to make medicine for hepatitis C. According to another gardener, Leonid Kravchuk from Kholonev, Gorokhiv district, Volyn region, who grows about 30 varieties of dogwood, the fruits of dogwood occupy one of the first places in terms of the vitamin C content, they normalize blood pressure and the main value is not in the pulp, but in the pits. Therefore, recently, more and more producers have begun to look for alternative sources of income – they grow niche crops, including dogwood, which is actively grown in the Zhytomyr region, Vinnytsia region, Mykolaiv region, Zaporizhzhia, Kyiv region, Rivne region, Volyn, Cherkasy region and Transcarpathia. The reason is that all the useful properties of dogwood are preserved during shock freezing, and the berry becomes even tastier. At present, the cultivation, processing and production of high-quality products from dogwood fruits on an industrial basis is gaining relevance

in Ukraine, although dogwood plants have been actively grown on plots.

According to AgroReview (2023), as of the fall of 2021, the largest organic dogwood garden in Europe has been formed on the basis of the Olshanskyi enterprise (TM Famberry, Zaporizhzhia region). They are developing their own processing. A new plant has been launched, where the first batch of dogwood sauce "Lagidnyi" for cheese is produced. They are ready to process products to order: preservation and puree. Moreover, frozen fruits are better suited for processing, particularly for jelly - they are hard and somewhat unripe, so that they do not fall apart during the cooking process; for purees, sauces, jams, drops – they are maximally ripe to increase the yield of juice and natural sweetness.

Therefore, the analysis of literary sources shows the relevance of research on modern varieties of *Cornus mas L*., including the study of morphological features and biochemical properties of fruits as well as their use in processing and manufacturing of healthy food products. The purpose of the research was to conduct a comparative assessment of new forms of dogwood with regionalized ones according to the morphological characteristics and biochemical properties of the fruits, as well as to determine if they are suitabile for the production of healthy nutrition products.

MATERIAL AND METHODS

The research was conducted in 2017–2021 at the Institute of Horticulture of the National Academy of Agrarian Sciences of Ukraine (IH NAAS). The fruits of varieties and forms of dogwood of Ukrainian selection were studied, namely Radist, Olena, Lukyanivskyi, Vyshgorodskyi, Volodymyrskyi, Hrafskyi and Stoyan. Cornelian fruits at technical ripeness were provided by the Mliiv Research Station of Pomology named after L.P. Symyrenka of the National Academy of Sciences and by technical experts in the field of horticulture V.S. Francishko and M.S.Karpets. During the research, morphological parameters of fruits were measured according to *Methodology for examination of fruit, berry, nut and grape plant varieties for distinction, homogeneity and stability... (*2016). The analyses of dogwood fruits were conducted in the laboratory of selection and technology of growing berry crops, as well as the laboratory of the post-harvest quality of fruit and berry products of IH NAAS and independent laboratories for assessing the quality of fruits. It was found that the weight and quality of fruit samples met the requirements of Methodology for Assessing the Quality of Fruit and Berry Products (Kondratenko et al., 2008) and DSTU ISO 874-2002 (2003). The content of dry and dry crumb substances, flavonoids, pectin substances, total sugars, ascorbic acid, anthocyanins, polyphenolic substances were based on such indicators. The fruits were selected according to DSTU ISO 874-2002 (2003). The content of polyphenol compounds was determined according to DSTU 4373:2005 (2006), soluble solids – DSTU ISO 2173:2007 (2010), sugars – DSTU 4954:2008 (2009), titrated acidity – DSTU 4957:2008 (2009), pectin substances – DSTU 8069:2015 (2017), ascorbic acid – DSTU ISO 6557-2:2014 (2015). The laboratory of innovative food technologies of the Institute of Horticulture of the National Academy of Sciences of Ukraine under the leadership of Professor O.M. Litovchenka used fresh dogwood fruits of various forms in accordance with DSTU 4283:2007 (2007), fresh apples for industrial processing according to DSTU 7075:2009 (2009), white crystalline sugar, according to DSTU 2316-93 (1994), drinking water – according to DSanPiN 2.2.4-171-10 (2022) with a hardness of no more than 2.0 mol-eq/dm^3 for softened water or up to 7 mol-eq/dm^3 for natural unsoftened water, dry substances or moisture – according to DSTU 7804:2015 (2015). Preparation of samples for laboratory analyses was made according to DSTU 7040:2009 (2009).

The studies were performed in triplicate, statistically processed in the Excel-2007 program. Experimental studies of dogwood plants (both cultivars and forms), including fruit collection, followed institutional, national or international guidelines. The authors followed the standards of the Convention on the Protection of Biological Diversity (1992) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (1979).

RESULTS AND DISCUSSION

It was determined that the fruits of the large-fruited variety Radist are collected in the third decade of August. It should be noted that the fruits ripen almost simultaneously. The average weight of the fruit is 5.8 g, the maximum is about

7 g. It has been found that the fruits of this variety are pear-shaped, the color of the skin is bright red, the pulp is red-pink, juicy, the pulp is very well separated from the pit.

For the mid-ripening Lukyanivskyi variety, the fruits are collected at the end of August and the beginning of September. Biometric tests have shown that the fruits of this variety are bottle- or pear-shaped, large, the average weight of which exceeds 5.5 g. The average size of the fruits is 35.4 × 15.6 mm. The pulp of the fruits is dark red in color, juicy, with specific cornelian flavour.

It was found that the fruits of the Volodymyrskyi variety are also medium-ripening, ripen almost evenly, are very well attached and remain on the tree for a long time after ripening; in terms of size – large-fruited, with an average weight of 7.2 g, size – 27 mm long, 6.9 mm wide, oval-cylindrical in shape, somewhat flattened on both sides, the skin of which is shiny, red or dark red, when full ripening – very dark red or black, as shown in Figure 1.

The pulp of the fruits of this variety is crunchy, dense, its sweet-sour taste is rich. The fruits of the early ripening variety Vyshgorodskyi ripen in the first decade of August. The average fruit weight is 4.5 g. Fruits are sweet and sour in taste, oval-cylindrical, barrel-shaped. The shape of the fruit is varied even within the same plant, the average fruit size is 22.5 × 14.5 mm. The skin of the fruit is thin-walled and shiny, when fully ripe it is dark cherry in color, and the juicy pulp is bright red.

The fruits of another early-ripening Olena variety, which ripen at the beginning of the second decade of August, are prone to shedding, so the crop must be harvested a few days before full ripeness. Fruits are round-oval in shape, have an average weight of 5.6 g, and are about 25 mm long. The skin of the fruits of this variety is shiny, bright red, and when fully ripe – dark red. The pulp of the fruit is red, tender, very juicy with medium density. The taste of fruits is sweet-sour and sweet when ripe.

The fruits of the late-ripening form of the Stoyan dogwood (F-32-5-18) ripen at the beginning of the second decade of September. Fruits have an average weight of 5.6 g, length – 19 mm and are elongated pear-shaped. The skin of the fruit at technical ripeness is dark red in color, the pulp is red with medium density and high taste qualities. The fruits have high transportability and shelf life. The fruits of another late-ripening Hrafskyi form, which ripen also at the beginning of the second decade of September, are broad-pear-shaped, about 20 mm long and have an average weight of 5.3 g, as shown in Figure 2.

The skin of the fruit acquires a very dark red or dark ruby color when it is technically ripe. The pulp is defined by its red color, medium density, high taste qualities. Its taste is slightly acidic with noticeable hints of tartness. The fruits have high transportability and shelf life. During the research, it has become clear that it is possible to extend the shelf life of vitamin dogwood fruits by freezing or processing. It will help preserve their taste and healing properties for a long time. After all, dogwood has rather short shelf life: at a temperature of 0–1°C, the fruits are stored for no more than 7 days.

According to the results of the biochemical tests, it was found that the fruits of the studied

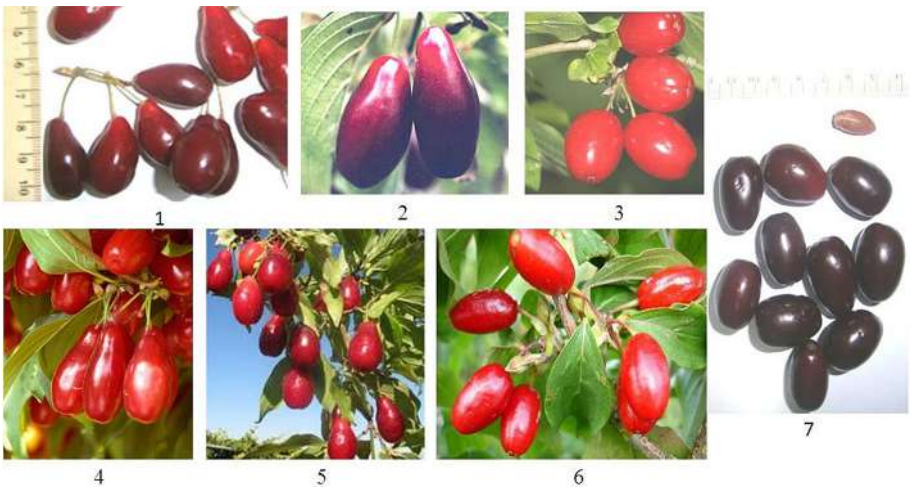

Fig. 1. Fruits of studied varieties of *Cornus mas*: 1 – Stoyan; 2 – Radist; 3 – Olena; 4 – Lukyanivskyi; 5 – Vyshgorodskyi; 6 – Volodymyrskyi; 7 – Hrafskyi

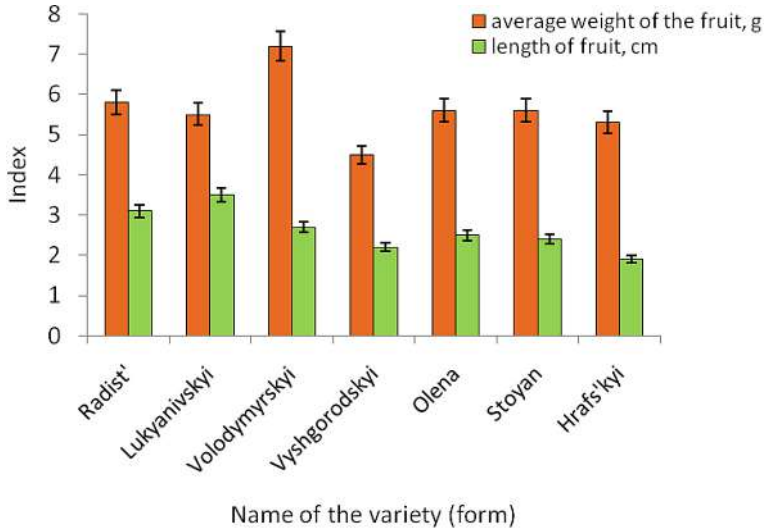

Fig. 2. Biometric parameters of dogwood fruits depending on the variety (form)

varieties of dogwood contain 16.7±0.3% of dry matter, the maximum amount is in the fruits of Vyshhorodskyi (23.3±0.3%). Fruits of the Olena (18.3±0.6%), Radist (18.6±0.3%) and Stoyan forms (F-32-5-18) accumulate a little less, but more than the average indicator of dry matter – 18.7%/100 g, respectively. The Lukyanivskyi and Volodymyrskyi varieties contain the least of it (12.6±0.3 and 11.8±0.4%, respectively). Dry soluble substances in the fruits of dogwood vary within the highest value of 19.5±0.3% for the Vyshgorodskyi variety and the lowest for Volodymyrskyi, 13.6±0.3%, with an average value of 15.6±0.2% per 100 g of raw mass. A trend in the accumulation of dry matter and dry soluble substances has been noted in dogwood fruits. The varieties with a high content of dry matter similarly have a high content of dry soluble substances. It is shown in Figure 3.

The fruits of Vyshgorodskyi (11.4±0.2) and Olena (10.7±0.6% per raw weight) stand out among the varieties under study having the

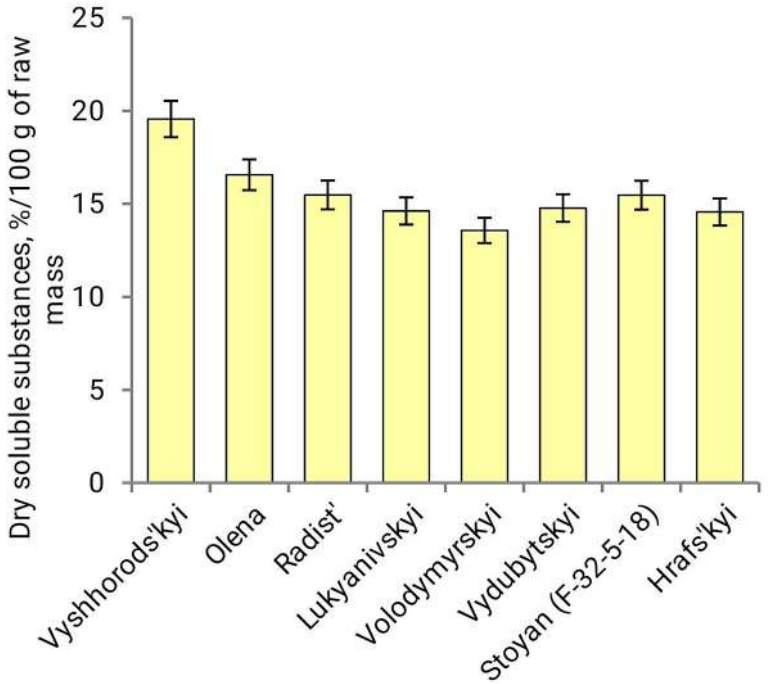

Fig. 3. The average content of dry soluble substances in dogwood fruits depending on the variety (form), %/100 g of raw weight

highest content of total sugars, while the average intervarietal content is 9.7%. In addition to the afore-mentioned varieties, fruits of the Stoyan (F-32-5-18) form (9.9±0.2) accumulate sugars above this value. The fruits of the Lukyanivskyi variety (8.56±0.29) and Vydubytskyi variety (8.7±0.18% per 100 g of raw mass) have the least amount of sugars. Hrafskyi fruits (1.7±0.14%) have the lowest number of titrated acids among the studied varieties of dogwood. Olena (3.1±0.23) and Radist (3.05±0.18% per 100 g of raw mass) have the highest amount. The low content of titrated acids in the Hrafskyi variety contribute to obtaining fruits with a balanced taste, as evidenced by the sugar-acid index at the level of 5.5. The fruits of the Vyshgorodskyi and Volodymyrskyi varieties, have the sugar-acid index at the level of 4.3 and 4.2, respectively. The lowest taste index of 3.2 and 3.4 has been noted for the fruits of dogwood varieties Radist, Olena and Lukyanivskyi. It is shown in Figure 4. For the studied dogwood varieties Radist, Vyshgorodskyi and Lukyanivskyi, the content of pectin substances is at the level of the average intervarietal indicator of 0.54±0.03%/100 g of raw mass, which is 17% less than for the Hrafskyi form. The highest content of pectins at the level of 1.0±0.01 and 1.12±0.06% has been found in the fruits of the Volodymyrskyi and Vydubytskyi varieties. The fruits of the Olena variety (0.33±0.03) and the Stoyan form (F-32-5-18) (0.38±0.01) accumulate the least amount of pectin substances. It is shown in Figure 5.

It was found that the C-vitamin content of dogwood fruits is at the level of the average value of 46.6±0.3 mg/100 g of raw weight. The fruits of the Vyshgorodskyi, Radist and Olena varieties accumulate the highest amount of ascorbic acid among the studied varieties (51.3±1.9; 53.6±0.3 and 59.2 mg per 100 raw weight, respectively). The fruits of the Volodymyrskyi (44.9±2.6), Vydubytskyi (44.38±0.31), Lukyanivskyi (37.4±0.3), Hrafskyi (41.4±0, 3) and Stoyan forms (F-32-5-18) (41.4±0.3 mg/100g) contain less than average vitamin C.

The number of polyphenols in the fruits of the dogwood vary within the maximum value of 944±13 – the Stoyan form (F-32-5-18) and the minimum of 275±5; the average intervarietal content is 470±7 mg/100 g. Except for the specified form, the fruits of the Hrafskyi form (483±12 mg/100 g) accumulate above the average amount. The rest of the studied varieties have the content of polyphenolic substances from 275±5 to 463±11 mg/100 g. It is shown in Figure 6. The fruits of the Stoyan form, which contain the largest amount of polyphenolic substances among the studied samples, as well as the Hrafskyi form, have the highest content of flavonoids – 107.5±4.4 and 102.5±2.0 mg/100 g, respectively. The fruits of Vyshgorodskyi accumulate more than the average amount of flavonoids for this group of varieties (64.0±3.3 mg/100 g), while Vydubytskyi has about 11, Volodymyrskyi and Lukyanivskyi have 20 each. It is shown in Figure 7.

It was found that the Vyshgorodskyi, Olena and Radist varieties contain the highest amount of anthocyanins (64.3±0.3; 68.6 and 77.4 mg/100 g of raw weight, respectively). Hrafskyi fruits also have above average content (52.83±1.92 mg/100 g). The fruits of Lukyanivskyi (6.3±0.1), Volodymyrskyi (8.4±0.3) and Vydubytskyi (8.1±0.2 mg/100 g) accumulate the least amount of anthocyanin substances from this group of varieties. The chalcone component, as well as the anthocyanin component, is the highest in the fruits

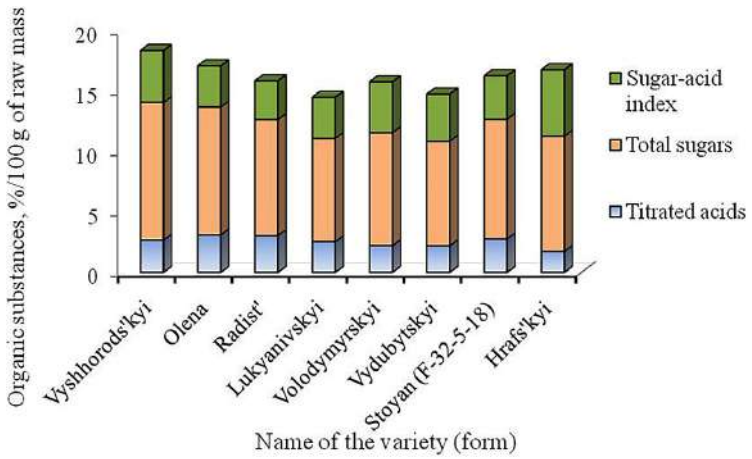

Fig. 4. The average content of organic substances in the fruits of dogwood depending on the variety (form)

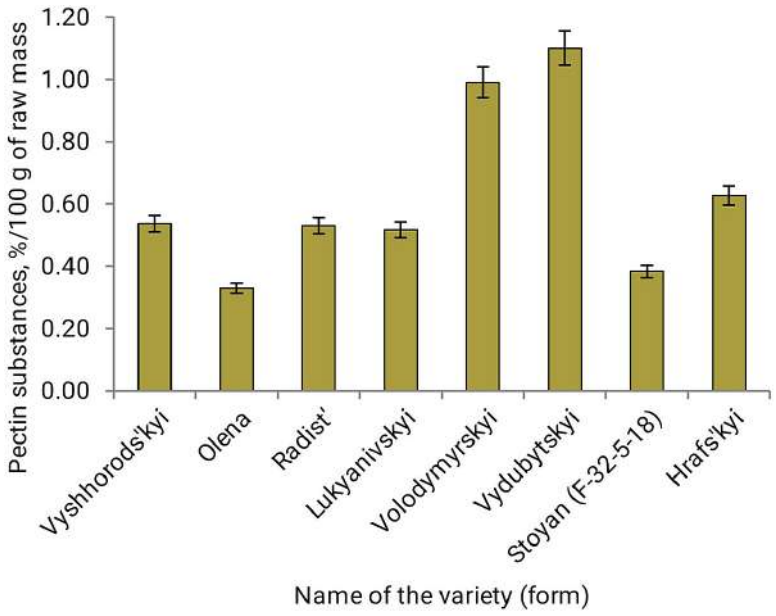

Fig. 5. The average content of pectin substances in dogwood fruits depending on the variety (form), %/100 g of raw mass

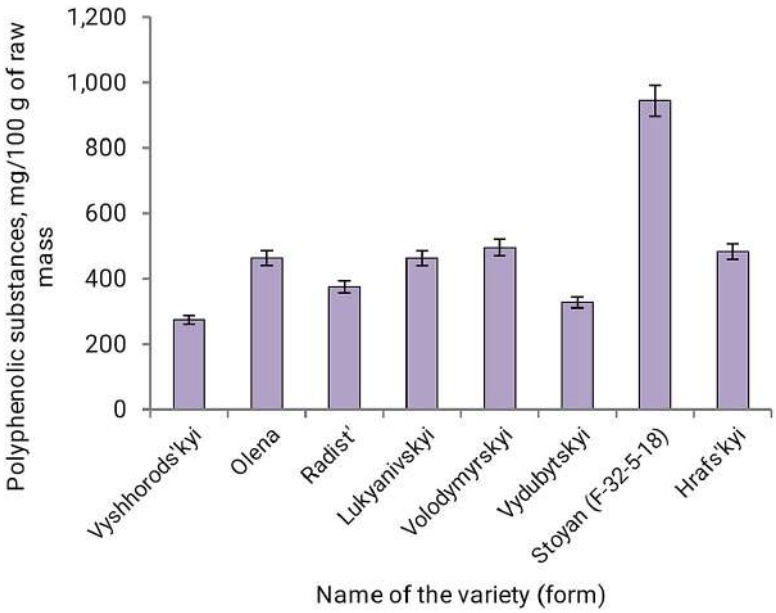

Fig. 6. The content of polyphenolic substances in dogwood fruits depending on the variety (form), mg/100 g of raw mass

of the Radist (32.5±0.3), Olena (27.6±0.4) and Vyshgorodskyi varieties (25.5±0.3 mg/100g raw mass). The fruits of Lukyanivskyi, Volodymyrskyi, Vydubytskyi, Hrafskyi and Stoyan have less than average content of chalcones.

The levels of acidity level of dogwood fruits juice varies within the highest value being 3.7±1.1 for the Vyshgorodskyi variety and the lowest being 3.3±0.3 for the F-32-5-18 form. The average value is 3.4±0.6. The levels of acidity value of the juice is higher in fruits of Volodymyrskyi (3.5±0.6) and Vydubytskyi (3.5±0.6) varieties. The pH of the Radist (3.4±0.6) and Lukyanivskyi varieties (3.3±0.4) have lower than the average indicator. It is shown in Table 1.

The highest redox potential among the studied varieties is observed in the fruits of the Stoyan form (F-32-5-18) (224.0±1.1 mV), the lowest – in the Lukyanivskyi variety (211.1±1.1 mV). The ORP of all other varieties varies within

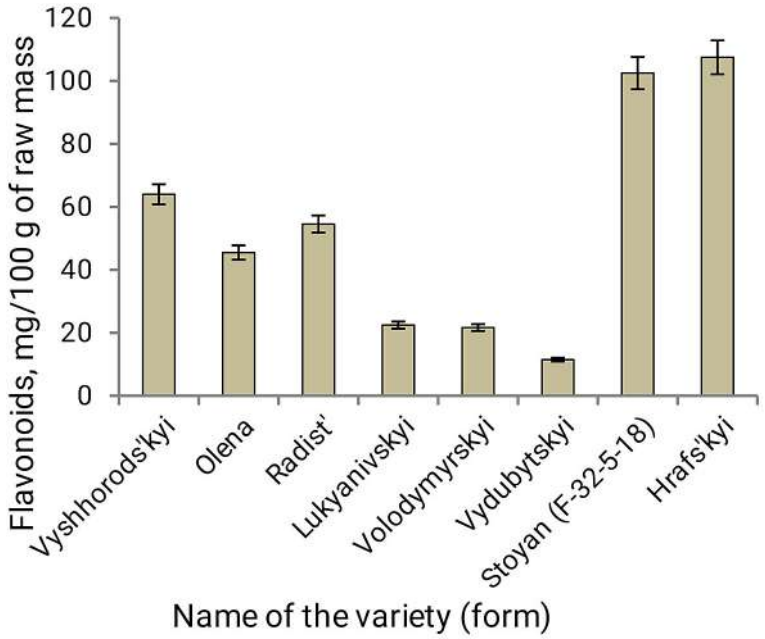

Fig. 7. The average content of flavonoids in dogwood fruits depending on the variety (form)

Table 1. Levels of acidity of juice and redox potential (ORP) of fruits depending on the variety (form) of dogwood

Name of the variety (form)	pH of juice	ORP, mV
Vyshgorodskyi	3.7±1.1	221.3±3.7
Olena	3.3±0.5	222.1±2.1
Radist	3.4±0.6	222.0±2.3
Lukyanivskyi	3.3±0.4	211.1±1.1
Volodymyrskyi	3.5±0.6	215.8±0.8
Vydubytskyi	3.5±0.5	213.6±0.6
Stoyan (F-32-5-18)	3.3±0.3	224.0±1.1
Hrafskyi	3.3±0.4	216.5±0.5

the indicated limits, the average value is at the level of 218.3±1.2 mV. According to the content of dry soluble substances, dogwood fruits of the Vyshgorodskyi and Olena varieties can be used for the production of reconstituted juices and fruit powders. The high content of sugars in the specified varieties of 11.4 and 10.7% per raw weight, as well as titrated acids of 2.7 and 3.1% per raw weight, indicates the suitability of the fruits of the 346 mentioned varieties for the production of high-sugar types of processing, as well as jelly. The fruits of these varieties are good raw materials for making compotes and drinks.

The amount of pectin substances, more than 1.0%, and titrated acids more than 2.0% makes the fruits of the Volodymyrskyi and Vydubytskyi varieties suitable for the production of processed jelly products, as well as jams and pastilles.

On the basis of the results of biochemical analysis of the studied varieties (forms) of dogwood, it can be said that according to the quantitative content of biologically active substances, varieties Vyshgorodskyi, Olena, Radist and the Stoyan and Hrafskyi forms are more suitable for the production of products with increased biological value. As noted by Szot et al. (2022), the high and homogeneous fruit quality can be obtained exclusively by growing varieties adapted to specific climatic conditions in specialized farms. At the same time, the yield of dogwood fruits is not constant, and according to the authors (Skender et al., 2022), 7–8 times in 10 years, the average yield in dogwood orchards can reach 10–15 t/ha, and from natural plots - 0.5–1 t/ha. The yield from native dogwood plants is usually formed by smaller, more acidic and less juicy fruits with large pits, but with a high content of nutrients, which have increased antioxidant activity, especially determined by glucuronide. As for the nutritional value of dogwood fruits, it is known that 100 g of dogwood pulp contains 1.5 g of dietary fiber and 4 mg of iron (the daily norm is 10 mg for men and 18 mg for women), as well as 30% of the daily need for vitamin C, 15% – potassium, 13% – folic acid. In addition, 365 dogwood, is characterized as an early honey and pollen bearer (a bee colony can collect from 550–850 g

of pollen), since flowering occurs in early spring (March-April), before the vegetative buds open, releasing nectar which is collected by bees along with light yellow pollen and glue. Serbian scientists Dokoupil and Řezníček (2023) studying the varieties Elegantní, Fruchtal, Jaltský, Jolico, Lukjanovský, Vydubecký, Vyšegorodský have found out that the Lukjanovský (292 mg/kg^{-1}) and Vyšegorodský varieties are characterized by an increased content of magnesium. In general, the varieties differ slightly by the content of potassium (3500–3798 mg/kg^{-1}), calcium 372 and phosphorus (301 and 365 mg/kg^{-1} and 313 and 412), the content of Zn varies from 2.65 to 3.52 mg/kg^{-1}, Fe – about 41, Zn ranged from 2.65 to 3.52 mg/kg^{-1}, Cu from 1.09 to 1.74 mg/kg^{-1}, 374 Mn from 24 to 29 mg/kg^{-1}. It is noted that the honey productivity of 1 hectare of planting is 50–65 kg, less often – up to 140 kg/ha, which depends on weather and climatic factors, in particular, during precipitation, nectar secretion from flowers decreases. Aspects of studying mineral composition of fruits are planned in further studies.

The dogwood samples having fruits with a significant potential for antioxidant activity (>80% radical scavenging activity) have been selected under natural conditions and studied by researchers Kazapatzak et al. (2022). As noted by Klymenko and Ilyinska (2023), the new Ukrainian variety "Vytivka Svitlany" is characterized by a very early ripening period. Its fruits have high taste qualities and nutrient composition (sugars – 8.97%, ascorbic acid – 62.82 mg/%, titratableacidity – 2.92 %, tannins – 0.53%, carotenes – 97/98,0.39 mg/%) and are suitable both for fresh consumption and for 385 processing in the food industry. According to Serhii Olshanskyi, on consultations with Professor Svilana Klymenko, this variety is recommended to be grown like other varieties, the scheme is 4 × 5 m, although there are options of 4 × 3 m at a rate of 830 plants/hectare. At the same time, the planting schemes offered for organic gardening are as follows: 6 × 6 m; 5 × 5 m – with irrigation; 5 × 4 m; 4 × 4 m – without irrigation; 9x9m; 8 × 8 m – when compacted by berry crops (blueberry, black currant).

Thus, horticultural producers form the future harvest, which will be characterized by flavour, which, as noted by Kazimierski et al. (2019), is generally considered to be tart, sour and in some cases sweet, resembling pineapple. It will have biological value about which there is a lot of information. According to the results of the presented article, the taste of dogwood fruits depends on the variety. Particularly, the Olena, Vyshgorodskyi, Volodymyrskyi varieties have the fruits with sweet-sour or sweet flavor (the Olena variety), the new form Hrafskyi is slightly sour with noticeable notes of tartness. Biologically active compounds of plant origin are becoming increasingly popular as food ingredients with beneficial effects on human health (Tenuta et al., 2022; Odžaković et al., 2022).

However, the nutritional composition of the fruits changes depending on the place of growth. For example, in Montenegro, dogwood fruits have a high level of vitamin C (48–108 mg/100 g), malic acid (104–375 mg/100 g) and total polyphenols (158–591 mg). GAE/100 g), including phenolic acids (7.69–19.87 mg/100 g), flavonoids (10.87–44.34 mg/100 g), anthocyanins (11.85–195.43 mg/100 g) and iridoids (129, 07–341.20 mg/100 g), showing high 405 antioxidant activity according to the results of DPPH (623-1903 μmol TE /100 g) (Martinović&Cavoski, 2020). And according to Skender et al. (2022), dogwood fruits grown under the conditions of north-western part of Bosnia and Herzegovina, are characterized by the following content of dry matter – 11.67–21.89%, polyphenols – from 1240 to 6958 mg equivalent g FW, phosphorus and iron – from 155.52 to 263.06 mg per 100 g and from 0.25 to 0.93 mg per 100 g, vitamin C – from 25.85 to 58.75 mg/100 g. It is shown that the main sugars in dogwood fruits are glucose (3.02±0.9%) and fructose (1.57±0.4%), whereas the total content of polyphenols, flavonoids, anthocyanins, proanthocyanins, tannins, and ascorbic acid ranges from 230.4–559.8 mg,

GAE/100 g, 28.3–94,7 mg CE/100 g, 69.2–200.5 mg/100 g, 124.1–316.3 mg KE/100 g, 151.6–568.9 mg TAE/100 g, and 29.0–103.3 mg/100 g, respectively (Guzel, 2021). According to the results of the presented article, the maximum content of polyphenols is 944, the minimum – 275 mg/100 g, flavonoids – 109 and 20 mg/100 g, anthocyanins – about 77 and 6 mg/100 g, respectively.

Regarding the medicinal properties of dogwood fruits, many scientists note (Popović Djordjević et al., 2022) that recent reports increase the importance of their potential in the prevention of many diseases. The antimicrobial and antioxidant properties of dogwood fruit extract, as well as other therapeutic effects of *Cornus mas*

L., are described by Süntar et al. (2020). Mardani et al. (2020) claim that water-alcohol extracts from dogwood fruits promote wound healing, using rodents as an example.

Other researchers (Şengül, et al., 2022) testify to the antioxidant properties of phenolic and aromatic compounds synthesized from dogwood flowers. As the authors (Radbeh et al., 2020) note, dogwood fruits are used to prevent cancer. Odžaković et al. (2022) note that polyphenolic components of dogwood fruits have significant antimicrobial activity against *Bacillus cereus* and *Escherichia* coli cultures.

In general, the pharmacological properties of dogwood fruits, as well as their functional properties are well known. As noted by Martinović & Cavoski, dogwood fruits contain a large amount of vitamin C, polyphenols, iridoids and other biologically active substances, which, when consumed, show antioxidant, anti-inflammatory, antibacterial, antifungal, and antispasmodic properties. In particular, they are effective in the prevention and treatment of the central nervous system diseases, atherosclerosis, obesity, diabetes, glaucoma, breast cancer, colon cancer, lung cancer and stomach cancer (Lewandowski et al., 2022).

According to Adamant (2018), these effects can be obtained not only by consuming fresh and dried fruits as medicines for the elimination of many diseases, in particular kidney problems, but also by processing them and making food or by synthesizing certain biological substances. The question of the synthesis of nutrients from dogwood, the presence of which is determined by the characteristics of varieties or species, the place and methods of their cultivation, methods of processing, etc., is relevant (Dumitrașcu et al., 2021). In particular, the authors (Klymenko et al., 2021) note that interspecific hybrids of *C. mas* × *C. officinalis* contain more iridoids than *C. mas* and more anthocyanins than *C. officinalis*. Taş and Gundogdu report significant fluctuations in the anthocyanin content in dogwood fruits depending on the genotype of the variety.

According to the authors (Diaconeasa et al., 2020), the rapid synthesis and timely use of anthocyanins, as well as pigments of bright color, make it possible to effectively prevent many diseases, including skin cancer. A convincing argument lies in the significant antiatherogenic, anti-inflammatory and neuroprotective effect of anthocyanins, which are part of extracts from the fruits and leaves of *Cornus mas L.*. According to Szczepaniak et al. and Przybylska et al. this indicates their significant antioxidant potential. The same can be said for the synthesis of polyphenols from dogwood fruits and their health benefits. It is emphasized by Tešić et al.. Their effect on the lipid composition of blood is emphasized (Mohammadi et al., 2021). As Bayram and Ozturkcan (2020) note, dogwood fruits are a "superfood", being a source of polyphenols. This indicates the prospects of using dogwood fruit raw materials in the production of food products on an industrial basis. According to Chinese scientists Liu et al. (2023), it is a source with high nutritional value, which has been known since ancient times – in fact, at least 7 thousand years ago.

Due to the long-term evolution of processing dogwood fruits, it was found that they can be widely used for the production of syrup, jam, juice, vinegar and distillate (Kawa Rygielska et al., 2018). In particular, the authors of Salejda et al. (2018) demonstrate the high 465 efficiency of dogwood fruit juice in retarding lipid oxidation in beef hamburgers during storage.

It is worth noting that for the system of processing and production of fruit products in tandem, an equivalent system of fruit production must function (Lytovchenko et al., 2022). For example, in Turkey, the annual harvest is 14.8 thousand tons of dogwood fruits, which, according to experts (Vildan Beşe&Polatoğlu), is enough for the processing and production of jams, marmalade, pastilles, paste, sherbet, or ordinary dried fruits, both for own needs and for export.

However, due to non-simultaneous ripening of dogwood fruits on trees, for economic reasons, the fruits intended for processing are collected once or very late, when all overripe fruits fall to the ground, which reduces their taste and suitability for effective processing. Therefore, the sensorial properties and suitability of dogwood (*Cornus mas L.*) for processing are very closely related to the stage of its ripening, which to a certain extent can be recognized not only by the hardness and color of the peel, but also by the determination of flavonols, especially kaempferol-3-glucoside (in fruits of different varieties there are approximately 0.80 mg/kg, in wild ones – about 1.75 mg/kg). This enables to verify the proper ripeness of dogwood fruits for effective processing, regardless of species, variety, place of growth, harvest size (Gössinger et al., 2022). It is also worth noting that modern processing enterprises usually buy frozen fruits or purees on the market, and in order

to preserve their technological properties, they often use developed technologies. The treatment with aminobutyric acid and nitrogen oxide makes it possible to preserve the sensory and nutritional qualities of dogwood fruits during postharvest cold storage, delaying softening and enhancing phenolic accumulation (Agdham et al., 2019). It is worth noting the methods aimed at adding strains of microorganisms that improve the quality of the final product. An example would be the use of the *Lactiplantibacillus plantarum* DA100 strain, which due to its inherent probiotic properties, allows creating a marmalade-like product from dogwood nectar (Alp and Mısır).

Other authors also note the high quality of marmalade made from dogwood fruits (Savaş et al., 2020). It is also worth noting that in order to reduce the loss of physiological functionality of the ingredients of fruit and vegetable raw materials, including dogwood, Zagorulko et al. have improved the method for the production of jam, related to economical heat exchange operations, as well as the percentage content of dogwood fruits.

Other researchers also talk about the production of new, natural and fermented apple dogwood drinks rich in natural antioxidants (Adamenko et al., 2019). The use of extracts from dogwood fruits is of great industrial importance. In particular, it is proposed to be used as a multifunctional material for the production of cosmetic emulsions (Nizioł-Łukaszewska et al., 2018). As far as the loss of the antioxidant properties of the extract is concerned, scientists suggest using a natural deep eutectic solvent (Sik et al., 2023).

Considerable success has been achieved by researchers (Haghani et al., 2021) in the use of dogwood peel (Cornus mas L.) in the production of probiotic ice cream. It is also known that the nutritional value of cheese can be improved by enriching it with dogwood products (Andersen, 2023). According to Enache et al. (2021), jelly candies with vitamin C from dogwood fruit extracts have been made in Europe. It was determined that roasted seeds can be used as a substitute for coffee or as aromatic and bioactive additives to coffee beans (Spychaj et al.).

Ukraine also has the experience of using dogwood fruits in manufacturing functional products. In particular, this fruit and berry liqueur wine "Umansk Dogwood" is made on the basis of wine materials from pear and dogwood (Lytovchenko et al., 2022). It has a pleasant flavour with varietal shades of dogwood, a harmonious taste with tones of dried fruits and dogwood and the color from light ruby to ruby. At the same time, the alcohol content does not exceed 14.0% vol., sugar – 19.0%, with titrated acidity – 5.0-7.0 g/dm^3. Ukrainian Famberry Company, which has Europe's largest organic dogwood garden and 516 develops its own processing, has launched a new plant in Zaporizhzhia. In fact, the enterprise is mastering new types of products: dogwood jam without pits, marinated dogwood and dogwood stuffed with nuts or anchovies. It should also be noted that Oleksandr Ryabtsev, a specialist from the Dnipropetrovsk region, creates varieties of gin, both from the fruits of goumi, quince, viburnum, and dogwood.

Summarizing the above, it can be said that the increased interest of agrarians in dogwood cultivation as well as the search and selection of economically valuable forms and varieties on the basis of morphological, physiological and biochemical studies have prospects for further development. This is also true for processing of dogwood fruits, production and introduction of valuable consumer products, which even in small quantities will provide the human body's need for essential substances, preventing the development of food-dependent diseases, preventing the aging process and contributing to strengthening the immunity, eliminating the deficiency of vitamins, antioxidants, micro- and trace elements.

CONCLUSIONS

Some of the best varieties have been selected for the evaluation of dogwood according to the morphological features of the fruits, namely the Volodymyrskyi, Lukyanivskyi, Vydubytskyi, Radist, Vyshgorodskyi, Olena as well as the Stoyan and Hrafskyi forms. It was found that the longest fruit is formed by plants of the Lukyanivskyi variety, while the smallest fruit is of the Hrafskyi variety. The Vyshgorodskyi variety forms the largest mass of fruit.

It was shown that according to the chemical and technological assessment, in particular, the content of dry soluble substances, the fruits of dogwood of the Vyshgorodskyi and Olena varieties can be used for the production of reconstituted juices and fruit powders. The high content of sugars in the specified varieties (11.4 and 10.7%/raw weight), as well as titrated acids of 2.7 and 3.1% per raw weight, indicates

the suitability of the fruits of the mentioned varieties for the production of high-sugar types of processing. The fruits of these varieties are good raw materials for making compotes and drinks.

The amount of pectin substances, more than 1%, and titrated acids, more than 2%, characterizes the fruits of the Volodymyrskyi and Vydubytskyi varieties as excellent raw materials for the production of processed jelly products, as well as for jams and pastilles. The fruits of the Olena variety are a phytovaluable raw material in terms of the amount of biologically active substances, in particular, ascorbic acid (59.2 mg/100 g), the Stoyan form – in terms of polyphenolic substances (944 mg/100 g), the Hrafskyi form – flavonoids and anthocyanins (102, 5 and 52 mg/100 g).

The studied varieties and forms of dogwood Volodymyrskyi, Lukyanivskyi, Vydubytskyi, Radist, Vyshgorodskyi, Olena, Stoyan, Hrafskyi are promising for use in fruit horticulture system, including selection and breeding of high-yielding genotypes as well as the development of technological elements for processing fruits and manufacturing products for healthy nutrition.

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