

UDC 663.3

QUALITY FORMATION OF THE UNFORTIFIED WINE MATERIALS OBTAINED FROM BLACK ELDERBERRIES

DOI: <https://doi.org/10.15673/fst.v15i2.2108>

Article history

Received 18.01.2021
 Reviewed 20.03.2021
 Revised 15.05.2021
 Approved 08.06.2021

Correspondence:

L. Matenchuk
 E-mail: matenchuk77@gmail.com

A. Tokar¹, Doctor of Agricultural Sciences, Professor
 O. Lytovchenko², Doctor of Technical Sciences, Professor
 Chief Researcher, Honoured Worker of Science and Technology
 V. Khareba³, Doctor of Agricultural Sciences, Professor
 Academician of NAAS of Ukraine,

Honoured Master of Science and Technology of Ukraine

L. Matenchuk¹, Ph.D. of Agricultural Sciences, Associate Professor
 O. Pobirchenko⁴, Ph.D. of Pedagogical Sciences, Associate Professor

O. Khareba³, Doctor of Agricultural Sciences,
 Professor, Academician of NAAS of Ukraine

¹Department of Food Technology, Uman National University of Horticulture
 1, Instytutska Street, Uman, Ukraine, 20305

²Institute of Horticulture of NAAS of Ukraine, 23, Sadova St., Kyiv-27

³Presidium of NAAS of Ukraine,

9, Mykhailo Omelianovych-Pavlenko Street, Kyiv, 01010

⁴Department of Fine Arts

Cite as Vancouver style citation

Tokar A., Lytovchenko O., Khareba V., Matenchuk L., Pobirchenko O., Khareba O. Quality formation of the unfortified wine materials obtained from black elderberries. Food science and technology. 2021;15(2): 61-70. DOI: <https://doi.org/10.15673/fst.v15i2.2108>

Цитування згідно ДСТУ 8302:2015

Quality formation of the unfortified wine materials obtained from black elderberries
 / Tokar A. et al // Food science and technology. 2021. Vol. 15, Issue 2. P. 61-70 DOI: <https://doi.org/10.15673/fst.v15i2.2108>

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Introduction. Formulation of the problem

Since the potential of conventional raw materials is nearly exhausted, today's topical issue is how to use highly-promising non-conventional ones in the food processing industry. To create innovative products, manufacturers widely use synthetic colourants and flavouring agents. However, these have been arousing customer's strong aversion lately, which can hardly add to the products' popularity. On the other hand,

Abstract. The use of local non-conventional raw materials will allow significantly enriching unfortified fruit wines with ascorbic acid and phenolic substances and make it possible to obtain products with increased biological value. The paper considers black elderberries grown in the forest steppe zone of Ukraine. It has been determined that they contain 12–13% of soluble solids, 6.9–8.1 of sugars, 0.93–1.2% of titratable acids, 33.4–53.1 mg/100 g of ascorbic acid, and 2331–3888 mg/100 g of phenolic substances. The pressing process and its dependence on the method of treating berries have been studied. It has been proved that juice extraction from black elderberries is the highest when they are pretreated with heat at 98±2°C for 3–5 minutes, with 15% of water added. Depending on the treatment method, juices retain ascorbic acid (15.8–33.4 mg/100 g) and phenolic substances (2538–3888 mg/100 g), which indicates their high biological value. Juices like these can be used to improve the biological composition of blended juices and wines. To ferment high-sugar black elderberry must, active dry yeast was used, namely the yeast races EC-1118 of the genus *Saccharomyces bayanus* (France) and ENSIS LE-1 or ENSIS LE-5 of the genus *Saccharomyces cerevisiae* (Spain). The musts were fermented for 36–62 days. The period of vigorous fermentation coincides with the period of initial fermentation and ends in 9–10 days, with accumulation of 12–14% of ethanol by volume. Unfortified wine materials obtained from black elderberries contain 22–38.3 mg/100 g of ascorbic acid (its content in wine materials is by 7.8–49.55% lower than in fresh berries) and 1750–3510 mg/100 g of phenolic substances (which is lower by 9.7–39.6%, as compared with fresh elderberries). The active acidity of black elderberry wine materials is 3.90–4.09 pH units, depending on the yeast race. A similar difference has been found for the redox potential (160–176 mV), which indicates that the wine materials from black elderberries are low-oxidised. The intensity of colour of the wine materials obtained from black elderberries ($D_{420} + D_{520}$) varied from 3.08 to 3.20, and the colour shade from 0.88 to 0.92, which is typical of young red wines. These wine materials can be used to increase the quality and biological value of blended wines.

Key words: black elderberry, juice, must, yeast, unfortified wine materials, ascorbic acid, phenolic substances.

there is a problem that customers are finding more and more urgent: how to stay healthy in the adverse environment. Total deficiency of immunosupportive and immune-enhancing natural substances results in higher occurrence of diseases of civilisation. That is why today's main concern is finding plants rich in bioactive substances that can withstand adverse environmental factors and checking whether these plants can prove useful in developing innovative foodstuffs.

Black elderberry is a medicinal plant. Its glossy berries are coloured dark purple to almost black. They contain 13.2–17.2% of soluble solids, 3.6–10.1% of total sugars, 2.0–5.6 g/dm³ of titratable acids, 10.8–17.1 g/dm³ of colouring substances, 0.55–0.63% of pectic substances, 51.0–53.5 mg% of vitamin C [1]. However, black elderberries are not consumed fresh, and wines from them are only homemade. In Ukraine, no wines using black elderberries are manufactured industrially.

That is why beverage manufacturers should consider using these berries. Bioactive substances contained in them can help develop new wine products of higher biological value, which makes this research topical.

Analysis of recent research and publications

Black elderberry (*Sambucus nigra* L.) is a foliaceous shrub common in Europe, Asia, and North America. Its berries and flowers are used to make syrups, jams, pies, wines, etc. Besides, due to its antioxidant properties, it is applied in traditional medicine [2].

The plant grows (mostly wild) throughout almost all Ukraine in forests and shrubs, in wood-felling areas [3].

A black elderberry production system is being developed in Hungary [4]. Elderberry is organically grown in Switzerland, primarily for its flowers that are used to manufacture sweets [5]. The Polish scientists researched whether black elderberries collected in Lublin Province were safe to consume [6].

Black elderberry is a medicinal plant. In ancient times, countrymen regularly used it in their diet. In spring, they added its fresh sprouts to salads. Juice obtained from berries after fermentation was used to make strong alcoholic infusions.

The plant's berries, flowers, leaves, and bark find their application in folk medicine. Fresh and dried elderberries have properties beneficial for successful treatment and prevention of ulcers and hepatitis. Fresh elderberries are very useful against neuralgia, and dried elderberries are used to treat such a rare and serious disease as malaria. Medical investigations prove elderberry's healing potential to be so huge that the plant is recommended as an additional remedy for stomach and skin cancers [7-10].

Black elderberry juice, rich in antioxidants, inhibits the spread of the influenza virus. This antiviral activity is due to anti-cyanide compounds, in particular, cyanidin-3-glucoside and phytonutrients [11,12]. Sambucol, a product based on standardised black elderberry extract, helps against 10 influenza virus strains and reduces the period of influenza symptoms manifestation to 3–4 days. Sambucol is also an immune protector and immunostimulant when it is given to cancer or AIDS sufferers in combination with other treatment methods (chemotherapy, etc.) [13].

Numerous methods folk medicine offers to treat a number of diseases involve using black elderberries [14].

Elderberries belong to plants that are the highest in anthocyanins. For example, in powdered elderberries, the total content of monomeric anthocyanin is very high, making up to 13 mg/g (cyanidin-3-glucoside) [15].

Antioxidant properties are characteristic of both flowers and berries of the plant. Berries are rich in anthocyanins, in particular, they contain O-sambubioside, and flowers are high in polyphenols, especially in chlorogenic acid and rutin [16].

The research conducted in the EU has shown that total phenolic substances, including gallic acid, *p*-Coumaric acid, anthocyanins, flavanols, and flavonols, are the main factors promoting antioxidant activity. Juices from elderberries and pomegranates were found to be the richest in phenol and to have the highest antioxidant activity [17].

Elderberries are used to cook pies, jellies, punches, wines, or liqueurs, and are ingredients in many herbal medicines and dietary supplements. Elderberry-based products can provide, diuretic, antioxidant, and immunostimulant activities that offer protection against cold and influenza [18]. Due to the antioxidant and antimicrobial activities of fruit extracts (including those from elderberries), they can be considered good components for designing new functional foods and beverages, as well as nutraceuticals [19]. A correlation was established between the antioxidant activity of wines and the content of polyphenols. The correlation coefficient was $r=0.95$ [20].

Manufacturing and storage technologies affect the content of phenolic and colouring compounds in wines [21, 22]. To extract juice effectively from raw fruit and berries, they are treated by different methods: with pectolytic enzyme preparations, heating, electroplasmolysis, freezing, etc. A treatment method determines the amount and quality of juice obtained, and each one has its advantages and disadvantages, depending on the kind of fruit [23–27].

Producing unfortified wines from fruit and berries requires fermentation of must with a high initial sugar content. That is why choosing the right yeast race is so important to obtain wine materials of the required quality [28–30].

There has not been enough research on manufacturing natural unfortified wine materials from black elderberries. The aspect especially understudied is juice extraction, and selection of proper active dry yeast remains a topical problem. So, improving the effect that yeast races and methods of pretreatment of black elderberries have on the quality of unfortified wine materials is a point worth further investigation.

The **purpose of the research** is developing unfortified beverages of improved biological value using wine materials obtained from black elderberries.

To this end, the following **objectives** were set:

- to study the content of the chemical components in black elderberries grown in the Ukrainian forest steppe zone;
- to determine an efficient method of extracting juice to produce unfortified wine materials;
- to obtain wine materials from black elderberries suitable for unfortified wine production with the use of five yeast races;
- to research the physicochemical parameters, indirect quality indicators, and optical characteristics of wine materials from black elderberries;
- to establish the best yeast race for fermentation of musts from black elderberries;
- to study the contents of ascorbic acid and phenolic substances in unfortified wine materials from black elderberries.

Research materials and methods

The object of the research was wild black elderberries collected in the village of Rodnykivka (Uman Region, Cherkasy District). The studies were conducted in the research and production laboratory of the Food Products Technology Department (Uman National University of Horticulture) and in the processing laboratory at the Institute of Horticulture of the National Academy of Agrarian Sciences of Ukraine. In 2017, after berries were sorted, washed, and destalked, the extraction of juice was inspected in four ways. The reference sample: juice was extracted from pretreated berries by pressing. Variant 1: 10–15% of boiled drinking water was added to pretreated berries and heated to $98 \pm 2^\circ\text{C}$ for 3–5 minutes; after cooling down to $18\text{--}20^\circ\text{C}$, juice was extracted by pressing. Variant 2: pretreated elderberries were first frozen down to -18°C in a refrigerating chamber; then the berries were defrosted, and juice was extracted by pressing. Variant 3: the enzyme preparation Fructozyme was added to crushed berries, then they were rested for 30 min at 45°C , and juice was extracted by pressing.

The post-treatment pressing was carried out using a laboratory press. The juices obtained by the above methods (except for the one obtained in variant 1), were pre-pasteurised for 3–5 min at 80°C . To the must, a calculated amount of white sugar was added, and the initial sugar concentration was brought up to the required level. After the must was cooled down to $18\text{--}20^\circ\text{C}$, regenerated active dry yeast of the race EC-1118 was added to it. In 2018, after berries were prepared, washed, sorted, and destalked, they were pressed, heat-treated at 98°C for 3–5 min, with 15% of drinking water added (variant 1), then cooled down and pressed on a laboratory press. To the juice obtained, a calculated amount of white sugar was added, and thus must was prepared. The must was then poured into sterile containers, and active dry yeast was added to it,

according to the manufacturers' recommendations (20 g per 100 l of must). The following yeast races were used: EC-1118 (France, reference sample), ENSIS LE-C1, ENSIS LE-1, ENSIS LE-5, ENSIS LE-6 (Spain). The fermentation temperature in the musts was $18\text{--}25^\circ\text{C}$, and the process was under control. With fermentation finished, lees compacted, and wine material clarified, the must was drawn off the lees and kept in a container at $10\text{--}12^\circ\text{C}$.

The physicochemical quality parameters were determined by standard methods. The mass fraction of soluble solids in the berries was measured according to DSTU (State Standard of Ukraine) ISO 2173:2007 (ISO 2173:2003, IDT), the density by the areometric method (DSTU 4112.1:2002), the mass fraction of sugars by direct titration (DSTU 4112.5-2002), the mass fraction of titratable acids in the wine materials was found titrimetrically (DSTU 4112.13-2002), the ethanol volume fraction was measured according to DSTU 4112.3-2002, the mass concentration of volatile acids was determined using stepped distillation (DSTU 4112.14-2002). The pH (active acidity) and the redox potential were determined by the conventional procedures and according to the instrument certificate using a pH meter AD-130. The optical densities D_{420} , D_{520} were measured in a 1-mm thick cuvette, with calculations of the optical characteristics of the wine materials [31]. The ascorbic acid content was found by the iodate method according to DSTU 7803:2015, and phenolic substances were determined in terms of gallic acid [31]. The reagents used to determine ascorbic acid were hydrochloric acid (CP, Russia), potassium iodide (pharm., India), hypiodous potassium (CP, Ukraine). To determine phenolic substances, the reagents were obtained from *OOO Chimlaborreaktiv*: Folin–Ciocâlțeu reagent (AR, Ukraine), gallic acid (pharm., from Merck), sodium carbonate (pharm., Ukraine). The chemical and technological assessment of the yeast races was carried out by their physicochemical parameters. The best yeast race was determined by A. Tokar's method [32].

The studies were carried out no less than in triplicate. The findings were processed with Microsoft Excel software.

Results of the research and their discussion

The mandatory quality characteristics of wine raw materials are the mass fractions of soluble solids, sugars, and titratable acids. The essential parameters of biological value are the contents of ascorbic acid and phenolic substances.

The results obtained from the studies of the content of these chemical components in the raw materials are presented in Table 1.

Table 1 – Components of the chemical composition of fresh black elderberries

Year of harvesting	Mass fraction of soluble solids, %	Content of			
		sugars, %	titratable acids, %	ascorbic acid, mg/100 g	phenolic substances, mg/100 g
2017	13.0	8.1	1.20	33.4	3888
2018	12.0	6.9	0.93	53.1	2331
LSD ₀₅	0.2	0.9	0.09	8.6	494

On comparison of the results of studying black elderberries in 2017 with the results obtained in 2018, it becomes clear that accumulation of the chemical components depended on the environmental conditions of a certain year. Thus, in 2017, the level of soluble solids accumulated in berries was higher by 1%, that of sugars was higher by 1.2%, and that of titratable acids was higher by 0.27%. The berries collected in 2017, as compared with those in 2018, were far richer in phenolic substances (by 1.7 times). However, they contained by 1.6 times less ascorbic acid.

So, black elderberries can accumulate 12–13% of soluble solids, 6.9–8.1% of sugars, 0.93–1.2% of titratable acids, 33.4–53.1 mg/100 g of ascorbic acid, and 2331–3888 mg/100 g of phenolic substances.

The research has allowed finding the average quantities of the berries wasted or lost when processed into juices, which made up 33% of the weight of the raw materials. The yield of juice in variants 2 and 3 did not differ significantly from that in the reference variant. This does not exceed LSD₀₅, that is why these methods of treatment had no appreciable effect on increasing the yield of black elderberry juice. With variant 1 applied, though, the difference between these findings is quite significant, being twice as big as LSD₀₅. Thus, this pretreatment method has shown a positive result, and we can recommend heat treatment, with 15% of water added, as a way to increase the yield of juice from elderberries (Table 2).

A method of treating black elderberries had an effect on the physicochemical characteristics of juices, too (Table 2). With heat treatment at 98±2°C, with 15% of water added, the mass fraction of soluble solids

was lower by 3%, as compared with other variants, which had an impact on the juice density and on other parameters.

In this variant, the sugar content was by 1.5 times lower than it was in other ones. That is why more sugar will be expended while preparing must from juice obtained by this variant.

There are substantial and significant differences in the mass concentration of titratable acids in juices. In the juice obtained in the reference variant, this parameter was only by 0.3 g/dm³ higher than it was in variant 1. This difference is smaller than LSD₀₅, so these juices can be viewed as having about the same content of titratable acids.

The juice obtained from the berries after they had been frozen contained more titratable acids (by 1.0 g/dm³) than the reference sample did, and the juice from crushed berries treated with enzyme preparations contained by 2.7 g/dm³ more of them. These differences exceed LSD₀₅. They are substantial and significant and prove that a method of pretreating berries has an effect on the content of titratable acids in juice.

By the content of bioactive substances (including ascorbic acid) and phenols, the reference variant is preferable. It contained 1.3 times as much of ascorbic acid as in the variants involving heat and enzymatic treatment, and 2.1 times as little of ascorbic acid as in the juice obtained from frozen berries.

As for the content of phenolic substances, the largest amount of them was destroyed during treatment with the enzyme preparation. This juice contained by 1.5 times less of them than the reference did.

Table 2 – Yield of juice and the physicochemical quality characteristics of juices depending on the method of treatment of black elderberries

Method of treatment	Yield of juice, %	Mass fraction of soluble solids, %	Density, g/cm ³	Mass concentration of			
				sugars, g/dm ³	titratable acids, g/dm ³	ascorbic acid, mg/100 g	phenolic substances, mg/100 g
No treatment (reference)	61.15	13.0	1.068	87.9	11.0	33.44	3888
Heat treatment: heating to 98±2°C for 3–5 min (variant 1)	73.65	10.0	1.045	59.9	10.7	26.40	3618
Preliminary freezing of the berries (-18°C) (variant 2)	62.30	13.0	1.063	87.9	12.0	15.84	3348
Treating the crushed berries with the enzyme preparation Fructozyme (variant 3)	63.00	13.0	1.064	87.9	13.7	26.40	2538
LSD ₀₅	5.6	0.2		6.1	0.9	1.92	310

In the other variants, the mass concentration of phenolic substances was higher, but still it was smaller than in the reference variant. In particular, the juice from berries treated in water at $98\pm 2^\circ\text{C}$ contained by 1.1 times smaller amount of these substances, and in the juice from frozen berries, there was by 1.2 times less of them.

Thus, the yield and characteristics of juice depend on the methods of treating black elderberries before juice is extracted. The yield of black elderberry juice is the highest when the berries are pretreated by heat at $98\pm 2^\circ\text{C}$ for 3–5 min with 15% of water added. Depending on the treatment, juices retain ascorbic acid (15.8–33.4 mg/100 g) and phenolic substances (2538–3888 mg/100 g), which indicates their high biological value. Juices like these can be used to improve the biological composition of blended juices and wines.

In 2017, must fermentation was quite an intensive process, which, in all variants, ended no later than in

36 days. The physicochemical quality characteristics of wine materials are shown in Table 3. A method of pretreating black elderberries had an effect not only on the accumulation of ethanol by volume, but on other physicochemical parameters of the wine materials as well. In particular, it determined the mass concentration of invert sugars in the wine materials, which depended on the initial mass concentration of sugars in musts and on the amount of sugars used by yeast in the course of fermentation.

With heat pretreatment at $98\pm 2^\circ\text{C}$ and addition of 15% of water, the volume fraction of ethanol was smaller by 0.8%, as compared with the reference variant, but in the variant where crushed berries were treated with the enzyme preparation, the ethanol volume fraction was larger by 0.3%. The reference sample and the must from berries that had been frozen had the same mass concentrations of titratable acids and the same quantities of ethanol.

Table 3 – Physicochemical characteristics of the wine materials under study obtained from black elderberries harvested in 2017

Method of treatment	Ethanol by volume, %	Mass concentration, g/dm ³ , of			Content, mg/100 g, of	
		sugars	titratable acids	residual extract	ascorbic acid	phenolic substances
No treatment (reference)	15.9	0	5.8	48.5	30.8	3375
Heating to $98\pm 2^\circ\text{C}$ (variant 1)	15.1	90	6.6	65.9	26.4	3510
Freezing the berries to -18°C (variant 2)	15.8	0	5.8	43.3	26.4	2592
Treating the crushed berries with the enzyme preparation (variant 3)	16.2	–	7.3	47.0	22.0	2349
LSD ₀₅	0.4	–	0.6	3.1	2.5	258

The must with heat pretreatment contained the smallest amount of ethanol, but this sample had the highest mass concentration of the residual extract – 65.9 g/dm³. This is by 17.4 g/dm³ higher than in the reference sample, by 22.6 g/dm³ higher than in variant 2, and by 18.9 g/dm³ higher than in the sample treated with the enzyme preparation. These differences far exceed LSD₀₅=3.1, are substantial and significant, and prove that a method of treating berries affects the residual extract content and the concentration of titratable acids. Of the latter, the lowest level (5.8 g/dm³) was retained after fermentation in the musts with no pretreatment and in those obtained from berries that had been frozen. Conversely, the must where the crushed berries had been pretreated with the enzyme preparation retained titratable acids by 1.5 g/dm³ more than the reference sample and variant 2 did, and by 0.7 g/dm³ more than it was in variant 1. These differences exceed LSD₀₅, so we can say that fermentation was accompanied by different losses of titratable acids in the musts. By the ascorbic acid content, the reference is the preferable variant, as it contained by 4.4 mg/100 g more of the vitamin than variants 1 and 2 did.

The biggest loss of ascorbic acid (by 8.8 mg/100 g less of it than in the reference sample) is observed in the wine material where the crushed berries were pretreated with the enzyme preparation. These differences, too, exceed LSD₀₅ and thus confirm again that treatment affects the biological value of wine materials. The wine materials retained 65.9–92.2% of the ascorbic acid contained in the fresh berries collected in 2017.

As for the content of phenolic substances, their smallest quantity retained (by 1.4 times less than in the reference) was observed in the variant where crushed berries had been treated with the enzyme preparation. Their highest content was in the variant with heat pretreatment of the berries, and the biggest loss was observed during the preliminary freezing of the berries and treatment of crushed berries with the enzyme preparation. This can be explained by inactivation of oxidative enzymes during heat treatment. The wine materials retained 60.4–90.3% of the phenolic substances contained in the fresh berries collected in 2017.

Yeast is an important prerequisite of good alcoholic fermentation. That is why, in 2018, we

carried out research to establish the yeast races most suitable for fermentation of musts obtained from black elderberries. Earlier, A. Tokar [32] had conducted similar research. She had found that the best races to ferment musts from black elderberries were Vyshneva 33, Moskva 30, and the race EC-1118 of active dry yeast *Saccharomyces bayanus*. Lately, the market has been flooded with various kinds and races of active dry yeast, so it should be checked how suitable they are for fermentation of musts produced from fruit and berries, in particular, from black elderberries.

Table 4 presents the calculation of must from juices of black elderberries harvested in 2018.

Table 4 – Preparation of must in 2018

Material	Quantity		Density, kg/dm ³	Invert sugar content		Content of acids in terms of malic acid	
	dm ³	kg		g/100 cm ³	kg	g/dm ³	kg
Juice from black elderberries	10.00	10.54	1.054	6.9	0.69	0.93	0.0093
Sugar	1.26	2.03(2.026)			2.14		
Must	11.26	12.57	1.116	25.1	2.83	8.3	0.0093

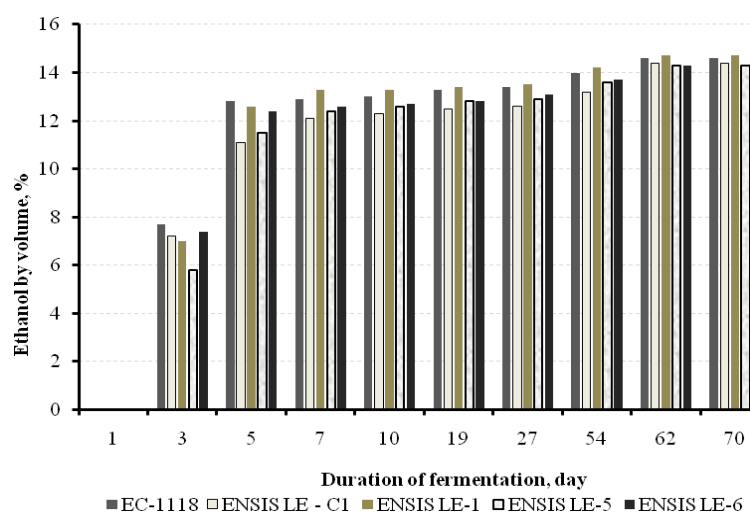


Fig. 1. Dynamics of ethanol accumulation depending on the yeast race (2018), LSD₀₅=0.2 vol%

Up to day 27, the ethanol volume fraction in the variant with the yeast race EC-1118 (reference) reached 13.4%, and the variants with other races contained less of it (by 0.3–0.8%). Only in the variant with the race ENSIS LE-1, the volume fraction of ethanol was at the same level as that in the reference sample. The difference with which the fermentation in this variant ended (0.1 vol%) was nonsignificant. During secondary fermentation, which lasted from day 10 to day 54, the intensity of ethanol accumulation was 0.02–0.023 vol% a day. Conversely, at the final stage (day 54 to day 62), the intensity increased and reached 0.075–0.150 vol% a day. In our opinion, this is due to the completion of biochemical transformations of substances in the must.

In 2018, the maximum ethanol volume fraction during must fermentation resulted from application of the races EC-1118 (reference) and ENSIS LE-1: they utilised almost all invert sugar (Table 5). The loss of titratable

In 2018, the expenditure of sugar was 180.3 g per 1 dm³ of must.

The results of monitoring the fermentation of the musts are shown in Fig. 1. In 2018, the period of initial fermentation of the musts (Fig. 1) coincided with their vigorous fermentation. By the third day, the musts had accumulated 5.8–7.7% of ethanol, and the average intensity of the process was 1.9–2.6 vol% a day. It can be stated that vigorous fermentation ended in 5 days, and its average rate was 2.2–2.6 vol% a day. Further, the process slowed down noticeably, and the volume fraction of ethanol increased but insignificantly: from day 5 to day 10, this parameter in the musts only increased by 0.2–1.2 (depending on the yeast race).

acids during fermentation was bigger with the race ENSIS LE-5, and in this variant, no loss was observed.

There were, though, losses in the variants with other races: EC-1118 (reference) – 14.5%, ENSIS LE – C1 – 15.7%, ENSIS LE-1 – 13.3%, ENSIS LE-6 – 13.3% (see Tables 4, 5). In all the variants, the content of volatile acids is below the permissible level of 1.3 g/dm³. The smallest quantity of volatile acids accumulated was observed in the variants with the races EC-1118 (reference) and ENSIS LE-6.

By the mass concentration of residual extract, the race ENSIS LE-1 is to be preferred.

Table 6 gives the results of calculations done to determine the best yeast race. The active dry yeast races most suitable for fermentation of black elderberry musts were EC-1118 (reference), ENSIS LE-1, and ENSIS LE-5. They can be recommended for fermentation of black elderberry musts when preparing unfortified wine materials.

Table 5 – Physicochemical quality characteristics of the wine materials from black elderberries harvested in 2018

Yeast race	Ethanol by volume, %	Mass concentration, g/dm ³ , of				Mass concentration of ascorbic acid, mg/dm ³
		residual sugars	titratable acids	volatile acids	residual extract	
EC-1118 (reference)	14.6	3.0	7.1	1.06	27.40	317
ENSIS LE - C1	14.4	6.0	7.0	1.16	24.45	268
ENSIS LE-1	14.6	3.0	7.2	1.20	29.81	317
ENSIS LE-5	14.3	10.0	8.4	1.22	22.95	383
ENSIS LE-6	14.3	8.0	7.2	1.10	22.35	295
LSD ₀₅	0.2	0.5	0.2	0.05	1.47	51

Table 6 – Chemical and technological assessment of the yeast races according to the wine materials from black elderberries collected in 2018

Yeast race	By the duration of fermentation	Assessment by the content of					Summative assessment
		alcohol	residual sugar	loss of titratable acids	volatile acids	residual extract	
EC-1118 (reference)	1.0	0.95	1.0	0.00	1.00	0.86	4.81
ENSIS LE-C1	1.0	0.85	0.85	0.00	0.90	0.46	4.06
ENSIS LE-1	1.0	1.00	1.00	0.07	0.86	1.00	4.93
ENSIS LE-5	1.0	0.80	0.65	1.00	0.84	0.33	4.62
ENSIS LE-6	1.0	0.80	0.75	0.07	0.96	0.25	3.83

The mass concentration of ascorbic acid in the wine materials was compared with its content in fresh berries (Tables 1, 5). The comparison has shown that the unfortified wine materials retained 50.5 to 72.1% of its amount in fresh berries. In an average sample of wine materials from black elderberries harvested in 2018, the mass concentration of phenolic substances is 1750 mg/dm³, which makes 75% of their amount found in fresh berries.

Active acidity affects the taste and microbiological stability of wine materials. This parameter depended on the yeast race. In the wine materials from black elderberries, it was 3.9–4.09 pH units (Table 7). Wine materials from black elderberries are low-oxidised. The redox potential is within 160–176 mV.

Table 7 – Active acidity and redox potential of the unfortified wine materials from black elderberries

Yeast race	Active acidity, pH unit	Redox potential, mV
EC-1118 (reference)	4.01	168
ENSIS LE-C1	4.09	160
ENSIS LE-1	3.95	173
ENSIS LE-5	3.90	176
ENSIS LE-6	3.90	175
LSD ₀₅	0.05	3.5

The optical characteristics of wine materials and wines are, first and foremost, indicative of their quality, age, and the specific features of the technology used. A wine's colour allows judging about its age and composition. Some specific features of the colour can be evidence of flaws, defects, or diseases of the wine [31].

The intensity of the colour in wine materials from black elderberries is quite high, far higher than that of grape materials and wines (Table 8). The shade of colour indicated that red colourants predominate in the wine materials.

By Z. Kyshkovsky and A. Merzhanian's data [33], in young red wines, anthocyanins prevail, the colour intensity ranges 1–3, and the colour shade is less than 1. Our studies confirm these findings.

Table 8 – Optical characteristics, colour intensity, and colour shade of the wine materials from black elderberries harvested in 2018

Yeast race	D ₄₂₀	D ₅₂₀	Colour intensity, I = D ₄₂₀ + D ₅₂₀	Colour shade, T = D ₄₂₀ /D ₅₂₀
EC-1118 (reference)	1.50	1.70	3.20	0.88
ENSIS LE-C1	1.50	1.63	3.13	0.92
ENSIS LE-1	1.48	1.66	3.14	0.89
ENSIS LE-5	1.48	1.66	3.14	0.89
ENSIS LE-6	1.44	1.64	3.08	0.88
LSD ₀₅	0.02	0.02		

The problem deserves to be studied further. Probably, prior to determining the optical characteristics, black elderberry wine materials should be diluted, at a ratio of 1:1, with distilled water, so as to reduce the values of the optical characteristics to a level suitable for a spectrophotometer.

So, a yeast race used takes part in the formation of the quality of wine materials. During must fermentation, it affects ethanol accumulation, the physicochemical and indirect quality indicators, and

the degree of retention of bioactive substances in wine materials.

Field testing of the research results. The findings can be used to make unfortified dessert fruit wines *Skarby Sofii* (TI 00011050-244-2008) and *Mnoholita* (TI 3741967-291-2013) at enterprises manufacturing wines from fruit and berries, as well as at farming and household enterprises.

Conclusions

1. Black elderberries can contain 12–13% of soluble solids, 6.9–8.1% of sugars, 0.93–1.2% of titratable acids, 33.4–53.1 mg/100 g of ascorbic acid, and 2331–3888 mg/100 g of phenolic substances.

2. The yield of juice and the physicochemical quality parameters depend on the methods of pretreating black elderberries prior to juice extraction. The highest yield of juice from black elderberries was after heat pretreatment at $98 \pm 2^\circ\text{C}$ for 3–5 min, with addition of 15% of water. Depending on the pretreatment method, juices retain ascorbic acid (15.8–33.4 mg/100 g) and phenolic substances (2538–3888 mg/100 g), which indicates their high biological value.

Juices like these can be used to improve the composition of blended juices and wines.

3. To ferment high-sugar musts from black elderberries, the following races of active dry yeast can be recommended: EC-1118 of the genus *Saccharomyces bayanus* (France), and ENSIS LE-1 or ENSIS LE-5 of the genus *Saccharomyces cerevisiae* (Spain). The musts are fermented for 36–62 days. The period of vigorous fermentation coincides with the period of initial fermentation and ends in 9–10 days, with accumulation of 12–14% of ethanol by volume.

4. Unfortified wine materials from black elderberries retain 22–38.3 mg/100 g of ascorbic acid (which is 50.5–92.2% of its content in fresh berries) and 1750–3510 mg/100 g of phenolic substances (which is 60.4–90.3% of its content in fresh berries). Wine materials like these can be used to increase the biological value of blended wines.

5. Using local non-conventional raw materials (among them black elderberries) will allow enriching beverages significantly with bioactive substances and obtaining products with a biochemical composition of full value.

References:

- Klymenko SV, Kolisnyk LM. Buzyna varta poshany. Dim, sad, horod.2006; 9:12-16.
- Bizera M, Mindrila G, Botu M. Identification of Black Elderberry (*Sambucus Nigra* L.) Valuable Biotypes from the Spontaneous Flora of Oltenia Region. Scientific Papers-Series B-Horticulture. 2019;63(1):109-114.
- Buzyna chorna [Internet]. [cited 2020 Dec 27]. Available from: <https://medfond.com/korysni-produkty/buzina-korist-ta-shkoda.html>.
- Holb JJ, Gall JM, Fodor B. Effect of Production System and Pruning on Temporal Development of *Cercospora depazeoides* and on Berry Yield in Black Elderberry Orchards. Plant Dis.2009; 93(6): 625-631. <https://doi.org/10.1094/PDIS-93-6-0625>.
- Michel VV. First Report of *Chalara elegans* on Roots of Black Elderberry. Plant Dis.2009;93(9): 963. <https://doi.org/10.1094/PDIS-93-9-0963A>.
- Ognik K, Rusinek E, Sembratowicz I, Truchlinski J. Contents of heavy metals, nitrate (V), and nitrate (III) in fruits of elderberry and black chokeberry depending on harvest site and vegetation period. Rocznik Panstw Zakl Hig.2006;57(3): 235-241.
- Buzyna chorna[Internet]. [cited 2020 Dec 27]. Available from: <https://ideas-center.com.ua/?p=18171>.
- Farrell N, Norris G, Lee SG, Chun OK, Blesso CN. Anthocyanin-rich black elderberry extract improves markers of HDL function and reduces aortic cholesterol in hyperlipidemic mice. Food Funct.2015;6(4):1278-1287. <https://doi.org/10.1039/c4fo01036a>.
- Celli GB, Ghanem A, Brooks MSL. A theoretical physiologically based pharmacokinetic approach for modeling the fate of anthocyanins in vivo. Critical Reviews in Food Science and Nutrition. 2017;57(15):3197-3207. <https://doi.org/10.1080/10408398>.
- David L, Moldovan B, Vulcu A, Olenic L, Perde-Schrepler M, Fischer-Fodor E, et al. Green synthesis, characterization and anti-inflammatory activity of silver nanoparticles using European black elderberry fruits extract. Colloids Surf B Biointerfaces.2014; 767-777 <https://doi.org/10.1016/j.colsurfb.2014.08.018>.
- Hawkins J., Baker C., Cherry L., & Dunne E. Black elderberry (*Sambucus nigra*) supplementation effectively treats upper respiratory symptoms: A meta-analysis of randomized, controlled clinical trials. Complement Ther Med. 2019; 42:361-365. <https://doi.org/10.1016/j.ctim.2018.12.004>.
- Buzyna chernaia [Internet]. [cited 2020 Dec 27]. Available from: https://ru.wikipedia.org/wiki/%D0%91%D1%83%D0%B7%D0%B8%D0%BD%D0%B0_%D1%87%D1%91%D1%80%D0%BD%D0%B0%D1%8F.
- Barak V, Halperin T, Kalickman I. The effect of Sambucol, a black elderberry-based, natural product, on the production of human cytokines: I. Inflammatory cytokines. Eur Cytokine Netw. 2001;12(2):290-296.
- Buzyna chorna [Internet]. [cited 2020 Dec 27]. Available from: <https://ideas-center.com.ua/>.
- Baeza R, SanchezV, Saliermo G, Molinari F, Lopez P, Chirife J. Storage stability of anthocyanins in freeze-dried elderberry pulp using low proportions of encapsulating agents. Food Sci Technol Int.2020; 12:135-144. <https://doi.org/10.1177/1082013220937867>
- Malgorzata D, Aleksandra P, MonikaT, Ireneusz K. A New Black Elderberry Dye Enriched in Antioxidants Designed for Healthy Sweets Production. Antioxidants (Basel).2019;8(8). <https://doi.org/10.3390/antiox8080257>
- Granato D, Karnopp AR, van Ruth SM. Characterization and comparison of phenolic composition, antioxidant capacity and instrumental taste profile of juices from different botanical origins. Journal of the Science of Food and Agriculture.2015;95(10):1997-2006. <https://doi.org/10.1002/jsfa.6910>
- Glensk M, Gliniski JA, Wlodarczyk M, Stefanowicz P. Determination of Ursolic and Oleanolic Acid in Sambuci Fructus. Chemistry & Biodiversity.2014;11(12):1939-1944. <https://doi.org/10.1002/cbdv.201400118>
- Coman MM, Oancea AM, Verdenelli MC, Cecchini C, Bahrim GE, Orpianesi C, et al. Polyphenol content and in vitro evaluation of antioxidant, antimicrobial and prebiotic properties of red fruit extracts. European Food Research and Technology. 2018; 244(4):735-745. <https://doi.org/10.1007/s00217-017-2997-9>
- Sanchez-Niorenco C, Larrauri JA, Saura-Salixto F. Free radical scavenging capacity of selected red, rose and white wines. J.Sc.Food Agr. 1999; 79 (10):1301-1304. [https://doi.org/10.1002/\(SICI\)1097-0010\(19990715\)79:10<1301::AID-JSFA367>3.0.CO;2-Y](https://doi.org/10.1002/(SICI)1097-0010(19990715)79:10<1301::AID-JSFA367>3.0.CO;2-Y)
- Landrault N, Pouchet P, Ravel P, Gasc F, Cros G, Teissedre PL. Antioxidant capacities and phenolics levels of French wines from different varieties and vintages. J.agr.Food Chem. 2001; 49 (7):3341-3348. <https://doi.org/10.1021/jf010128f>

22. Oganiesiantse LA, Teliagin IuA, Senkina ZE. Antioksidantnaia aktivnost vinomaterialov dlia vin kaketinskogo tipa i ee zavisimost ot fenolnykh soedinenii. Vinodelie i vinogradarstvo. 2005; 6: 28-29.
23. Mekhuzla NA, Panasiuk AL. Plodovo-iagodnye vina. Moskva: Legkaia i pishchevaia prom-st; 1984.
24. Shobinger U. Plodovo-iagodnye i ovoshchnye soki. Moskva: Legkaia i pishchevaia prom-st; 1982.
25. Flaumenbaum BL, Bezusov AN, Storozhuk VM, Khomych HP. Fyzyko-khimichni, biolohichni osnovy konservnoho vyrobnytstva. Odesa: Druk; 2006.
26. Osokina MN. Formuvannia yakosti plodiv chornoj smorodny ta yii zberezhenia v produktakh konservuvannia. Extended abstract of Doctor's thesis. Uman; 2007.
27. Lytovchenko OM, Tokar AYU. Vynorobstvo iz plodiv ta yahid. Uman; 2007.
28. Erasmus DJ, van der Merwe G, van Vuuren HJJ. Genome-wide expression analyses: Metabolic adaptation of *Saccharomyces cerevisiae* to high sugar stress. Fems Yeast Research. 2003; 3:375-399. [https://doi.org/10.1016/S1567-1356\(02\)00203-9](https://doi.org/10.1016/S1567-1356(02)00203-9)
29. Quiros M, Martinez-Moreno R, Albiol J, Morales P, Vazquez-Lima F, Barreiro-Vazquez A, Ferrer P, Gonzalez R. Metabolic Flux Analysis during the Exponential Growth Phase of *Saccharomyces cerevisiae* in Wine Fermentations. PLoS ONE. 2013; 8: 1-14. <https://doi.org/10.1371/journal.pone.0071909>
30. Lukic I, Radeka S, Grozaj N, Staver M, Persuric D. Changes in physico-chemical and volatile aroma compound composition of Gewurztraminer wine as a result of late and ice harvest. Food Chemistry. 2016; 196: 1048-1057. <https://doi.org/10.1016/j.foodchem.2015.10.061>
31. Herzhykova VH, editor. Metody tekhnokhimichnoho kontroliu u vynorobstvi. Simferopol: Tavrida; 2009.
32. Tokar AYU. Formuvannia yakosti plodiv i yahid ta yii zberezhenia za udoskonalenoj tekhnolohii nekrupnykh vynomaterialiv. Doctor's thesis. Uman; 2010.
33. Kishkovskii ZN, Merzhanian AA. Tekhnologii vina. Moskva: Legkaia i pishch. prom-st; 1984.

ФОРМУВАННЯ ЯКОСТІ НЕКРІПЛЕНИХ ВІНОМАТЕРІАЛІВ З ПЛОДІВ БУЗИНИ ЧОРНОЇ

А.Ю. Токар¹, доктор сільськогосподарських наук, професор, *E-mail*: anastasi.oleynik@gmail.com
О.М. Литовченко², доктор технічних наук, професор, головний науковий співробітник,
 заслужений діяч науки і техніки, *E-mail*: amlitovchenko@ukr.net
В.В. Хареба³, доктор сільськогосподарських наук, професор академік НААН України,
 Заслужений діяч науки і техніки України, *E-mail*: vkhareba@ukr.net
Л.Ю. Матенчук¹, канд. сільськогосподарських наук, доцент, *E-mail*: matenchuk77@gmail.com
О.М.Побірченко⁴, канд. педагогічних наук, доцент, *E-mail*: robirchenkoolena@gmail.com
О.В. Хареба⁵, доктор сільськогосподарських наук, старший науковий співробітник, професор,
E-mail: lena.1060725@gmail.com

¹Кафедра технологій харчових продуктів

Уманський національний університет садівництва, вул. Інститутська, 1, м. Умань, Україна, 20305

² Інститут садівництва НААН України, м. Київ-27, вул. Садова, 23

³Президія НААН України, вул. Михайла Омеляновича-Павленка, 9, м. Київ, 01010

⁴Кафедра образотворчого мистецтва, Уманський державний педагогічний університет імені Павла Тичини
 вул. Садова, 28, м. Умань, Черкаська обл., 20308

⁵ кафедра овочівництва і закритого ґрунту НУБіП, апарат Президії НААН України

Список літератури:

1. Клименко С. В., Колісник Л. М. Бузина варта пошани. *Дім, сад, город*. Київ, 2006. №9. С.12–16.
2. Bizera M., Mindrila G., & Botu M. Identification of Black Elderberry (*Sambucus nigra* L.) Valuable Biotypes from the Spontaneous Flora of Oltenia Region. *Scientific Papers-Series B-Horticulture*. 2019.63(1).P. 109–114.
3. Бузина чорна. URL: <https://medfond.com/korysni-produkty/buzina-korist-ta-shkoda.html> (дата звернення 27.12.2020).
4. Holb I. J., Gall J. M. & Fodor B. Effect of Production System and Pruning on Temporal Development of *Cercospora depazeoides* and on Berry Yield in Black Elderberry Orchards. *Plant Dis*.2009. 93(6).P. 625–631. doi: 10.1094/PDIS-93-6-0625.
5. Michel V. V. First Report of *Chalara elegans* on Roots of Black Elderberry. *Plant Dis*.2009. 93(9), P. 963. doi: 10.1094/PDIS-93-9-0963A.
6. Ognik K., Rusinek E., Sembratowicz I., & Truchlinski J. Contents of heavy metals, nitrate (V), and nitrate (III) in fruits of elderberry and black chokeberry depending on harvest site and vegetation period. *Rocz Panstw Zakl Hig*.2006. 57(3), P. 235–241.
7. Бузина чорна. URL: <https://ideas-center.com.ua/?p=18171> (дата звернення 27.12.2020).
8. Farrell N., Norris G., Lee S. G., Chun O. K., & Blesso C. N. Anthocyanin-rich black elderberry extract improves markers of HDL function and reduces aortic cholesterol in hyperlipidemic mice. *Food Funct*.2015. 6(4), P. 1278–1287. doi: 10.1039/c4fo01036a.
9. Celli G. B., Ghanem A., & Brooks M. S. L. A theoretical physiologically based pharmacokinetic approach for modeling the fate of anthocyanins in vivo. *Critical Reviews in Food Science and Nutrition*. 2017. 57(15), P. 3197–3207. doi: 10.1080/10408398.
10. David L., Moldovan B., Vulcu A., Olenic L., Perde-Schrepler M., Fischer-Fodor, E., . . . Filip, G. A. Green synthesis, characterization and anti-inflammatory activity of silver nanoparticles using European black elderberry fruits extract. *Colloids Surf B Biointerfaces*, 2014. P. 767–777. doi: 10.1016/j.colsurfb.2014.08.018
11. Hawkins J., Baker C., Cherry L., & Dunne E. Black elderberry (*Sambucus nigra*) supplementation effectively treats upper respiratory symptoms: A meta-analysis of randomized, controlled clinical trials. *Complement Ther Med*.2019. 42. P. 361–365. doi: 10.1016/j.ctim.2018.12.004
12. Бузина черная. URL: https://ru.wikipedia.org/wiki/%D0%91%D1%83%D0%B7%D0%B8%D0%BD%D0%B0_%D1%87%D1%91%D1%80%D0%BD%D0%B0%D1%8F (дата звернення 27.12.2020).
13. Barak V., Halperin T., & Kalickman I. The effect of Sambucol, a black elderberry-based, natural product, on the production of human cytokines: I. Inflammatory cytokines. *Eur Cytokine Netw*, 2001. 12(2), P. 290–296.
14. Бузина чорна. URL: <https://ideas-center.com.ua/> (дата звернення 27.12.2020).

15. Baeza R., Sanchez V., Salierno G., Molinari F., Lopez P., & Chirife J. Storage stability of anthocyanins in freeze-dried elderberry pulp using low proportions of encapsulating agents. *Food Sci Technol Int*, 2020. 12. P. 135–144. <https://doi.org/10.1177/1082013220937867>
16. Malgorzata D., Aleksandra P., Monika T., & Ireneusz K.. A New Black Elderberry Dye Enriched in Antioxidants Designed for Healthy Sweets Production. *Antioxidants (Basel)*, 2019. 8(8). doi: 10.3390/antiox8080257
17. Granato D., Karnopp A. R., & van Ruth S. M. Characterization and comparison of phenolic composition, antioxidant capacity and instrumental taste profile of juices from different botanical origins. *Journal of the Science of Food and Agriculture*, 2015. 95(10), P.1997–2006. doi: 10.1002/jsfa.6910
18. Glensk M., Glinski J. A., Wlodarczyk M., & Stefanowicz P. Determination of Ursolic and Oleanolic Acid in Sambuci Fructus. *Chemistry & Biodiversity*, 2014. 11(12), P.1939–1944. doi: 10.1002/cbdv.201400118
19. Coman M. M., Oancea A. M., Verdenelli M. C., Cecchini C., Bahrim G. E., Orpianesi C.,... Silvi S. Polyphenol content and in vitro evaluation of antioxidant, antimicrobial and prebiotic properties of red fruit extracts. *European Food Research and Technology*, 2018. 244(4), P. 735–745. doi: 10.1007/s00217-017-2997-9
20. Sanchez-Nioren C., Larrauri J.A., Saura-Salixto F. Free radical scavenging capacity of selected red, rose and white wines. *J.Sc.Food Agr.* 1999, 79 (10), P. 1301–1304.
21. Landrault N., Poucheret P., Ravel P., Gasc F., Cros G., Teissedre P. L. Antioxidant capacities and phenolics levels of French wines from different varieties and vintages. *J.agr.Food Chem.* 2001. Vol. 49. № 7. P. 3341–3348.
22. Оганесянц Л.А., Телягин Ю.А., Сенькина З.Е. Антиоксидантная активность виноматериалов для вин кахетинского типа и ее зависимость от фенольных соединений. *Виноделие и виноградарство*. 2005. № 6. С. 28–29.
23. Мехуза Н. А., Панасюк А. Л. Плодово-ягодные вина. Москва : Легкая и пищевая пром-сть, 1984. 240 с.
24. Шобингер У. Плодово-ягодные и овощные соки. Москва : Легкая и пищевая пром-сть, 1982. 472 с.
25. ФлауменбаумБ. Л., Безусова. Г., СторожукВ. М., Хомич Г. П. Фізико-хімічні, біологічні основи консервного виробництва. Одеса: Друк, 2006. 400с.
26. Осокіна М. Н. Формування якості плодів чорної смородини та її збереження в продуктах консервування: автореф. дис. ... доктора с.-г. наук: 06.01.15. Умань, 2007. 40 с.
27. Литовченко О. М., Токар А.Ю. Виноробство із плодів та ягід: підручник [для студ. вищ. навч. закл.]. Умань, 2007. 430 с.
28. Erasmus D.J., van der Merwe, G.K., van Vuuren. H.J.J. Genome –wide expression analyses: Metabolic adaptation of *Saccharomyces cerevisiae* to high sugar stress. *Fems Yeast Research*. 2003. Vol. 3. P.375–399.
29. Quiros M., Martinez-Moreno R., Albiol J., Morales P., Vazquez-Lima F., Barreiro- Vazquez A., Ferrer P., Gonzalez R. Metabolic Flux Analysis during the Exponential Growth Phase of *Saccharomyces cerevisiae* in Wine Fermentations. *PLoS ONE*. 2013. Vol. 8. P. 1–14.
30. Lukic I., Radeka S., Grozaj N., Staver M., Persuric D. Changes in physico-chemical and volatile aroma compound composition of Gewurztraminer wine as a result of late and ice harvest. *Food Chemistry*. 2016. Vol. 196. P. 1048–1057.
31. Методи технохімічного контролю у виноробстві / за ред. В.Г. Гержикової. Сімферополь: Тавріда, 2009. 304 с.
32. Токар А. Ю. Формування якості плодів і ягід та її збереження за удосконаленої технології некріплених виноматеріалів: дис. ... доктора с.-г. наук: 06.01.15. Умань, 2010. 566 с.
33. Кишковский З.Н., Мерджаниан А.А. Технология вина. Москва : Легкая и пищ. пром-сть, 1984. 504 с.