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ASCORBIC ACID AND PHENOLIC SUBSTANCES IN STRAWBERRY-BASED UNFORTIFIED WINE MATERIALS

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Abstract. The content of ascorbic acid and phenolic substances has been investigated in natural juices and unfortified wine materials obtained from garden strawberries of the varieties Polka and Pegasus. The juices considered contained 271–417 mg/dm^3 of ascorbic acid, and 1280–1500 mg/dm^3 of phenolic substances. The content of these ingredients depends on the varietal characteristics. To prepare unfortified wine materials for dessert wines, 230 g of white sugar was added to one dm^3 of strawberry juice. The must was pasteurised at 85°C for 5 minutes, cooled, and fermented with active dry yeast. The yeast was of the races EC 1118 (France), ENSIS LE-C1, ENSIS LE-1, ENSIS LE-5, ENSIS LE-6 (Spain), which were used in accordance with the manufacturers' recommendations. It has been found that the content of ascorbic acid and phenolic substances decreases while musts are being prepared and fermented. The average loss of ascorbic acid during must preparation is 17.4%, and that of phenolic substances is 1.1–4.9%. A decrease in these components due to dilution with sugar in the course of must preparation is 14–15%. Fermentation of strawberry musts, with the initial concentration of invert sugars 274 g/dm^3, lasts 70–77 days. The yield of cleared wine material after fermentation depends on the varietal characteristics and the yeast race used, and ranges 86.9 to 92.7%. The loss of ascorbic acid during must fermentation averages 49.3%, and that of phenolic substances 21.6%. Strawberry-based unfortified wine materials have been found to contain 86–158 mg/dm^3 of ascorbic acid and 720–1080 mg/dm^3 of phenolic substances. In particular, according to the average data of two years' research, the content of phenolic substances in wine materials from strawberries of the Polka variety was by 197 mg/dm^3 higher than their content in wine materials from the Pegasus variety. The wine materials retain 25.4–41.3% (33.6% on average) of ascorbic acid contained in juices (and in fresh berries, too), and 56.2–72.0% of phenolic substances (62.6% on average). The yeast race ENSISLE-C1 (Spain) should be used for better preservation of ascorbic acid, and EC-1118 (France) should be used to preserve phenolic substances. The research results confirm that unfortified dessert wines from strawberries can be regarded as products with preventive capacities.

Key words: garden strawberries, must, yeast, unfortified wine materials, ascorbic acid, phenolic substances.

Introduction. Formulation of the problem

All over the world, governments support small farming businesses and encourage setting them up. This stimulates the development of horticulture, viticulture, and beekeeping. There is a persistent tendency for an increase in the business activity of small and medium winemaking enterprises. Ukraine is now showing a trend towards expansion of berry plantations, as people are returning to living directly from the soil, to consuming complete natural products [1]. The garden strawberry is used to make fine, fragrant wines of quite good quality [2]. In places with no markets close by, it can be difficult to find where to sell berries, so it is really practical to make them into wine, which is slightly pink in colour. The problem is important, as strawberry losses are absolutely unacceptable, and by processing berries, we can obtain products that retain natural bioactive substances, like ascorbic acid (AA) and phenolic substances (PS).

Analysis of recent research and publications

The strawberry is a small fruit crop. Its fruit are high in vitamin C (50–100 mg%), and contain vitamins of the groups B, A, P, PP, E, and K. Besides, there is carotene, organic acids (0.5–2.5%), sugars (6–8%), ash constituents [1].

In products of processing, the amount of vitamins is determined by their content in the raw materials, and by how much of them is lost in the course of processing. Most vitamins are unstable. They are destroyed, to a greater or lesser extent, by adverse factors: high temperatures, exposure to oxygen from the air, action of metals, ultraviolet spectrum [3,4]. Water-soluble vitamins can be lost when the raw material is being processed in water (especially if it is warm), and in cases when the fruit's skin is damaged [5]. High temperatures have a negative effect on them: in the presence of oxygen, vitamin C is destroyed if as hot as 50°C. However, without oxygen, in an acidic environment, ascorbic acid is far more resistant to heating. During manufacture of pulp-containing juices and fruit purées (if the fruit crushed are fresh, and their oxidative and pectolytic enzymes are not inactivated), ascorbic acid can be oxidised, and other components destroyed [6,7]. Besides, fruit and vegetables contain substances that stabilise vitamin destruction. The stabilising capacity is observed in table salt, sugars, starch, lipids, flavonols, organic acids [7]. Vitamin losses while processing raw materials into wine can be significant, but are avoidable [8,9]. Clarified juices, in the course of their production, can lose 70–75% of vitamin C, and nectars lose 49–62% of it. The higher the vitamin C content in raw materials, the more of it is lost during processing [10]. When fruit are heat-treated, they can lose as much of vitamin C as 33–60% [7,9].

Vitamin C increases the body's resistance to adverse impacts of the environment and to infections. It promotes the body's growth, takes part in redox processes, cellular respiration, and amino acid exchange. It effects on the central nervous system, improves the liver function, contributes to assimilation of iron, normalises blood formation and vitamin exchange. Ascorbic acid contained in berries prevents aggressiveness, allergy, depression, fatigue, and immunosuppression [11,12]. It is commonly known as an antioxidant [13-15]. It can reduce quinones to the corresponding phenols [16,17]. Up to 150 mg/dm^3 of ascorbic acid is allowed to be added to wines as an antioxidant before they are bottled [18].

Throughout the world, great attention is paid to finding high-performance compounds that are antioxidants and can prevent cardiovascular diseases. In the composition of strawberries, there are flavonoids, anthocyanidins, phenolcarboxylic acids, which are natural antioxidants. The antioxidant properties of products are due to polyphenolic substances in their composition, which can bind free radicals and inhibit lipid oxidation thus preventing atherosclerosis, cardiovascular diseases, and cancer.

Fruit and berries, including strawberries, belong to products that are a source of group P vitamins. P-vitamin activity is a feature of quite a number of phenolic substances (catechins, anthocyans) and phenylglycosides (rutin, hesperidin, quercetin), folic acid [19,20].

Phenolic substances have specific anti-inflammatory activity [21]. Besides, they are cardioprotective and reduce the death rate fro cardiovascular diseases [22]. The content of phenolic substances in wines depends on the grape variety and the technology of must processing [23-27]. In particular, their content decreases during technological operations [28,29]. However, phenolic compounds are also present in products obtained as a result of processing fruit and berries. Wine is one of these products, so it should be popularised not as an alcoholic drink, but as a nutrition product [20]. A significant improvement of the flavour and health qualities of wines from fruit and berries (with 13–16% of alcohol produced by their own fermentation) can be achieved by using pure yeast cultures [30].

The yeast race tells on the wine quality, too [31]. To make unfortified fruit wines, yeast races should be used that are able to ferment musts high in sugar [23,31-34]. Though unfortified fruit wines have far better sensory qualities than fortified, their technology is rather complex. This is why scientists, unfortunately, pay little attention to them.

The purpose of the research is to develop unfortified beverages from strawberry raw materials, and to study the loss of ascorbic acid and phenolic substances in the course of their manufacture.

The **objectives** to solve while achieving the purpose:

– to study the content of ascorbic acid and phenolic substances in freshly squeezed juices from two strawberry cultivars;

– to prepare unfortified wine materials (with 15.3–17.0% of ethanol, and with the mass concentration of titrated acids 5.5–9.1 g/dm^3) suitable for making dessert wines with the use of five yeast races;

– to study the yield of musts and unfortified wine materials;

– to study the content of ascorbic acid and phenolic substances, and analyse their losses in the course of preparing and fermenting musts.

Research materials and methods

In the research, strawberries of the varieties Polka and Pegasus were used grown on experimental plots of Uman National University of Horticulture. The raw materials were processed into juice in the research and production laboratory of the Food Products Technology Department. The juices were made into musts of the required sugar content. The musts were then pasteurised at 85°C during 5 minutes, cooled down, and poured into germproof vessels, where active dry yeast was added in quantities recommended by the manufacturers (25 g of yeast per 100 g of must). The yeast used was EC 1118 (France), ENSIS LE-C1, ENSIS LE-1, ENSIS LE-5, and ENSIS LE-6 (Spain). The temperature of must fermentation was 20–25°C. After the fermentation, compaction of sediment, and clarification of the wine material, its yield was determined, and the losses [7] in ascorbic acid and phenolic substances were calculated by the formula:

$$B = \frac{A \times C - B \times K}{A \times C} \times 100 \qquad (1)$$

where B – ingredient losses, %; A – amount of the semi-processed material that entered the technological process, dm^3; C – mass concentration of the ingredient in the semi-processed material that entered the technological process, mg/dm^3; B – yield of the material from the process, dm^3; K – mass concentration of an ingredient in the semi-processed material that left the technological process, mg/dm^3.

The ascorbic acid content was determined by the iodate method (State Standard 7803:2015), and the content of phenolic substances by expressing it in terms of gallic acid [35]. To determine ascorbic acid, the reagents used were: hydrochloric acid (chemically pure, Russia), potassium iodide (pharmaceutical, India), hypoiodous potassium (chemically pure, Ukraine). To determine phenolic substances, the reagents were obtained from LLC *Khimlaborreaktiv*: the Folin – Ciocalteu reagent (analytical grade, Ukraine), gallic acid (pharmaceutical, by the Merck company), sodium carbonate (pharmaceutical, Ukraine).

There were at least three replications of each test. The results were processed with Microsoft Excel software.

Results of the research and their discussion

In both years of the research, strawberries of the Pegasus variety contained more AA than Polka strawberries (Table 1): under the same manufacturing conditions, juices from Pegasus strawberries were higher in ascorbic acid by 82 mg/dm^3 on average. Thus, the AA content largely depended on the individual varietal features.

Table 1 – Content of ascorbic acid and phenolic substances in juices from garden strawberries, mg/dm^3

Strawberry variety	Year of research	Ascorbic acid	Phenolic substances
Polka	2016	271.0	1500
	2017	340.0	1430
Pegasus	2016	358.0	1320
	2017	417.0	1280
LSD_{05}		2.8	70
Polka	average	305.5	1465
Pegasus	average	387.5	1300

In the two years of the research, the juices made from Polka strawberries contained 1.1 times as much of phenolic substances as juices from Pegasus strawberries.

The results of studying the strawberry juices allow drawing a conclusion about what amount of sugar is needed to make must. To prepare storable unfortified (with 16% of ethanol by volume) wine materials for unfortified dessert fruit wine, 231.1 g of sugar (which can be rounded to 230 g) should be added into each 1 dm^3 of juice (Table 2). The increase in the volume of the must after sweetening it with sugar makes the mass concentration of titrated acids, on average, 1.13 times lower.

The results of studying the content of ascorbic acid and phenolic substances in the musts prior to their fermentation are presented in Table 3.

Table 2 – Accounts of the preparation of strawberry musts

Variety	Harvested in	Volume of juice	Mass concentration in juice, g/dm^3		Amount of sugar added, g	Volume of must, dm^3	Mass concentration in must, g/dm^3	
			sugars, in terms of invert sugars	titrated acids, in terms of malic acid			sugars, in terms of invert sugars	titrated acids, in terms of malic acid
Polka	2016	8.000	78.0	10.7	1776.3	9.101	273.7	9.4
	2017	8.000	57.0	10.8	1966.6	9.219	273.7	9.4
Pegasus	2016	8.000	69.0	8.8	1857.9	9.152	273.7	7.7
	2017	8.000	76.0	11.5	1794.5	9.113	273.7	10.1
Average		8.000	70.0	10.4	1848.8	9.146	273.7	9.2

Table 3 – Content and losses of ascorbic acid and phenolic substances in the course of preparation of musts for unfortified strawberry wine materials

Variety	Harvested in	Ascorbic acid		Phenolic substances	
		content, mg/dm^3	loss, %	content, mg/dm^3	loss, %
Polka	2016	160	32.8	1100	16.6
	2017	208	29.5	1000	19.4
Pegasus	2016	208	33.5	980	15.1
	2017	253	30.9	900	19.9
Polka	average	184	31.2	1050	18.0
Pegasus	average	230	32.2	940	17.5

The content of ascorbic acid in the musts depended on its content in the fresh juices used to make them (Tables 3 and 1).

Some AA (up to 33.5% of it) was lost during must preparation (Table 3). This is due to dilution with sugar and destruction by the temperature and exposure to the air, as musts are supposed to be mixed with sugar and pasteurised. Analysis of the data in Table 2 shows that dilution by adding sugar can make the AA content lower by 14–15%. Then, the level of AA destruction due to the temperature and air will be 14.5–19.5% (17.4% on average) of its content in juices that are used to make strawberry musts.

Besides, the content of phenolic substances was observed to decrease in the musts before fermentation, compared to their content in the strawberry juices. The losses were maximum (19.9%) in 2017, during the preparation of must from Pegasus strawberries. Dilution with sugar can result in as big a loss of PS as of ascorbic acid. However, the PS losses caused by the temperature and aeration are far smaller (1.1 to 4.9%), which means that PS of strawberry juice are more resistant to these factors than ascorbic acid is. Perhaps, pasteurisation of musts inactivates enzymes and prevents oxidation of phenolic substances.

The fermentation of musts lasted 70–77 days. After compaction of sediment and decantation of the wine material, the yield of unfortified strawberry wine materials, depending on the strawberry cultivar and the yeast race, was established as follows (Table 4).

The yield of wine materials after fermentation of the musts depended on the strawberry cultivar and on the yeast race (Table 4). Irrespective of the variant, the yield of the wine material averaged 90.1%. Thus, in the course of preparation of unfortified wine materials, losses during must fermentation were much bigger than those during fermentation of natural fruit juices, the latter being about 4.0% [36].

Table 4 – Yield of the wine material after must fermentation, %

Variety	Yeast race	Harvested in	
		2016	2017
Polka	EC 1118 (control)	88.6	90.2
	ENSIS LE–C1	91.8	92.1
	ENSIS LE–1	91.8	92.0
	ENSIS LE–5	88.4	88.8
	ENSIS LE–6	91.6	92.7
Pegasus	EC 1118 (control)	86.9	88.0
	ENSIS LE–C1	91.0	92.2
	ENSIS LE–1	88.1	90.1
	ENSIS LE–5	89.3	90.3
	ENSIS LE–6	88.1	89.6
Polka	average	90.4	91.2
Pegasus	average	88.7	90.0

The research has established that in the wine materials from Polka strawberries harvested in 2016, the highest ascorbic acid content was in the sample fermented by the yeast race ENSIS LE–C1 (Table 5). The biggest significant difference with this variant is 26 mg/dm^3 (the race ENSIS LE–6). The difference between the variants where the races EC 1118 (control) and ENSIS LE–1 were used was insignificant (only 2 mg/dm^3).

Table 5 – Content of ascorbic acid and phenolic substances in unfortified strawberry wine materials, mg/dm^3

Variety	Yeast race	Ascorbic acid, mg/dm^3		Phenolic substances, mg/dm^3	
		Harvested in		Harvested in	
		2016	2017	2016	2017
Polka	EC 1118 (control)	104	106	1050	890
	ENSIS LE–C1	112	114	1080	930
	ENSIS LE–1	102	106	900	780
	ENSIS LE–5	110	114	1060	950
	ENSIS LE–6	86	88	1050	980
Pegasus	EC 1118 (control)	108	106	880	820
	ENSIS LE–C1	140	158	750	750
	ENSIS LE–1	128	141	750	780
	ENSIS LE–5	118	132	750	720
	ENSIS LE–6	106	123	750	750
LSD_{05}		5.0		45	
Polka	average	104.2		967	
Pegasus	average	126.0		770	

AA in the wine materials from Pegasus strawberries harvested in 2016 was also the highest in the variant with the yeast race ENSIS LE–C1. Compared to this race, the test result for the control variant was worse by 32 mg/dm^3, for the race ENSIS LE–6 by 34 mg/dm^3, and for the race ENSIS LE–5 by 22 mg/dm^3. In 2017, the tendency for the highest AA content in unfortified strawberry wine materials was still observed. This parameter was the highest in the variant with the yeast race ENSIS LE–C1. This variant was far superior to those with the races ENSIS LE–6 (26 mg/dm^3), EC 1118 (control), ENSIS LE–1 (8 mg/dm^3) used in the Polka strawberry wine materials, and to all the variants from Pegasus strawberries (the differences in the contents were 17–52 mg/dm^3 > LSD_{05}=5.0 mg/dm^3).

According to the data on nutritive and caloric values in [9], the vitamin C content in strawberry jam is 8.4 mg/100 g, in black currant jam 40 mg/100 g, and in apple purée 1.6 mg/100 g. The unfortified wine materials prepared in the course of this research were higher in ascorbic acid (8.6–15.8 mg/100 g) than strawberry jam is (the latter having the density about 1.000 g/cm^3).

The use of the race ENSIS LE–1 resulted in a significantly lower (by 1.1–1.3 times) PS content in the wine materials from Polka strawberries in the years 2016 and 2017 (Table 5). In 2016, most variants differed but slightly irrespective of the yeast race used. In 2017, on the contrary, the wine materials obtained after fermentation of musts with the races EC 1118 (control) and ENSIS LE–C1 were far inferior to those fermented with ENSIS LE–6. However, in 2016, the wine materials from Pegasus strawberries were higher in phenolic substances by 130 mg/dm^3, and in 2017, by 70–100 mg/dm^3 in the control variant. In 2017, there was a slight difference in the PS content between the control variant and the one with the race ENSIS LE–1. Analysis of variance has shown that the PS content of the wine materials was determined mostly by the varietal features. In particular, the average data for the two years show that the wine materials from Polka strawberries were by 197 mg/dm^3 higher in phenolic substances than the wine materials from Pegasus strawberries. The content of phenolic substances in the unfortified strawberry wine materials was 0.72–1.08 g/dm^3. This perfectly corresponds to the characteristics of white wines with a rosy tint, as it is known [18] that the PS content of white wines is 0.2–1.0 g/dm^3, of red 1.5–4.0 g/dm^3, of Kakhetian 0.6 g/dm^3.

The wine materials decreased in ascorbic acid and phenolic substances as they lost much of them during the must preparation and in the course of fermentation (Table 6). The losses of ascorbic acid during fermentation of strawberry musts varied by cultivar, year of harvesting, and yeast race. The loss of ascorbic acid during fermentation of the Polka strawberry musts was smaller by 3% than during fermentation of the Pegasus strawberry musts. The least of AA was lost in the musts fermented with the race ENSIS LE–C1 (41.6%). It is 14.2% less than the maximum loss, which was observed with the use of the race ENSIS LE–6. According to two years' average data for the two cultivars and five yeast races, the AA losses during fermentation of musts were 49.3%.

The loss of phenolic substances in the course of strawberry must fermentation was smaller than that of ascorbic acid, still significant. During fermentation of Pegasus strawberry musts, there was by 10.4 % more of PS lost than during fermentation of Polka strawberry musts. The musts fermented by the races EC 1118, ENSIS LE–C1, and ENSIS LE–6, lost about the same amounts of PS on average. With the race ENSIS LE–1, the loss was as big as 26.9%, and with the race ENSIS LE–6, 22.5%. In total, during the two years of research, the PS losses for the two cultivars and five yeast races averaged 21.6%.

Table 6 – Losses of ascorbic acid and phenolic substances during fermentation of strawberry musts, %

Variety	Yeast race	Ascorbic acid		Phenolic substances	
		Harvested in		Harvested in	
		2016	2017	2016	2017
Polka	EC 1118 (control)	42.4	54.0	15.4	19.7
	ENSIS LE–C1	35.7	49.5	9.9	14.4
	ENSIS LE–1	41.5	53.1	24.9	28.2
	ENSIS LE–5	39.2	51.3	14.8	15.6
	ENSIS LE–6	50.8	60.8	12.6	9.2
Pegasus	EC 1118 (control)	54.8	63.1	22.0	19.8
	ENSIS LE–C1	38.8	42.4	30.4	23.2
	ENSIS LE–1	45.8	49.8	32.6	21.9
	ENSIS LE–5	49.3	52.9	31.7	27.8
	ENSIS LE–6	55.1	56.4	32.6	25.3
Polka	average	41.9	53.7	15.5	17.4
Pegasus	average	48.8	52.9	29.9	23.6

It is necessary to find out how well ascorbic acid and phenolic substances are retained in unfortified wine materials compared to their content in the juices used to make them (Table 7).

The highest AA in the Polka strawberry wine materials, as compared to fresh juices, was in the variant with ENSIS LE–C1. In it, the AA content was 1.1–1.3 times as high as in the other variants. For the Pegasus variety, this parameter was by 1.5 times higher than in the control variant in 2017. The variants with ENSIS LE–5 for Polka wine materials can be viewed as an exception in both years of research. Thus, the yeast race ENSIS LE–C1 should be considered the one that ensures the best preservation of AA in unfortified strawberry materials. The AA content of the unfortified strawberry materials amounted, on average, to 33.6% of AA present in fresh juices.

Table 7 – Content of ascorbic acid and phenolic substances in unfortified strawberry wine materials compared to their content in fresh juices, %

Variety	Yeast race	Ascorbic acid		Phenolic substances	
		Harvested in		Harvested in	
		2016	2017	2016	2017
Polka	EC 1118 (control)	38.4	31.2	70.0	62.2
	ENSIS LE–C1	41.3	33.5	72.0	65.0
	ENSIS LE–1	37.6	31.2	60.0	54.5
	ENSIS LE–5	40.6	33.5	70.7	66.4
	ENSIS LE–6	31.7	25.9	70.0	68.5
Pegasus	EC 1118 (control)	30.2	25.4	66.7	64.1
	ENSIS LE–C1	39.1	37.9	56.8	58.6
	ENSIS LE–1	35.8	33.8	56.8	60.9
	ENSIS LE–5	33.0	31.7	56.8	56.2
	ENSIS LE–6	29.6	29.5	56.8	58.6
Polka	average	37.9	31.1	68.5	63.3
Pegasus	average	33.5	31.7	58.8	59.7

In 2016, in the wine materials from Polka strawberries, like in those from Pegasus strawberries, the PS content was by 3.2–15.2% higher than it was in juices (Table 7). However, in 2017, it was not so for most of the variants. The exceptions were the variants with EC 1118 (control) and ENSIS LE–1, for which the differences are inverted 1.9 and 6.4%. It can be concluded that PS in Polka strawberries are less destructible than in Pegasus strawberries. Over the two years of research involving the use of five yeast races, the total PS content in Polka and Pegasus strawberries was, on average, 62.6% of their content in fresh juices. The best preservation of phenolic substances was achieved by using the yeast race EC 1118 (France).

Approbation of results

The research data obtained have made it possible to be granted with a utility model patent (No. 89334. Method of production of unfortified dessert varietal fruit wine *Sunychne*). These data can be used to manufacture unfortified strawberry wines by fruit wine industries, farms, and households. Unfortified strawberry raw materials can be used in the formulation of the unfortified dessert fruit wine *Sofiyivski Zori* (utility model patent No. 89333).

Conclusion

1. Natural juices from Polka strawberries contain 305.5 mg/dm^3 of ascorbic acid and 1465 mg/dm^3 of phenolic substances, and those from Pegasus strawberries 387.5 and 1300 mg/dm^3, respectively.

2. Some part of ascorbic acid and phenolic substances is lost at the technological stage of making strawberry musts. The decrease in their content due to dilution with sugar makes up 14–15%. Due to heat treatment and aeration, the loss of ascorbic acid is 14.5–19.5%, and that of phenolic substances is 1.1–4.9%.

3. After 70–77 days of fermentation of musts, the yield of unfortified wine materials is 90.1%. Fermentation, too, is accompanied by losses in ascorbic acid (49.3%) and phenolic substances (21.6%).

4. Strawberry-based unfortified wine materials for dessert wines contain 86–158.0 mg/dm^3 of ascorbic acid, which is, on average, 33.6% of its content in natural juices. The best preservation of ascorbic acid is achieved by using the yeast race ENSIS LE–C1 (Spain).

5. Unfortified strawberry wine materials contain 720–1080 mg/dm^3 of phenolic substances, which is, on average, 62.6% of its content in juices.

6. The research results confirm that unfortified dessert wines from strawberries can be regarded as products with preventive capacities. In the future, we intend to determine the antioxidant properties of fruit-based unfortified wines.

References:

1. Janovsjkyj JP. Jaghidnyctvo. Kyiv: Kyiv; 2009.
2. Polevitskiy NI. Domashnee prigotovlenie plodovikh i yagodnykh vin. po izdaniyu Leningrad, 1925. Kiev: MP «Muza»; 1991.
3. Anokhina VI, Serdjuk TL. Dovidnyk po pererobci ovochiv i plodiv bashtannykh kuljtur. Kyiv: Urozhaj; 1992.
4. Stolmakovoy AI, Martynyuka OI, pod redakcie. Populyarno o pitanii. Kiev: Zdorove; 1989.
5. Kurovsjkyj JA. Skarbnycja zdorov'ja. Kyiv: Urozhaj; 1994.
6. Samsonova AN, Usheva VV. Fruktovye i ovoshchnye soki. Moskva: Agropromizdat; 1980.
7. Flaumenbaum BL, Tanchev SS, Grishin MA. Osnovy konservirovaniya pishchevykh produktov. Moskva: Agropromizdat; 1986.
8. Laskovska J, Czyzycki A, Wlodarczyk M. Witamina C N procesie otrzymywania win z czanej porzechi. Przem.ferment.owoc. Warz:2001;45(4):12-14.
9. Skurikhin IM, Tutelyan VA. Tablitsy khimicheskogo sostava i kaloriynosti rossiyskikh produktov pitaniya: Spravochnik. Moskva: DeLi print; 2008.
10. Ruskov A. Tekhnologiya na plodive i zelenchuki. Plovdiv: Khristo G., Danov; 1970.

11. Shabrov AV, Dadali VA, Makarov VG. Biokhimicheskie osnovy deystviya mikrokomponentov pishchi. Moskva: OOO «LYeOVITnutrio»; 2003.
12. Mogilnyy MP. Pishchevye i biologicheski aktivnye veshchestva v pitanii. Moskva: DeLiprint; 2007.
13. Clark AC. Chemistry of sulfur dioxide and ascorbic acid anti-oxidant system in white wine. Melbourne; 2010.
14. Commision regulation (EC) № 423/2008. Official Journal of European Union [Internet]. 2008 [cited 2018 Jun 18]; 423: [13-56pp.]. Available from: URL: http://faolex.fao.org/eur79194.pdf.
15. El Hosry L, Auezova L, Sakt A, Hajj-Moussa E. Browning susceptibility of wine and antioxidant effect of glutathione. International Journal of Food Science & Technology. 2009;44(12):2459-2463. https://doi.org/10.1111/j.1365-2621.2009.02036.x
16. Danilewicz J. Review of reaction mechanisms of oxygen and proposed intermediate redaction products in wine: central role of iron and copper. Amer. J. Enol. Vitic: 2003:54(2):73-85.
17. Scollary GR. Mechanism of oxidative browning of white wine by copper (II) and ascorbic acid. Melbourne: 2004.
18. Mekhuzla NA, red. Sbornik mezhdunarodnykh metodov analiza i otsenki vin i susel. Moskva: Pishch. prom-st; 1993.
19. Markovsjkogho VS, za red. Dovidnyk po jaghidnyctvu. Kyiv: Urozhaj; 1989.
20. Vlasov V. Vino neobkhodimo propagandirovat ne kak alkogolnyy, a kak pishchevoy produkt . Napitki. Tekhnologii i Innovatsii. 2011;Iyul–Avgust:26-29.
21. Stuard JA, Robb EL. Bioaktive Poliphenols from Wine Grapes .Springer. 2013;457:83. https://doi.org/10.1007/978-1-4614-6968-1.
22. Gaudette NJ, Pickering GJ. Sensory and chemical characteristics of trans-resveratrol fortified wine. Aust. J Grape Wine Res. 2011;17:249-257. https://doi.org/10.1111/j.1755-0238.2011.00144.x.
23. Reynolds AG. Managing Wine Quality. Volum 2: Oenology and Wine Quality. Oxford: Woodhead Publishing; 2010. https://doi.org/10.1533/9781845699987.
24. Jing W, Min L, Jixin L, Tengzhen M, Shunyu H, Morata A, et al. Biotechnology of ice wine production. In Advances in Biotechnology for Food Industry: Academic Press. 2018:267-300. https://doi.org/10.1016/B978-0-12-811443-8.00010-4.
25. Patel P, Herbst-Johnstone M, Lee SA, Gardner RC, Weaver R, Nicolau L, et al. Influence of juice pressing conditions on polyphenols, antioxidants, and varietal aroma of Sauvignon blanc microferments. Journal of Agricultural and Food Chemistry. 2010;58(12):7280-7288. https://doi.org/10.1021/jf100200e.
26. Perez-Magarino S, Gonzalez-San ML. Polyphenols and colour variability of red wines made from grapes harvested at different ripeness grade. Food Chemistry. 2006;96(2):197-208. https://doi.org/10.1016/j.foodchem.2005.02.021.
27. Ristic R, Bindon K, Francis IL, Herderich MJ, Iland PG. Flavonoids and C13-norisoprenoids in Vitisvinifera L. cv. Shiraz: relationships between grape and wine composition, wine colour and wine sensory properties. Australian Journal of Grape and Wine Research. 2010;16(3):369-388. https://doi.org/10.1111/j.1755-0238.2010.00099.x.
28. Quetsch KH. Flaschengarung nach der Methode des Champagne. Der Deutsche Weinbau. 1987;3:117-120.
29. Usseglio-Tomasset L, Ubigli M. La quatita dello spumante in funzione delle caratteristiche del vino base. Riv. viticult. enol. 1990;42(3):19-22.
30. Sholts-Kulikov YP, pod red Valuyko GG. Vinodelie po-novomu. Simferopol: Tavrida; 2009.
31. Pozo-Bayon MA, Pueyo E, Martin-Alvarez PJ, Martinez-Rodriguez AJ, Polo MC. Influence of Yeast Strain, Bentonite Addition, and Aging Time on Volatile Compounds of Sparkling Wines. American Journal of Enology Viticulture January. 2003;54(4):273-278.
32. Austin I. Canadian Winery Matures to Draw Suitors. The New York Times. 2005;554:140-148.
33. Erasmus DJ, van der Merwe GK, van Vuuren HJ. Genome-wide expression analyses: metabolic adaptation of Saccharomyces cerevisiae to high sugar stress. FEMS yeast research. 2003;3(4):375-399. https://doi.org/10.1016/S1567-1356(02)00203-9.
34. Noti O, Vaudano E, Pessione E, Garcia-Moruno E. Shot–term response of different Saccharomyces cerevisiae strains to hyperosmotic stress caused by inoculation in grape must: RT–qPCR study and metabolite analysis. Food Microbiology. 2015;52:49-58. https://doi.org/10.1016/j.fm.2015.06.011.
35. Gherzhykovoji VG, za red. Metody tekhnokhimichnogho kontrolju u vynorobstvi. Simferopolj: Tavrida; 2009.
36. Paperno GA, Dashkevich TN. Spravochnoe posobie po plodovo-yagodnomu vinodeliyu. Minsk: Urozhay; 1968.

АСКОРБІНОВА КИСЛОТА ТА ФЕНОЛЬНІ РЕЧОВИНИ У НЕКРІПЛЕНИХ СУНИЧНИХ ВИНОМАТЕРІАЛАХ

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Анотація. Досліджено вміст аскорбінової кислоти і фенольних речовин у натуральних соках та некріплених виноматеріалах з ягід суниці садової сортів Полка і Пегас. Аскорбінової кислоти у соках містилось 271–417 мг/дм^3, фенольних речовин – 1280–1500 мг/дм^3. Вміст зазначених інгредієнтів залежить від особливостей сорту. Для виготовлення некріплених виноматеріалів, призначених для десертних вин, до одного дм^3 суничного соку додавали 230 г цукру білого. Сусло пастеризували за температури 85˚С впродовж 5 хвилин, охолоджували та зброджували із застосуванням активних сухих дріжджів: раси EC 1118 (Франція), ENSIS LE–C1, ENSIS LE–1, ENSIS LE–5, ENSIS LE–6 (Іспанія) у відповідності до рекомендацій виробників. Встановлено, що вміст аскорбінової кислоти та фенольних речовини зменшується під час приготування сусел та бродіння. Втрати аскорбінової кислоти під час приготування сусла складають в середньому 17.4%, фенольних речовин – від 1.1 до 4.9%. Зниження вмісту даних компонентів внаслідок розведення цукром під час приготування сусла складає 14–15%. Тривалість бродіння суничних сусел з початковою масовою концентрацією інвертних цукрів 274 г/дм^3 складає 70–77 діб. Вихід просвітленого виноматеріалу після бродіння залежить від особливостей сорту, та застосованої раси дріжджів і складає від 86.9 до 92.7%. Втрати аскорбінової кислоти під час бродіння сусел в середньому 49.3 %, фенольних речовини 21.6%. Встановлено, що у

складі некріплених суничних виноматеріалах вміст аскорбінової кислоти складає 86–158 мг/дм^3, фенольних речовин – 720–1080 мг/дм^3. Зокрема за середніми даними двох років, вміст фенольних речовин у виноматеріалах з ягід суниці сорту Полка був на 197 мг/дм^3 вищим порівняно з їхнім вмістом у виноматеріалах з ягід суниці сорту Пегас. Вміст аскорбінової кислоти у виноматеріалах по відношенню до вмісту в соках, що відповідає свіжим ягодам, складає 25.4–41.3%, в середньому – 33.6%; фенольних речовин – 56.2–72.0%, в середньому 62.6%. З метою кращого збереження аскорбінової кислоти варто застосовувати расу дріжджів ENSIS LE–C1 (Іспанія), фенольних речовин – EC 1118 (Франція). Результати досліджень підтверджують, що некріплені десертні вина з ягід суниці можна віднести до харчових продуктів з профілактичними властивостями.

Ключові слова: суниця садова, сусло, дріжджі, некріплені виноматеріали, аскорбінова кислота, фенольні речовини.

Список літератури:

1. Ягідництво / Яновський Ю.П. та ін. Київ, 2009. 216 с.
2. Полевицкий Н.И. Домашнее приготовление плодових и ягодных вин. Киев: МП «Муза», 1991. 144 с.
3. Анохіна В.І., Сердюк Т.Л. Довідник по переробці овочів і плодів баштанних культур. Київ: Урожай, 1992. 44 с.
4. Популярно о питании / под. ред. А.И. Столмаковой и О.И. Мартынюка; Киев: Здоровье, 1989. 272 с.
5. Куровський Ю.А. Скарбниця здоров’я. Київ: Урожай, 1994. 304 с.
6. Самсонова А.Н., Ушева В.В. Фруктовые и овощные соки. Москва: Агропромиздат, 1980. 287 с.
7. Флауменбаум Б.Л., Танчев С.С., Гришин М.А. Основы консервирования пищевых продуктов. Москва: Агропромиздат, 1986. 494 с.
8. Laskovska J., Czyzycki A., Wlodarczyk M. Witamina C N procesie otrzymywania win z czanej porzechi// Przem.ferment.owoc. – warz. 2001. T. 45, № 4. S. 12-14.
9. Скурихин И.М., Тутельян В.А. Таблицы химического состава и калорийности российских продуктов питания: Справочник. Москва: ДеЛи принт, 2008. 276 с.
10. Русков А. Технология на плодиве и зеленчуки. Пловдив: Христо Г, Данов, 1970. 326 с.
11. Шабров А.В., Дадали В.А., Макаров В.Г. Биохимические основы действия микрокомпонентов пищи. Москва: ООО «ЛЕОВИТнутрио», 2003. 184 с.
12. Могильный М. П. Пищевые и биологически активные вещества в питании. Москва: ДеЛи принт, 2007. 240 с.
13. Clark A.C. Chemistry of sulfur dioxide and ascorbic acid anti-oxidant system in white wine. Melbourne, 2010. 56 p.
14. Commision regulation (EC) № 423/2008. Official Journal of European Union. 2008. P. 13-56. URL: http://faolex.fao.org/eur79194.pdf. (дата звернення: 18.06.2018).
15. Browning susceptibility of wine and antioxidant effect of glutathione / El Hosry L., et al // International Journal of Food Science & Technology. 2009. № 44(12). P. 2459-2463. https://doi.org/10.1111/j.1365-2621.2009.02036.x
16. Danilewicz J. Review of reaction mechanisms of oxygen and proposed intermediate redaction products in wine: central role of iron and copper. Amer. J. Enol. Vitic. 2003. Vol. 54, № 2. P. 73-85.
17. Scollary G. R. Mechanism of oxidative browning of white wine by copper (II) and ascorbic acid. Melbourne, 2004. 45 p.
18. Сборник международных методов анализа и оценки вин и сусел / пер. с франц. и общ. ред. Н.А. Мехузла. Москва: Пищ. пром-сть, 1993. 320 с.
19. Довідник по ягідництву / за ред. В.С. Марковського. Київ: Урожай, 1989. 223 с.
20. Власов В. Вино необходимо пропагандировать не как алкогольный, а как пищевой продукт // Напитки. Технологии и Инновации. 2011. Июль–Август. С. 26-29.
21. Stuard J.A., Robb E.L. Bioaktive Poliphenols from Wine Grapes // Springer, 2013. Vol. 457. 83 p. https://doi.org/10.1007/978-1-4614-6968-1.
22. Gaudette N.J., Pickering G.J. Sensory and chemical characteristics of trans-resveratrol fortified wine // Aust. J Grape Wine Res. 2011. Vol. 17. P. 249-257. https://doi.org/10.1111/j.1755-0238.2011.00144.x.
23. Reynolds A. G. Managing Wine Quality. Volum 2: Oenology and Wine Quality. Oxford: Woodhead Publishing, 2010. P. 650. https://doi.org/10.1533/9781845699987.
24. Biotechnology of ice wine production / Jing W. et al // Advances in Biotechnology for Food Industry: Academic Press. 2018:267-300. https://doi.org/10.1016/B978-0-12-811443-8.00010-4.
25. Influence of Juice Pressing Conditions on Polyphenols, Antioxidants, and Varietal Aroma of Sauvignon blanc Microferments / Patel P. et al // Journal of Agricultural and Food Chemistry. 2010. Vol. 58(12). P. 7280-7288. https://doi.org/10.1021/jf100200e.
26. Perez-Magarino S., Gonzalez-San M. L. Polyphenols and colour variability of red wines made from grapes harvested at different ripeness grade // Food Chemistry. 2006. Vol. 96 (2). P. 197-208. https://doi.org/10.1016/j.foodchem.2005.02.021.
27. Flavonoids and C13-norisoprenoids in Vitisvinifera L. cv. Shiraz: relationships between grape and wine composition, wine colour and wine sensory properties. / Ristic R. et al // Australian Journal of Grape and Wine Research. 2010. Vol. 16 (3). P. 369–388. https://doi.org/10.1111/j.1755-0238.2010.00099.x.
28. Quetsch K. H. Flaschengarung nach der Methode des Champagne. Der Deutsche Weinbau. 1987. № 3. S.117-120.
29. Usseglio-Tomasset L., Ubigli M. La quatita dello spumante in funzione delle caratteristiche del vino base // Riv. viticult. enol. 1990. 42, № 3. S. 19-22.
30. Шольц-Куликов Е.П. Виноделие по-новому/под ред. Г.Г. Валуйко. Симферополь:Таврида, 2009. 320 с.
31. Influence of Yeast Strain, Bentonite Addition, and Aging Time on Volatile Compounds of Sparkling Wines. / Pozo-Bayon M. A. et al // American Journal of Enology Viticulture January. 2003. № 54(4). P. 273-278.
32. Austin I. Canadian Winery Matures to Draw Suitors // The New York Times. 2005. № 554. P. 140–148.
33. Erasmus D.J., van der Merwe, G. K., van Vuuren. H.J. Genome – wide expression analyses: Metabolic adaptation of Saccharomyces cerevisiae to high sugar stress // FEMS Yeast Research. 2003. Vol.3 (4). P. 375–399. https://doi.org/10.1016/S1567-1356(02)00203-9.
34. Shot-term response of different Saccharomyces cerevisiae strains to hyperosmotic stress caused by inoculation in grape must: RT–qPCR study and metabolite analysis / Noti O. et al // Food Microbiology. 2015. Vol. 52. P. 49-58. https://doi.org/10.1016/j.fm.2015.06.011.
35. Методи технохімічного контролю у виноробстві / за ред. В.Г. Гержикової. Сімферополь: Тавріда, 2009. 304 с.
36. Паперно Г.А., Дашкевич Т.Н. Справочное пособие по плодово-ягодному виноделию. Минск: Урожай, 1968. 260 с.