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The influence of genetic traits of the variety on the preservation of bioactive compounds in blue honeysuckle (*Lonícera caeruléa* L.) fruits during sublimation and drying

Abstract. The value of blue honeysuckle fruits lies in their significant content of biologically active substances that perform antioxidant functions in the human body. Since fresh honeysuckle has a short shelf life, the goal of this research was to find processing methods that would ensure maximum preservation of both sensory and phytochemical properties. Fresh, dried, and freeze-dried fruits were tested in the laboratory to determine the content of vitamin C, polyphenols, flavonoids, and anthocyanins, and to conduct a sensory assessment of the quality of the samples under study. Statistical analysis of the research data was performed using STATISTICA software suite and ANOVA variance analysis. As a result of the research, it was found that the sensory quality indicators, namely, appearance and colour, were best preserved in the freeze-dried fruits of the Duet variety, while the Spokusa berries had an excellent taste rating of 4.8 points. It was determined that freeze-dried blue honeysuckle fruits retained 27.5% more ascorbic acid than dried ones, which accounts for 89.5% of the content found in fresh fruit. The least vitamin C was lost in the fruits of the Alicia variety. The loss of total phenols during drying ranged from 19.0% to 46.2%, which is 10.0% to 23.1% more than during freeze-drying. The most significant losses of total phenols occurred in the Duet variety for both drying and freeze-drying, while the least occurred in the Aurora variety. During drying and freeze-drying, blue honeysuckle fruits lost the most flavonoids and anthocyanins – 76.8% and 43.8%, respectively. The amount of anthocyanins decreased by 137 mg during freeze-drying and by 239 mg during drying. The results of this research can be used by producers to select blue honeysuckle varieties for the establishment of industrial plantations for drying and freeze-drying

Keywords: freeze-drying; vitamin C; polyphenols; flavonoids; anthocyanins

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INTRODUCTION

The food market is evolving rapidly, with healthy eating as a major trend. At the centre of this evolution are natural bio-organic extracts rich in antioxidants, polyphenols, flavonoids, carotenoids, and vitamins, which can enrich traditional food products, including fruit juices, increasing their value for human health (Sorrenti *et al.*, 2023; Krakowska-Sieprawska *et al.*, 2024). One of these valuable foods is the fruit of berry crops. As noted by O. Golovinskaia & C. Wang (2021), whether consumed fresh, frozen, freeze-dried, or dried, they offer significant health benefits. Blue honeysuckle is a valuable crop because its fruits ripen the earliest and have significant biochemical value. Due to the presence of biologically active substances with health benefits, including antioxidant and anti-inflammatory functions, blue honeysuckle fruits have gained attention from health-conscious consumers (Rupasinghe *et al.*, 2018).

In recent years, a new berry crop, blue honeysuckle, has been introduced to Ukraine's plantations that has not been grown before. Its value lies in its high winter hardiness and significant resistance to disease and pests. In addition, the fruits of blue honeysuckle open the season of fresh berries. With good agricultural practices, it is possible to get up to 4-5 kg of fruit from a bush. Other valuable compounds in blue honeysuckle include polyphenolic substances. However, according to E. Bassey *et al.* (2021), due to their high water content, these berries spoil quickly. To minimise qualitative and quantitative losses after harvesting, advanced processing technologies are required to prevent undesirable changes in weight, colour, texture, and flavour (Mencarelli & Bellincontro, 2020).

Drying is one of the simplest and most energy-efficient methods of processing fruit products. Hot air drying involves heating the air using thermal energy to evaporate moisture from the fruit. However, according to X. Zhang *et al.* (2023), traditional drying methods are inefficient and result in poor quality, although this statement does not apply to all fruit crops. Currently, vacuum freeze-drying, a more advanced technology, is gaining popularity (Liu *et al.*, 2022). Freeze-drying is a process in which water in the form of ice is removed from a material under low pressure by sublimation (Stevanović *et al.*, 2021). As noted by Y. Qi *et al.* (2021), this dehydration technique preserves fruit and its juices, extending shelf life while reducing volume and weight, which lowers packaging, storage, and transportation costs. Freeze-drying is the preferred method for drying foods containing temperature-sensitive and oxidation-prone compounds, as it operates at low temperatures and under high vacuum conditions. Lyophilised berries, due to their biologically active compounds and extended shelf life without compromising nutritional value, can be used as ready-made functional foods (Silicka *et al.*, 2020). Freeze-drying is one of the most expensive methods of fruit processing, as it requires expensive equipment that first freezes the produce and then extracts moisture from it. For this reason, this processing method is not always affordable for producers. The preservation of product quality indicators depends heavily on the biological characteristics of the variety.

Blue honeysuckle is a new crop for the Ukrainian market that requires a comprehensive study. Particular attention should be focused on establishing the areas of product use, as honeysuckle is a new product on the Ukrainian market. In addition, the presence of a large amount of water in the berries makes it a product of short consumption period. In view of this, the research was aimed at establishing the suitability of blue honeysuckle fruits for processing by methods that would maximise the preservation of the product's sensory and consumer quality indicators. The purpose of the study was to determine the suitability of different varieties of honeysuckle for processing by hot air drying and freeze-drying according to a set of quality indicators, including sensory factors (appearance, colour, taste) and the content of biologically active substances (vitamin C, total phenols, flavonoids, anthocyanins). This is important for further recommendations on the use of the fruits of the blue honeysuckle varieties Spokusa, Alicia, Aurora, Karina, and Duet.

MATERIALS AND METHODS

The research was carried out in the analytical laboratory of the Department of Storage, Processing, and Analytical Research of the Institute of Horticulture of the National Academy of Agrarian Sciences of Ukraine (IS NAAS). The fruits of blue honeysuckle varieties Spokusa, Alicia, Aurora, Karina, and Duet were collected for analytical studies, drying, and freeze-drying in the experimental plantations of the IS NAAS, 2023 harvest. On the day of harvest, fresh fruits were analysed, dried, and freeze-dried. Blue honeysuckle fruits were dried for 14 hours at 65°C in a drying oven "Sadochok 2M" (Ukraine). Freeze-drying of blue honeysuckle berries was carried out in a Ukrainian-made freeze-dryer S.S.02 in two stages. The berries were frozen for 12 hours at -10°C and dried for 15 hours at +55°C. For drying and freeze-drying, the fruits were cut in half and then placed in a single layer on trays for feeding into the drying oven and freeze-dryer. Immediately after drying and freeze-drying, the samples were packed in 85 µm thick plastic bags and stored in a dark place. Analytical studies of dried and freeze-dried fruits were performed on the second day after the completion of the drying and freezing process.

The sensory evaluation of dried and freeze-dried blue honeysuckle fruits was carried out by tasting and expressed in points. The samples were evaluated by experienced experts on the following sensory parameters: appearance, colour, taste, and aroma. The tasting group consisted of 9 scientists from the Institute of Horticulture of the National Academy of Sciences of Ukraine. The sensory analysis of dried and freeze-dried samples was performed on a 5-point hedonic scale with the following levels of preference: from 5 to 4 points – optimal quality, from 4 to 3 points – good quality, from 3 to 2 points – acceptable quality, from 2 to 1 point – poor quality, 1 point – very poor quality (Kondratenko *et al.*, 2008). To evaluate the sensory quality of dried and freeze-dried fruits, each taster was given 40 g samples on a separate plate. Each sample had an individual number. The results of the evaluation of sensory quality indicators, namely: appearance, colour, and taste, were reflected in points, mathematically processed, and presented as the mean value ± standard error (mean ± SE).

The content of vitamin C, total phenols, flavonoids, and anthocyanins was determined in fresh, dried, and freeze-dried fruits according to the Methodology for Assessing the Quality of Fruit and Berry Products (Kondratenko *et al.*, 2008). Fresh, dried, and freeze-dried fruit samples were prepared to determine the content of polyphenols, vitamin C, flavonoids, and anthocyanins using a Waring 800S blender (USA). The dry matter content of blue honeysuckle fruits was determined by drying at 105°C to constant weight. The difference in weight between the fresh and dried samples was used to calculate the dry matter content (%).

To determine the content of vitamin C in fresh, dried, and freeze-dried fruits, a method was used that involves the extraction of crushed samples for 10 minutes with aqueous solutions of oxalic and hydrochloric acid (80 + 20, v/v). After settling, the working solution was filtered. Subsequently, 10 ml of the solution was taken from the filtrate, which was titrated with a solution of the sodium salt of 2.6-dichlorophenol-indophenol. The content of vitamin C was determined by the amount of sodium salt solution used to filter the working solution until it changed colour to yellow. The control was a mixture of acetic and oxalic acids (Kondratenko *et al.*, 2008).

The content of total phenolics in the fruits of blue honeysuckle was determined by the method of extraction of samples with ethyl alcohol. Filtering of the crushed fruit sample, which was washed until the colour disappeared with ethyl alcohol, was carried out through a blue paper filter into a Bunsen flask. Filtering of blue honeysuckle samples of fresh and dried fruits was carried out 3 times, and freeze-dried fruits – 5 times. The volume of alcohol used for filtration was recorded. The subsequent process of determining total phenols involved mixing for 3 minutes a mixture of 0.1 ml of alcoholic fruit extract, 1 ml of Folin-Dennis reagent and 7.9 ml of distilled water, followed by the addition of 1 ml of saturated sodium carbonate solution. After an hour of settling the working solution, the content of total phenols in fresh, dried, and freeze-dried samples was determined. A ULAB 102UV spectrophotometer (China) with a wavelength of 640 nm was used for the determination. A mixture of distilled water with 1 ml of Folin-Dennis reagent and 1 ml of saturated sodium carbonate solution was used as a control for the experimental samples (Kondratenko *et al.*, 2008).

The amount of phenols in fresh, dried, and freeze-dried fruits of blue honeysuckle was determined by the equation (1):

$$X = (A \times V \times 100) \div (V_1 \times M), \quad (1)$$

where X – content of total polyphenols in the sample, mg/100 g; A – amount of chlorogenic acid in the volume taken for spectrophotometric determination, found by the calibration chart, µg; V – total volume of the final sample extract, ml; V_1 – volume of the aliquot of the final sample extract taken for analysis, ml; M – mass of the sample, g (Kondratenko *et al.*, 2008).

The amount of flavonoids in the samples of blue honeysuckle under study was determined using a ULAB 102UV spectrophotometer (China) at a wavelength of 410 nm. The method of absorption spectrophotometry for the determination of flavonoids is based on the measurement of the absorption of the flavonoid complex by a 3% aluminium chloride solution (Vronska, 2018). For the determination of anthocyanins from fresh, dried, and freeze-dried blue honeysuckle fruits, an alcohol extract was prepared and acidified with 3.5% hydrochloric acid. Subsequently, anthocyanins were determined at a wavelength of 530 nm using a ULAB 102UV spectrophotometer (China) (Kryventsov, 1982).

The data obtained as a result of statistical processing were presented as mean ± standard error (x ± SE), for this purpose, the STATISTICA 13/1 software suite (StatSoft, Inc., USA) was used. The ANOVA statistical analysis was used to determine the correspondence between replicates and the mean value between varieties. The data obtained were presented at the level of significance $P < 0.05$. The analysis of the reliability of the influence of biological characteristics of the variety and drying methods on the content of vitamin C, total phenols, flavonoids, and anthocyanins was performed using one-factor analysis of variance in Excel, 'Data analysis' tab. The research was carried out as part of scientific work, the results presented in the paper comply with the standards of the Convention on Biological Diversity (1992) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973).

RESULTS AND DISCUSSION

According to Ya. Yevchuk *et al.* (2019), drying is the easiest way to extend the shelf life of fruits, especially berries. Every year, the technology of vacuum freeze drying is becoming more and more widely used (Gronbach *et al.*, 2021). The sensory quality of dried and freeze-dried products largely determines their price on the market, which significantly affects the economic efficiency of freeze-dried and dried fruit production. Preserving the natural colour of dried food products is very important, as visual appearance is one of the first judgments consumers make. During the drying and freeze-drying process, physical characteristics such as colour, taste, and aroma change (Hamad *et al.*, 2023), and not always for the better, and these changes are highly dependent on the type of fruit and genetic characteristics of the variety. Of the blue honeysuckle varieties under study, the freeze-dried fruits of the Duet variety had the highest tasting score of 4.8 points for appearance and 4.9 points for colour (Fig. 1).

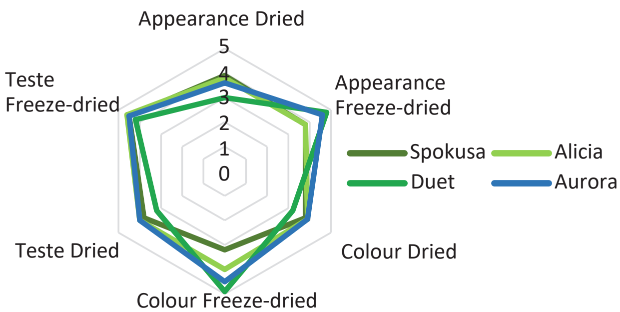

Figure 1. Sensory evaluation of dried and freeze-dried blue honeysuckle fruits
Source: photographed by the authors

The berries of this variety had no signs of cracking and wrinkling and also had the colour typical of fresh berries with a blue waxy bloom characteristic of honeysuckle. The freeze-dried berries of the Alicia and Spokusa varieties were rated 3.8 points for their appearance, as some of them had minor cracks in the samples submitted for tasting. The dried honeysuckle fruits were much worse in appearance. The fruits of all varieties, without exception, were wrinkled, dull black in colour without the blue waxy coating typical of honeysuckle fruits. The taste of freeze-dried fruits was rated at 4.2 (Duet) and 4.6 points (Temptation). This trend of priorities was maintained when evaluating the taste of dried fruits, the highest score was given to Spokusa, and the lowest to Duet, with 3.8 and 3.2 points, respectively (Fig. 1).

The content of vitamin C in dried fruits of blue honeysuckle varied from 103 to 138 mg/100, which is 32.9-43.7% less than in fresh berries. In all the studied varieties, the loss of ascorbic acid during the drying process was significant in relation to the content in both fresh and freeze-dried fruits. The amount of ascorbic acid in freeze-dried honeysuckle was the lowest in the Spokusa variety (123 mg/100 g), and the highest in the Alicia variety (185 mg/100 g), which was 20.5% and 4.8% of the loss, respectively, compared to the content in fresh fruits. Insignificant losses of this vitamin were also observed in fruits of the Aurora variety (9.0%) (Table 1).

Table 1. Ascorbic acid content in fresh, dried and freeze-dried fruits of blue honeysuckle mg/100 g dry weight

Varieties	Fresh	Dried	Freeze-dried	Losses, %	
				In dried	In freeze-dried
Spokusa	155 ± 9.9^{b}	104 ± 6.7^{c}	123 ± 5.7^{bc}	32.9	20.5
Alicia	194 ± 12.3	117 ± 6.4^{cd}	185 ± 8.7	39.7	4.8
Duet	214 ± 12.3^{a}	138 ± 9.0^{cd}	194 ± 8.7^{a}	35.5	9.6
Aurora	182 ± 11.3	103 ± 8.1^{cd}	166 ± 11.0	43.7	9.0
Mean±SE	186 ± 11.5	116 ± 7.5^{cd}	167 ± 8.5	38.0	10.5
Coefficient of variation, %	13.3	14.3	18.7		
min	155 ± 9.9	103 ± 8.1^{cd}	123 ± 5.7	32.9	4.8
max	214 ± 12.3	138 ± 9.0^{cd}	194 ± 8.7	39.7	20.5

Note: the upper indices (a and b) in the rows next to the indicators indicate significantly different values of ascorbic acid relative to the average content (x), index (c) – relative to the content in fresh fruits for each variety, index (d) – relative to the content in freeze-dried fruits for the study group at $P < 0.05$
Source: developed by the authors

S. Bhatta *et al.* (2020) found that freeze-drying retains 34% more vitamin C than conventional drying. Therefore, freeze-dried fruits are beneficial for the human body (Vahapoglu *et al.*, 2021). Recent studies have also revealed anti-diabetic properties in blue honeysuckle (De Silva & Rupasinghe, 2020). These data are comparable to those obtained in studies of individual varieties, namely: Alicia, Duet, and Aurora, where the loss of vitamin C during freeze-drying was 34.9, 25.9, and 34.7% less than during drying, respectively. According to the average inter-varietal index, the loss of ascorbic acid during drying was 38.5%, and during freeze-drying – 10.0% compared to the content in fresh fruits (Table 1). Lower losses of ascorbic acid during freeze-drying compared to freeze-drying, but in sea buckthorn fruit, were reported by Z. Geng *et al.* (2023), they noted that the decrease in the content of this vitamin during freeze-drying was 45.39%, and after hot air drying 79.93% compared to fresh samples. M. Hawlader *et al.* (2006) proved that the preservation of vitamin C in papaya and guava after freeze-drying was 88 and 63%, respectively, which is also consistent with the data obtained in the present study. A. Krzykowski *et al.* (2023) noted that the loss of ascorbic acid during freeze-drying also significantly depends on the temperature of the heating plates, in particular, at a temperature of 30°C, the loss compared to fresh samples was approximately 15%, and at a temperature of 70°C – approximately 38%.

Of the studied varieties of blue honeysuckle, the highest content of total phenolics was found in the fruits of the Spokusa variety, 6,442 mg/100 g, which is significantly higher than the average value established for this group of varieties. In the dried fruits of blue honeysuckle, the content of total phenolics varied from 4,556 mg/100 g in Aurora to 2,801 mg/100 g in Duet, which is 53 mg and 1,163 mg less than in fresh fruits, or 19.0 and 46.2% less. The decrease in total phenols in dried fruits compared to fresh fruits was 18.2% higher than in freeze-dried fruits. In particular, Spokusa by 10.0%, Alicia by 23.0%, Duet by 23.9%, and Aurora by 18.1% (Table 2).

Table 2. Polyphenol content in fresh, dried and freeze-dried fruits of blue honeysuckle mg/100 g dry weight

Varieties	Fresh	Dried	Freeze-dried	Losses, %	
				in dried	in freeze-dried
Spokusa	6,442 ± 435[a]	4,312 ± 170[acd]	4,946 ± 46[ac]	33.1	23.1
Alicia	5,107 ± 286	3,331 ± 163[bcd]	4,506 ± 108[ac]	34.8	11.8
Duet	5,209 ± 279[b]	2,801 ± 119[bcd]	4,047 ± 101[bc]	46.2	22.3
Aurora	5,622 ± 300	4,556 ± 61[acd]	5,569 ± 134[a]	19.0	0.9
Mean ± SE	5,595 ± 188	3,750 ± 111[cd]	4,767 ± 97[c]	33.0	14.8
Coefficient of variation, %	11.2	22.0	13.6		
min	5,107 ± 286	2,801 ± 119[bcd]	4,047 ± 101[bc]	19.0	0.9
max	6,442 ± 435[a]	4,556 ± 61[acd]	5,569 ± 134[a]	46.2	23.1

Note: the upper indices (a and b) in the rows next to the indicators indicate significantly different values of total phenols relative to the average content (x), index (c) – relative to the content in fresh fruits for each variety, index (d) – relative to the content in freeze-dried fruits for the study group at P < 0.05
Source: developed by the authors

The highest losses of total phenols in freeze-dried honeysuckle fruits compared to fresh ones were observed in the varieties Spokusa (23.1%) and Duet (22.3%), while the content of these substances was almost unchanged in the Aurora variety (0.9%). The freeze-dried fruits of this variety contained the highest amount of total phenols – 5,569 mg/100 g, which is 802 mg more than the average content for this group of varieties (Table 2). The high level of retention of biologically active compounds by lyophilised fruit powders, in particular, polyphenols and anthocyanins from 68.2 to 99.6%, depending on the fruit, was reported by C. Casati *et al.* (2019). J. Samoticha *et al.* (2016) also noted that the highest content of biologically active substances was in freeze-dried samples compared to fresh ones. Other researchers have shown that freeze-drying retains 11% more total phenolics than conventional drying (Bhatta *et al.*, 2020). Studies with blue honeysuckle have shown that the retention of total phenolics in freeze-dried fruits was 10.0-23.9% higher than in dried fruits. There is an opposite opinion, which is not supported by the findings, in particular, that the freeze-drying process reduces the total polyphenol content by up to 63%, studies were carried out with blueberries (Muñoz-Fariña *et al.*, 2023).

The number of flavonoids in fresh fruits of blue honeysuckle varied from 1,150 (Spokusa) to 1,995 mg/100g (Duet). The highest losses of flavonoids during drying were observed in the fruits of the Duet variety (82.3%), while in the other studied varieties, they were above 70.0%, namely in the Spokusa variety – 74.6%, Alicia – 78.2%, and Aurora – 70.3%. The loss of flavonoids was also significant during freeze-drying, ranging from 43.8% (Spokusa) to 71.0% (Duet). However, the dried fruits of the studied varieties of blue honeysuckle contained 20.4% fewer flavonoids than the freeze-dried ones (Table 3). A. Synowiec-Wojtarowicz *et al.* (2014),

N. Osokina *et al.* (2022) showed that heat treatment has a positive effect on the flavonoid content of fruit juices. In the case of orange juice, they recorded a 31% increase. Other researchers have also reported a significantly higher flavonoid content in freeze-dried fruit compared to dried fruit. They noted that fruit samples obtained by freeze-drying contained 1.1-2.4 times more flavonoids than those obtained by hot air drying (Krzykowski *et al.*, 2023).

Table 3. Flavonoid content in fresh, dried and freeze-dried fruits of blue honeysuckle mg/100 g dry weight

Varieties	Fresh	Dried	Freeze-dried	Losses, %	
				in dried	in freeze-dried
Spokusa	1,150 ± 63[b]	292 ± 20.0[bcd]	646 ± 28.8[c]	74.6	43.8
Alicia	1,182 ± 83[b]	257 ± 9.5[bcd]	583 ± 24.0[bc]	78.2	50.7
Duet	1,995 ± 74[a]	352 ± 9.8[cd]	578 ± 10.7[bc]	82.3	71.0
Aurora	1,573 ± 64	467 ± 11.8[acd]	766 ± 24.8[ac]	70.3	51.3
Mean±SE	1,475 ± 71	342 ± 13.0[cd]	643 ± 24.8[c]	76.8	56.4
Coefficient of variation, %	26.8	26.8	13.6		
min	1,150 ± 63[b]	257 ± 9.5[c]	578 ± 10.7[c]	70.3	43.8
max	1,995 ± 74[a]	467 ± 11.8[c]	766 ± 24.8[c]	82.3	71.0

Note: the upper indices (a and b) in the rows next to the indicators indicate significantly different values of flavonoids relative to the average content (x), index (c) – relative to the content in fresh fruits for each variety, index (d) – relative to the content in freeze-dried fruits for the study group at $P < 0.05$

Source: developed by the authors

The anthocyanin component of fresh fruits of blue honeysuckle was 875 mg/100 g with a maximum of 996 (Aurora) and a minimum of 784 mg/100 g (Alicia). During the drying process, the loss of anthocyanins was 27%, which is 11% more than during freeze-drying (Table 4).

Table 4. Anthocyanin content in fresh, dried and freeze-dried fruits of blue honeysuckle mg/100 g dry weight

Varieties	Fresh	Dried	Freeze-dried	Losses, %	
				in dried	in freeze-dried
Spokusa	800 ± 43	640 ± 26[cd]	744 ± 18[c]	20	11
Alicia	784 ± 41[b]	643 ± 26[cd]	730 ± 19[c]	18	7
Duet	916 ± 41	539 ± 23[bcd]	706 ± 14[bc]	41	23
Aurora	996 ± 56[a]	716 ± 30[acd]	767 ± 11[ac]	28	23
Mean±SE	874 ± 45	635 ± 26[cd]	737 ± 16[c]	27	16
Coefficient of variation, %	15.5	15.5	3.5		
min	784 ± 41[b]	539 ± 23[bc]	706 ± 14[bc]	18	7
max	996 ± 56[a]	716 ± 30[ac]	767 ± 11[ac]	41	23

Note: the upper indices (a and b) in the rows next to the indicators indicate significantly different values of anthocyanins relative to the average content (x), index (c) – relative to the content in fresh fruits for each variety, index (d) – relative to the content in freeze-dried fruits for the study group at $P < 0.05$

Source: developed by the authors

Duet fruits lost most of this pigment during drying (41%), which is 18% or 167 mg more than during freeze-drying. Compared to fresh fruits, the anthocyanin content in the fruits of this variety decreased by 377 mg during drying. The loss of anthocyanins during drying was 20% and 28% in Spokusa and Aurora, respectively, which is significantly less than in dried chokeberry, where the loss was 43% to 80% (Samoticha *et al.*, 2016). In freeze-dried fruits, the highest losses of anthocyanins compared to fresh fruits were in Duet and Aurora varieties 210 mg and 229 mg, respectively, which amounted to 23% in both varieties. The lowest losses of anthocyanins, both during drying and freeze-drying, were in the variety Alicia 18% and 7%, respectively.

A 99.4% reduction in anthocyanins in extracts from jostaberry compared to freeze-drying was previously reported by V. Bulgaru *et al.* (2024). In turn, A. Wilkowska *et al.* (2016) observed that lyophilised powders had 1.5 times more anthocyanin retention than dried ones. In studies with blue honeysuckle, no significant difference was found; depending on the variety, the difference in anthocyanin content in freeze-dried and dried fruits was 1.1 (Alicia, Aurora), 1.2 (Spokusa), and 1.3 times (Duet).

CONCLUSIONS

As a result of the research, it was found that freeze-drying contributes to better preservation of sensory quality indicators and antioxidant properties of blue honeysuckle fruits of Alicia, Spokusa, Duet, and Aurora varieties than conventional hot air drying. According to the sensory quality indicators of appearance, colour, and taste, freeze-dried fruits of the Duet variety were rated the highest. After drying, blue honeysuckle berries contained 116.0 mg and 167 mg less ascorbic acid, respectively, which is 62.0% and 89.5% of the content they had in fresh form. The lowest losses of vitamin C during freeze-drying were in the Duet variety – 25.9%. The decrease in total phenols in dried fruits was 1,845 mg and in freeze-dried fruits 828 mg. The fruits of all studied varieties lost more than 32% of total phenols during freeze-drying. The loss of these substances during freeze-drying in three of the four studied varieties was less than 10.0%, namely: Alicia (4.8), Aurora (9.0), and Duet (9.6%). Heat treatment of blue honeysuckle fruits, both drying, and freeze-drying, had the most negative effect on the flavonoid content of the finished product, in particular, during drying, the loss of flavonoids was 76.8%, and during freeze-drying was 56.4%, the highest in the Duet variety. Conversely, the decrease in the amount of anthocyanins in both heat treatment methods was insignificant in relation to the content in fresh fruit. During freeze-drying, the loss of anthocyanins was 16% and during drying – 27%, in physical terms, it was 137 mg and 239 mg, respectively, while the content in fresh fruit was 874 mg/100g. The data obtained as a result of the research will be useful for scientists in the development of functional foods with increased biological value, and for producers in the creation of raw material plantations of blue honeysuckle and farms producing freeze-dried products. It is recommended to use the Duet variety for the production of whole freeze-dried berries. For the production of fruit powders with increased biological value in terms of total phenols, flavonoids, and anthocyanins, freeze-dried fruits of the Spokusa and Aurora varieties are the most suitable. The dried fruits of the latter variety can also be used to create functional foods, as they retain phytochemicals better than fresh ones. Given the prospect of widespread use of freeze-dried blue honeysuckle berries in the food industry, further research is required, the purpose of which will be to establish the duration of preservation of sensory and consumer qualities of freeze-dried berries, and the preservation of the content of bioactive substances in them in the manufacture of fruit powders.

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CONFLICT OF INTEREST

None.

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Вплив генетичних особливостей сорту на збереження біологічно активних речовин у плодах жимолості голубої (*Lonícera caeruléa* L.) при сублімуванні та сушінні

Анотація. Цінність плодів жимолості голубої полягає у значному вмісті біологічно активних речовин, які виконують антиоксидантну функцію в організмі людини. Оскільки свіжими вони мають нетривалий строк придатності, метою праведних досліджень був пошук способів перероблення, які б забезпечили максимальне збереження як сенсорних, так і фітоцінних речовин. Дослідження свіжих, сушених та сублімованих плодів проводилися в лабораторних умовах, визначали вміст вітаміну С, поліфенолів, флавоноїдів та антоціанів, а також робили сенсорну оцінку якості зразків, що досліджували. З допомогою програми STATISTICA та дисперсійного аналізу ANOVA виконували статистичний аналіз отриманих даних досліджень. В результаті досліджень було встановлено, що сенсорні показники якості, а саме зовнішній вигляд та забарвлення найкраще зберегли сублімовані плоди сорту Дует, відмінний смак на рівні 4,8 бала мали ягоди Спокуси. Було встановлено, що сублімовані плоди жимолості голубої зберігають на 27,5 % більше аскорбінової кислоти, ніж сушені, що становить 89,5 % від вмісту, який вони мали у свіжому вигляді. Найменше втрачали вітаміну С плоди сорту Алісія. Втрати загальних фенолів при сушінні становили 19,0-46,2 %, що більше, ніж при сублімуванні, на 10,0-23,1 %. Найбільш значними втрати загальних фенолів були у сорту Дует як при сушінні, так і при сублімуванні, а найменшими – у сорту Аврора. З біологічно активних речовин у процесі сушіння та сублімування плоди жимолості голубої найбільше втрачали флавоноїдів та антоціанів – 76,8, та 43,8 % відповідно. Кількість антоціанів у процесі сублімування знизилася на 137, а в процесі сушіння – на 239 мг. Результати досліджень можуть бути використані виробниками при підборі сортів жимолості голубої для створення промислових насаджень, цільове використання яких – сушіння та сублімування

Ключові слова: сублімування; вітамін С; поліфеноли; флавоноїди; антоціани