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DETERMINATION OF THE ANTIOXIDANT POTENTIAL OF PROCESSING PRODUCTS OF OSMOTICALLY DEHYDRATED CHOKEBERRY FRUITS AND BEER ENRICHED WITH THEM

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The demand for functional and health products, as well as the depletion of traditional raw materials, encourages the use of new types of resources. Aronia melanocarpa is a non-traditional plant raw material that has significant potential but is almost never used in the food industry. The aim of this study is to determine the antioxidant potential of processed products of osmotically dehydrated chokeberry fruits and beer enriched with them. The object of the study is the processing products of osmotically dehydrated chokeberry fruits and beer enriched with them.

Chokeberry fruits were dehydrated by osmotic dehydration and drying, ground into powders, and their antioxidant properties were determined. Osmotic solutions and fresh fruits were analyzed for flavonoids, anthocyanins and antioxidant activity. Three experimental samples of beer were produced using traditional technology (K) and with the addition of 6 % (D1) and 10 % (D2) osmotic solutions separated from partially dehydrated fruits. An organoleptic analysis of beer was carried out and its antioxidant activity was determined. The results showed that when using osmotic dehydration, the loss of flavonoids was significantly less (29.74 mg K/100 g) than when using the traditional drying method (39.13 mg K/100 g). When applying the proposed regime of fruit dehydration, about 70 % of anthocyanins are retained. While the traditional method preserves only 59 % of these pigments. The sugar solution on the surface of the fruit prevents significant loss of antioxidant compounds. This explains the higher antioxidant activity (9.86 mmol Trolox/100 g) in samples dehydrated using osmotic dehydration. Adding a chokeberry osmotic solution to beer in an amount of 6–10 % leads to an increase in its antioxidant activity by 9–16 mmol Trolox/100 g

Keywords: non-traditional raw materials, chokeberry, special beer, antioxidant properties, osmotic dehydration

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1. Introduction

Consumers are showing great interest in natural foods, the consumption of which helps improve the body's immunity. The demand for functional foods, dietary foods, etc., as well as the depletion of traditional raw materials, forces the use of new non-traditional raw materials to diversify the range [1]. Natural ingredients of non-traditional plant raw materials can be an alternative in the food industry [2]. Underutilized plant materials are of particular interest in functional food, nutraceuticals and personalized nutrition technologies. Natural biologically active compounds included in their composition can play a decisive role in the development of health products [3].

Manufacturers are looking for different ways to improve the nutritional value of traditional foods. A promising direction is the introduction of non-traditional plant raw materials into the recipe, containing a large number of individual essential food components. A non-traditional plant raw material that has significant potential, but is almost never used in the food industry, is chokeberry (*Aronia melanocarpa*). Due to its antioxidant properties and rich polyphenol content, chokeberry is commonly used for the production of medicines [4].

Chokeberry berries are rarely consumed directly due to their specific organoleptic properties, such as the unpleasant tart taste and bitter almond smell. Sugar-treated berries are used to make purees, jams and jellies. Chokeberry extracts are often mixed with juices, for example from apples, pears or black currants. Chokeberry is used not only in the food industry, but also for the production of liqueurs and alcohol, as well as components of fruit wines and raw materials for the production of food dyes [5, 6]. However, modern technologies for processing chokeberries lead to significant losses of their biologically active substances.

It has been proven that chokeberry products may well be useful as a "functional food" for disorders or diseases associated with oxidative stress [7]. Consuming chokeberry processing products can be a convenient and effective way to supplement the diet with natural antioxidants that can absorb free radicals [8]. However, in terms of food applications, *Aronia melanocarpa* is still an underutilized raw material. A growing number of studies on the phytochemicals, antioxidant potential and other bioactive properties of *Aronia melanocarpa* derivatives have shown promise for their use as innovative food ingredients [9]. Therefore, research devoted to the development of health products using chokeberry derivatives is relevant.

It is advisable to use a method of chokeberry processing that preserves the biological value of this type of raw material. Such methods include osmotic dehydration, the effectiveness of which for preserving the biological value of plant materials has been proven by many researchers [10, 11]. The data obtained may be of practical importance, since secondary products derived from osmotic dehydration of chokeberry fruits can be used to fortify a variety of food products.

2. Literature review and problem statement

The health benefits of chokeberry consumption are due to its high antioxidant capacity. Among the numerous preventive and therapeutic effects of chokeberry, inhibition of cancer cell proliferation, antimutagenic, hepaprotective, cardioprotective and antidiabetic effects are highlighted [12].

The antioxidant potential of chokeberry has been confirmed by numerous *in vitro* studies, where it is often associated with other medicinal properties. The work [13] shows the proven antihypertensive, hypolipidemic and anti-inflammatory effects of chokeberry. Chokeberry has been shown to exhibit one of the strongest *in vitro* radical scavenging activities among other berries [14]. The mechanisms of antioxidant activity of phenols themselves after absorption extend far beyond radical scavenging, including inhibition of reactive nitrogen and oxygen species, restoration of antioxidant enzymes, inhibition of pro-oxidants, and cellular signaling to regulate antioxidant levels [14]. However, heat treatment affects the antioxidant activity and phenolic content of the final products reaching consumers.

The main ingredients of *Aronia melanocarpa* fruits include phenolic compounds. Due to the content of phenolic compounds, chokeberry fruit extracts have antioxidant, anti-inflammatory and chemopreventive effects, and also have an effect on metabolic syndrome [15]. From a nutritional point of view, phenolic compounds are xenobiotics that are metabolized in the digestive system. The recommended daily intake of phenolic compounds remains unknown. The main group of biologically active components of chokeberry berries is polyphenols, especially flavonoids, anthocyanins and proanthocyanidins [4]. The presented research results [15] indicate that these substances are the main factor in the antioxidant properties of the plant.

Aronia melanocarpa is one of the richest sources of polyphenols in the plant kingdom [16]. The polyphenol content of chokeberry juice can range from 3,000 mg EGC/l to 11,000 mg EGC/l. The antioxidant activity of commercially available juices is 19.02–106.13 mmol Trolox/l [8]. In chokeberry powders, the polyphenol content is shown to be in the range of 2147.17–2484.60 mg EGC/100 g, depending on drying methods [17]. It should be noted that studies on the residual content of polyphenols and the antioxidant potential of chokeberry fruits dehydrated using osmotic dehydration have not been found.

Flavonoids are polyphenolic compounds containing two aromatic rings linked to each other by a C6–C3–C6 three-carbon bridge. They have numerous beneficial effects, including antioxidant, antimicrobial, antitumor, antidiabetic, and cardioprotective [18]. According to different researchers, the content of flavonoids in fresh fruits ranged from 47.67 mg/100 g to 71 mg/100 g [19, 20]. It is known that their quantity is significantly reduced during processing. The optimal alcohol concentration was determined to ensure the highest yield of flavonoids in chokeberry alcohol extracts. Such concentrations are 40 and 70 %. The largest amount of flavonoids is contained in 40 % concentration and is 16.0 mg/ml; in 70 % extracts their content is almost 6 mg/ml [21]. However, despite the significant antioxidant potential of alcoholic chokeberry extracts, they cannot be used to fortify a large number of food products. In particular, products for children. An alternative to the existing method can be osmotic dehydration, in which the resulting derivatives do not contain substances that may be harmful.

Anthocyanins are water-soluble pigments that cause the dark blue and even black color of fruits. They are the second largest group of phenolic compounds present in chokeberries. Their concentration ranges from 0.60 to 2.00 % in dry weight [22]. The average total intake of these compounds is approximately 200 mg/day. It has been shown that anthocyanins in chokeberry extract, constituting 34 % of the total phenolic content, are intensively metabolized [23]. The total anthocyanin content in chokeberry juice ranged from 0.15 to 3.04 g/l [24]. When using traditional juice production technology with high pasteurization temperatures, the anthocyanin content is reduced by 93 % [25]. Thus, alternative methods for chokeberry processing should be considered to preserve the anthocyanin content of the finished products.

From fresh chokeberry fruits you can get 11.1–17.4 % juice and 44.6–50 % pomace [26]. Although, as a rule, the pomace formed after the production of juices is disposed of. It is known that chokeberry pomace contains 10.7 % proteins. The main amino acid found in chokeberry fruits was glutamic acid (19.8 %), followed by aspartic acid (8.9 %) and arginine (7.9 %) [4]. Such results also indicate the need to use chokeberry processing products as preservatives. The sour taste of chokeberry fruits is due to the presence of organic acids, mainly malic (13.1 g/kg), citric (2.1 g/kg) and quinic (5.9 g/kg). Their total content, however, is lower than in other berries [27]. The content of organic acids ranges from 1.1 to 1.4 %. The content of free acids in the pomace is low, since they pass into the juice with other soluble substances. According to Sójka and others [28], galacturonic acid (5–16 g/kg) dominates among organic acids in pomace. The conducted studies indicate that the waste generated should be considered as a potential raw material for processing. Or it is advisable to use complex fruit processing, which will ensure complete preservation and subsequent use of all resource components.

Data in the literature demonstrate the potential of chokeberry for the use of its processed products in the food industry, in particular in the production of beverages, such as beer.

Beer is one of the most popular alcoholic drinks in the world, and its production has been known since ancient times. The nutritional value of beer is due to the content of micro- and macroelements, vitamins, phenolic substances, minerals and fiber, which make beer an excellent basis for fortified nutrients [29]. Regular beer tends to contain few phenolic compounds due to the presence of ethanol and multi-step temperature treatment. At the same time, the content of phenols is a key factor in determining the taste and bitterness of beer [30, 31]. Flavonoids are present in hops, but most of them are not absorbed by the human body [32]. The amount of phenols in beer can be significantly increased by using a variety of raw materials or by introducing additives into the composition. To do this, at the fermentation stage, fruit processing derivatives such as cherry, peach, orange and many others are added to beer [33]. Beer enriched with fruit and berry additives is called special. Typically, such a product contains a large amount of flavoring additives and artificial preservatives. The development of an alternative method for manufacturing this product based on natural ingredients will make it possible to obtain a product with greater benefits. In addition, at the first stage of fermentation, sugar solutions (glucose, fructose or sucrose) are added to beer to better ferment the yeast. Osmotic solutions can be an alternative to this additive.

Despite data on antioxidant activity and the content of some polyphenols in extracts, powders and pomace, no studies have been found on products of chokeberry processing using osmotic dehydration. All this gives grounds to assert that it is advisable to conduct a study on identifying the antioxidant properties of chokeberry processing derivatives, as well as their use in the production of special beer.

3. The aim and objectives of the study

The aim of this study is to determine the antioxidant potential of processed products of osmotically dehydrated chokeberry fruits and beer enriched with them. This will prove that the products formed after osmotic dehydration have antioxidant properties and can be used as functional food ingredients in the production of specialty beer and health products.

To achieve the aim, the following objectives are set:

– to evaluate the antioxidant properties of chokeberry fruits, their processed products and beer enriched with them;

– to determine the organoleptic characteristics of beer drinks;

– to develop a technological diagram for the production of special beer.

4. Materials and methods

4. 1. Object and hypothesis of the study

The object of the study is the processing products of osmotically dehydrated chokeberry fruits and beer enriched with them.

The subject of the study is the antioxidant activity of fruits and derivative products of chokeberry processing and special beer.

The research hypothesis is as follows. When chokeberry fruits are processed by osmotic dehydration, cell sap polyphenols are redistributed between the osmotic solution and partially dehydrated fruits due to osmosis. Since this method does not involve high-temperature treatment, the processed products retain a high content of polyphenols and antioxidant activity. These products can be used as functional food ingredients in the production of health or therapeutic products, as well as to increase the antioxidant activity of drinks, including beer.

During the osmotic dehydration of chokeberry fruits, two derivative products are formed: an osmotic solution (syrup) and partially dehydrated berries, which are dried and ground into powders. It is expected that these derivative products will have higher antioxidant activity than alcohol extracts or juices. Adding osmotic solutions (syrups) to beer during fermentation will increase its antioxidant activity.

4. 2. Materials

The fruits of *Aronia melanocarpa* were collected in November 2023 in the Sumy region. Thoroughly washed and dried chokeberry fruits were mixed with a 70 % sucrose solution (hydromodule 1), preheated to 65±5 °C. Osmotic dehydration of the fruits was carried out for 1 hour in a laboratory installation for osmotic dehydration [34]. The dehydration temperature was 50±5 °C. Partially dehydrated fruits were dried in an infrared laboratory dryer (t=50±5 °C) and crushed into powders. The separated osmotic solution and powders were analyzed. The results were compared with those of fresh fruits. At the same time, chokeberry fruits were dried in an infrared dryer at a temperature of t=50±5 °C without the use of osmotic dehydration. The dried fruits were ground into powders and the content of flavonoids, anthocyanins and antioxidant activity was determined.

At the next stage of the study, three beer samples were produced (Fig. 1): K (control using classical technology without additives), D1 (with the addition of 6 % osmotic chokeberry solution), D2 (with the addition of 10 % osmotic chokeberry solution). The amount of additive is due to the fact that 6–10 % glucose is usually added to intensify the fermentation process.

Osmotic solutions were added to the beer wort before fermentation. Beer wort was prepared in a laboratory craft brewery based on Bohemian Pilsner barley malt (Germany). Hopping was carried out with Galaxy hops (Australia). *Saccharomyces cerevisiae* Safbrew S-33 yeast (France) was used to ferment the wort.

Organoleptic evaluation of beer was carried out on a five-point scale at a temperature of 10–13 °C by non-professional tasters of 10 people. The evaluation descriptors were taste, aroma, color, transparency, foaminess and foam stability.

Fig. 1. Beer samples: K – without additives; D1 – with the addition of 6 % chokeberry syrup; D2 – with the addition of 10 % chokeberry syrup

Experimental studies were carried out at the Sumy National Agrarian University.

4. 3. Study of flavonoid content

The content of flavonoids was determined by measuring the signal for an experimental sample and a sample with a known addition of a buffer component. The concentration of the component in the sample was assessed graphically. Based on the acquired data, a graph was constructed of the dependence of the measurement results on the concentration of substances. The resulting graph was extrapolated to the intersection with the concentration axis (corresponding to zero concentration). The segment on the axis between the intersection point and the abscissa of the signal at concentration was taken as the value of the desired concentration. The results were expressed in mg of quercetin per 100 g.

4. 4. Study of anthocyanin content

The content of anthocyanins was determined by high-performance liquid chromatography (Agilent Technologies 1200, UV-Vis Abs detector, detection at λ=520 nm). Anthocyanins were separated using an Agilent TC-C18 column (5 μm, 4.6 mm×250 mm) at 25 °C. The following mobile phases were used: 5 % formic acid (A) and 100 % methanol (B) at a flow rate of 1.0 ml/min. Gradient conditions started at 15 % B and increased linearly to 30 % B after 20 min. The results were expressed in mg/100 g.

4. 5. Study of antioxidant activity

Antioxidant activity was measured using the DPPH radical by a modified method. The reaction mixture consisted of 0.2 ml of a test sample and 3 ml of a 0.1 M solution of the DPPH radical in methanol. The color change of the radical from dark purple to light purple was measured after 30 minutes at 515 nm using a Specol-11 spectrophotometer (Germany). The results were expressed in mmol Trolox/100 g.

4. 6. Statistical analysis

All results are presented as mean ± standard deviation. The data were compared by one-way analysis of variance (ANOVA) using Fisher's least significant difference test. The lowest statistical significance was found at $p<0.05$.

5. Results of the study of *Aronia melanocarpa* fruits and derivative products of their processing

5. 1. Results of the study of the antioxidant properties of chokeberry derivatives and products based on them

At the first stage of the study, the content of flavonoids, anthocyanins and antioxidant activity in the fruits and derivative products of chokeberry was determined. The results of the study are presented in Table 1.

The results of the study showed that during dehydration, the content of flavonoids decreases. However, the reduction when using the osmotic dehydration process before drying is less (29.74 mg K/100 g) than when using the traditional drying method (39.13 mg K/100 g). Some of the flavonoids diffuse into the osmotic solution (35.7 %), which makes it an effective ingredient for enriching food products and protecting the body from harmful environmental influences.

Table 1

Results of antioxidant properties of chokeberry processing derivatives and products based on them

Sample	Flavonoid content, mg K/100 g	Difference	**HIP** 05	Anthocyanin content, mg/100 g	Difference	**HIP** 05	Antioxidant activity, mmol Trolox/100 g	Difference	**HIP** 05
Fresh fruits	68.25±0.25	–	1541.11	468.40±0.25	–	668.548853	75.66±0.35	–	1473.173
Osmotic solution	24.34±0.25	43.91		195.13±0.25	273.27		40.33±0.35	35.33	
Powders made with osmotic dehydration	38.51±0.25	29.74		325.44±0.25	143.96		65.64±0.35	10.02	
Powders made without osmotic dehydration	29.12±0.25	39.13		278.18±0.25	190.22		55.78±0.35	19.88	
Beer K	–	–	–	–	–	–	39.52±0.35	–	47.95359
Enriched beer D1	–	–	–	–	–	–	48.95±0.35	–9.43	
Enriched beer D2	–	–	–	–	–	–	55.63±0.35	–16.11	

Since the actual difference is less than HIP05, the obtained values can be considered valid, and the null hypothesis about the equality of comparative values at the appropriate statistical level can be considered true.

Anthocyanins, which cause the bright violet-blue color of chokeberry fruits, are well preserved in derivatives of processing chokeberry fruits. They can be used as natural colorants in food production. When dehydration with osmotic dehydration and drying is used, almost 70 % of anthocyanins are retained. While the traditional dehydration method preserves only 59 % of these pigments. A fairly large amount of them passes into an osmotic solution (42 %), which can be used as a natural food coloring in the production of confectionery, alcoholic and non-alcoholic drinks.

Studies have shown that the drying process affects the antioxidant activity of chokeberry fruits. With the traditional drying method, antioxidant activity is reduced by 27 %. Its partial decrease (by 13 %) during osmotic dehydration occurs due to the migration of antioxidant compounds into the osmotic solution and changes occurring in the fruit peel. The sugar solution on the surface of the fruit prevents significant loss of antioxidant compounds. This explains the higher antioxidant activity (9.86 mmol Trolox/100 g) in samples dehydrated using osmotic dehydration.

Adding a chokeberry osmotic solution to beer in an amount of 6 % leads to an increase in its antioxidant activity by 9.43 mmol Trolox/100 g. When adding 10 % osmotic solutions, the antioxidant activity of beer increases by 16.11 mmol Trolox/100 g.

5. 2. Results of organoleptic evaluation of beer drinks

The organoleptic characteristics of beer samples were assessed (Fig. 2).

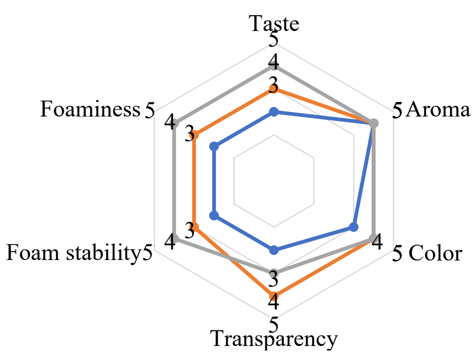

Fig. 2. Profilogram of organoleptic evaluation of experimental beer samples: K – without additives; D1 – with the addition of 6 % chokeberry syrup; D2 – with the addition of 10 % chokeberry syrup

Based on the sensory assessment, it was obvious that according to organoleptic indicators, the enriched beer samples had a richer taste and hop aroma. However, significant differences were observed in bitterness between the control sample K and enriched D1, D2. Sample K had a slightly more pronounced bitterness, but in samples D1 and D2 bitterness was also felt. The fortified beer samples (D1 and D2) had an expressive and pleasant berry-fruit taste and aroma of chokeberry. In sample 2, a slight astringency was felt. In general, the most preferred product among the three experimental beers was beer D2, made with the addition of 10 % chokeberry syrup formed after the osmotic dehydration of chokeberry fruits. The color of the enriched beer was more saturated, from amber (sample D1) to caramel (sample D2). The control sample showed slight turbidity. With the addition of chokeberry syrups, the foaminess and foam stability of the beer increased. Sample D2 had dense, stable foam, D1 had bubbly foam. In the control sample, foam formation was insignificant.

5. 3. Technological diagram for the production of fortified beer

The brewing and fermentation process involves several processing steps from malted barley to the finished product. Among them, the following are required: preparation of beer wort, heating during which biologically active components are extracted from malt into water, wort separation, high-temperature heating, hopping, cooling, fermentation and maturation. The technological flow diagram for the production of fortified beer is shown in Fig. 3.

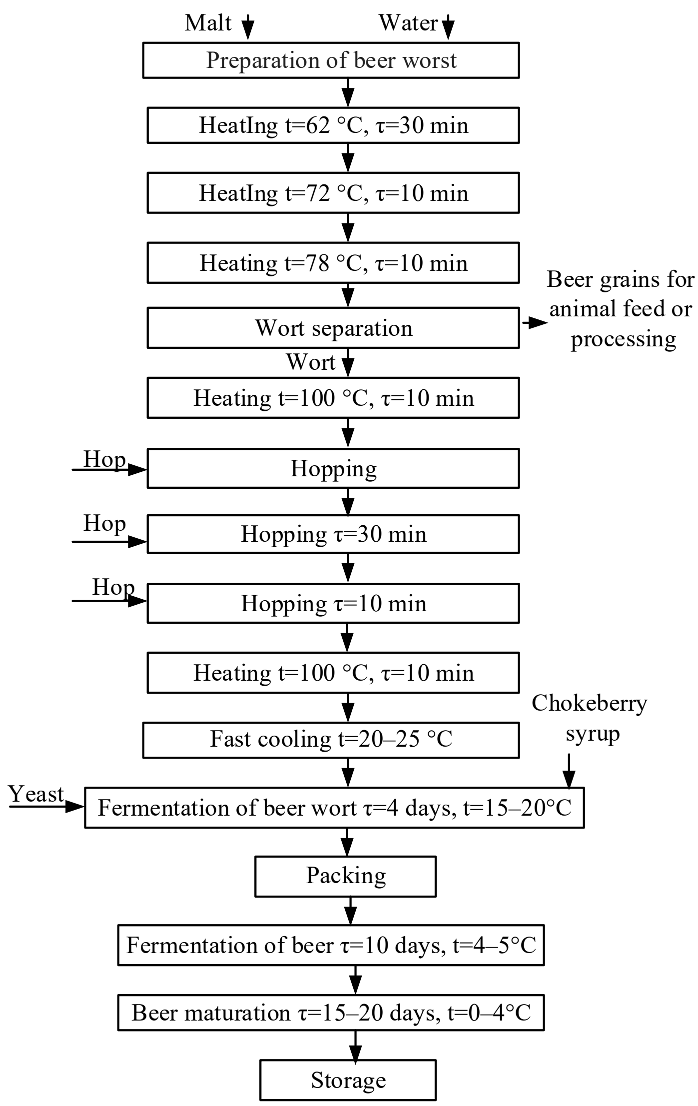

Fig. 3. Technological diagram for the production of special beer

Barley malt is mixed with pure drinking water in a ratio of 1:3 and heated to 65 °C. At the same time, mashing of the wort occurs – one of the most difficult stages of production, affecting the organoleptic properties of beer. Beer wort is subjected to multi-stage heating, during which it is necessary to ensure clearly defined temperature pauses (acid, protein, saccharification). After the saccharification stage, the spent grains are separated from the wort and hopped. For this purpose, you can use one or more types of hops, which impart certain flavor and aromatic properties to the beer. Hopped beer wort is brought to boiling temperature and then quickly cooled to fermentation temperature (15–20 °C). Along with yeast, chokeberry syrup is added to beer in an amount of 6–10 %. The fermentation duration is 4 days. This duration is sufficient to convert part of the sugar in the wort into alcohol. Afterwards, the beer is bottled into consumer containers and fermented for 10 days, which is sufficient time for bottom fermentation of beer at a temperature of 4–5 °C. Fermented beer is sent for maturation at lower temperatures of 0–4 °C, and then for storage.

6. Discussion of the results of the study of the antioxidant potential of *Aronia melanocarpa* fruit processing derivatives

The use of osmotic dehydration of chokeberry fruits as a treatment before the drying process showed an increase in the content of flavonoids in powders made on their basis by 9.39 mg K/100 g compared to the traditional drying method. According to the results presented in Table 1, in osmotic solutions the content of flavonoids is significantly higher than in alcohol extracts [21]. Given their fairly high sucrose content (50–60 %), they can be used as syrups to fortify many foods and drinks.

Similar results presented in Table 1 are also observed with the transition of anthocyanins. The total content of anthocyanins in osmotic solutions (195.13±0.25 mg/100 g) is higher than in chokeberry juice (150 mg/100 g) [24]. The traditional drying method reduces the anthocyanin content by 41 **%**. In the case of dehydration, which involves osmotic dehydration, their content is reduced by 30 %. When using traditional juice production technology with high pasteurization temperatures, the anthocyanin content is reduced by 93 % [25]. Such results indicate the need to use the proposed method for processing chokeberry fruits.

The results presented in Table 3 show that using the osmotic solution (70 %) for 60 minutes has a positive effect on antioxidant activity consistent with DPPH results. The antioxidant activity was 9.86 mmol Trolox/100 g higher than in the samples dehydrated using osmotic dehydration. A similar effect was observed during the dehydration of *Ugni molinae Turcz* [35] and strawberry fruits [36]. In fortified beer samples, an increase in antioxidant activity of 9–16 % was observed (Table 1). The antioxidant activity of fortified beer is characteristic of dark beers containing a higher content of phenolic compounds [37]. According to our study, fortified beer samples showed higher antioxidant activity, characteristic of dark and black beer. This indicates that fortified beer is beneficial to overall human health, but only in moderation (approximately 0.5 l per day) [38].

This is consistent with previous studies on the possibility of enriching beer with various natural additives [39]. The results showed that the addition of natural products (walnuts, chestnuts, cocoa, honey, green tea, coffee and licorice) during the fermentation process significantly increased the antioxidant activity of the beer and qualitatively and quantitatively improved its phenolic profile. The addition of jucara fruit pulp has a positive effect on the quality characteristics, phenol content and antioxidant potential of beer [40].

No information has been found in the scientific literature on the effect of adding functional osmotic solutions at individual stages of the production process and its consequences on the final physicochemical, sensory profile and antioxidant properties.

Fig. 2 shows that, despite the introduction of chokeberry syrups into the beer (samples D1, D2), the characteristic bitterness of the beer was preserved. However, it was lower than that of the sample without additives (K). The bitterness of beer comes mainly from hops, polyphenols and proteins. Since the same hopping regime was used in the study, it is likely that the differences in bitterness were due to polyphenols and proteins released from chokeberry fruits during osmotic dehydration.

Based on the research carried out, a technological diagram (Fig. 3) for the production of special beer based on chokeberry syrups was developed. All parameters of the technological process have been determined, which makes it possible to implement the proposed method in real production conditions.

The practical significance of this study is the possibility of expanding the range of natural special beer.

The limitations of this study include the fact that there is no regulatory technological documentation for the production of powders and syrups from the fruits of *Aronia melanocarpa*, which would allow their use as additives in beer production. In addition, the use of wild raw materials requires more effective control over their safety.

The disadvantage of this study is the lack of large areas for growing this type of raw material. Therefore, problems may arise with its preparation. However, the proposed method of processing chokeberry fruits is low-waste and will allow the production of two types of functional food ingredients (powders and syrups) at once. Enriching beer with chokeberry syrups will expand the range of special beer.

Further research will be aimed at developing food production technologies using powdered functional food ingredients from chokeberry.

7. Conclusions

1. It has been found that when using the process of osmotic dehydration before drying, the amount of flavonoids is higher (by 9.39 mg K/100 g) in chokeberry processed products than when using the traditional drying method. Also, chokeberry powders retain more anthocyanins (by 47.27 mg/100 g) and their antioxidant activity increases by 9.86 mmol Trolox/100 g. As a result of adding 10 % osmotic solutions to beer, its antioxidant activity increases by 16.11 mm Trolox/100 g.

2. Research has shown the possibility of obtaining biologically active compounds without neglecting sensory analysis of the product, since experimental beer samples received the same or better sensory analysis results. Beer made with the addition of 10 % chokeberry syrup had an expressive and pleasant berry-fruity, somewhat tart taste and aroma of chokeberry.

3. A technological diagram for special chokeberry beer has been developed, the peculiarity of which is that at the

fermentation stage, chokeberry syrup is added to the beer wort in an amount of 10 %.

Conflict of interest

The authors declare that they have no conflict of interest regarding this study, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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Data availability

The manuscript has no associated data.

Use of artificial intelligence tools

The authors confirm that they did not use artificial intelligence technologies when creating the presented work.

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