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THE QUALITY IMPACT OF FRUITS OF FOUR BERRY PLANT SPECIES AND THEIR MACERATION PERIOD ON THE QUALITY OF WINES

The research was conducted in the years 2010-11 at the Department of Horticulture, WPUT in Szczecin (Poland). The quality of fruits from four shrub species was compared (redcurrant, black currant, blue honeysuckle and highbush blueberry). The influence of the maceration duration (7 or 14 days) on the colour and chemical composition of the must and the wine made from it. Highbush blueberry were the largest fruits (197 g) with the highest SS (17.1 %) and with the lowest acidity (0.53 g) at the same time. Redcurrant fruits were the smallest (77 g), they contained the least SS (11.2 %) and polyphenolic compounds (38.5 mg). The acidity level in wines obtained from highbush blueberry fruits was too low (2.4 g L^{-1}). The acidity of wine obtained from black currant fruits was very high (7.4 g L^{-1}) and the lactic acid level was equally high (3.0 g L^{-1}). The blueberried honeysuckle fruits were the darkest (L* 22.38), as well the pulp made from them (L* 22.55) and the lightest pulp was obtained from redcurrant fruits (L* 34.56). During the maceration process, all pulps became darker (the L* parameter) and the colouring compounds were leached out of the skin (the parameters a* and b*). The extension of the maceration time intensified the process. All wines darkened during maturation. All wines obtained had a significantly lower polyphenol content than fruits. The length of the maceration process had little effect on the content of these compounds in wines.

Keywords: acidity, color, fruits, polyphenols, must, wine

Introduction. Scientists keep looking for new products, which are characterised not only by nutritional properties, but also have a beneficial effect on health. They should be characterised by a high antioxidant activity, i.e. be rich in vitamins A, C, E, polyphenols and carotenes (Wartanowicz and Ziemlański 1999). Such products are called functional food and it includes some fruits, called "superfruits", and preserves made from them. They are rich in polyphenolic compounds, which are antioxidants (Ehlenfeldt and Prior 2001; Moyer et al. 2002) and activate other antioxidants (Sikora et al. 2008), which constitute the so-called natural non-nutritious substances (Troszyńska et al. 2000). Dark fruits of berry plants are particularly valuable as they contain a lot of substances important for human health, i.e. organic acids, vitamins, minerals, polyphenols and colourants – anthocyanins and flavonoids as well as pectins (Grajkowski et al. 2010; Ochmian et al. 2009 a and b; Zheng et al. 2012; Pieszko and Orzoł 2012). Pro-health properties of berry fruits, especially dark-skinned ones have been known for a long time. They prevent numerous lifestyle diseases (including cancer), strengthen the body, have a positive effect on the circulatory system, relieve gastric problems and indigestion (Miller and Shukitt-Hale 2012; Manach et al. 2004; Halliwell 2001). Berries are a valuable ingredient for the food industry, they are perfect for broadly understood processing – they are used for making jams, marmalades, juices, nectars, jellies and numerous other products, including wine (Mucha 2006).

Wine, owing to its chemical properties, has a positive influence on the digestive system organs, the coronary circulatory system, the central and peripheral nervous systems and the immune system, as well as inhibits cancer development (Rein et al. 2000; Wang et al. 2002; Rasmussen et al. 2005). Flavonoids contained in wine have an

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antioxidant effect – they fight free radicals responsible for the acceleration of the ageing process. Drinking wine facilitates digestion of fat foods and it improves the appetite.

The first wine was probably made by accidental and uncontrolled fermentation of fruit juice. Those, who tasted that drink, did not stay indifferent to it. The originally primitive wine production was improved with time and today, detailed production methods of this alcohol are known. The so-called French paradox confirms the positive influence on the human body – the incidence of heart disease is the lowest in the French population, where grape wine is drunk with every meal in a limited amount (Renauld and De Lorgeril 1992; Constant 1997). Already in 1933, information was published in France that the average length expectancy of people drinking water was 59 years while it was 65 years for people drinking wine. In addition, 87 % of centenarians in France are wine drinkers. This certainly provides evidence that this flavonoid-rich drink protects the body against the development of the coronary disease and cancer and lowers the blood pressure (Nigdikar et al. 1998)

The wine maceration process is of some importance for their pro-health properties, during which phenols (tannins), colourants (anthocyanins) and aromatic substances are rinsed out of fruit seeds, skins and pulp. It is anthocyanins contained in the skin that give wine its reddish-purple colour (Świderski 1999). The polyphenol content in red wines is several times higher than in white wines (Czaplick et al. 2011), and out of red wines; dark ones have a better influence on the health of people who drink them.

The aim of this study was to assess the quality and usefulness of fruits from four species of berry plants for wine production. Changes of the colour and chemical composition of the must depend on the duration of the maceration process.

Material and methods. The study was performed in the years 2010-11 at the Department of Horticulture, West Pomeranian University of Technology in Szczecin (Poland). The research was focused on four species of berry plants: the red currant 'Rondom', black currant 'Tines', blueberried honeysuckle 'Zielona' and highbush blueberry 'Brygida'. The quality of fruits was determined immediately after harvest and the quality of wines obtained from them after 10 months. The bushes grew at the Experimental Station in Ostoja in a luvisol made from boulder clays, this soil was classified as arable land, valuation class IIIa and the good wheat complex. This soil was rich in macronutrients, so only nitrogen fertilisation was used every year at a dose of 60 kg.

Soluble solids content was determined with a digital refractometer PAL-1 (Atago, Japan). The determination of the extract contend during maceration and fermentation was performed in accordance with PN-90 A-79120/05, and a PAL-1 refractometer was used for readings.

Titratable acidity was determined by titration of a water extract of chokeberry homogenate with 0.1 N NaOH to an end point of pH 8.1 (measured with an multimeter Elmetron CX-732) according to PN-90/A-75101/04. **The total acid content and the lactic acid content** was determined using test strips, which were read using an electronic refractometer RQfleks10 (Merck USA).

The **HPLC** analyses of polyphenols were carried out with HPLC apparatus consisting of a Merck-Hitachi L-7455 diode array detector (DAD) and quaternary pump L-119 7100 equipped with D-7000 HSM Multisolvent Delivery System (Merck-Hitachi, Tokyo, Japan). The runs were monitored for phenolic acids at 320 nm, flavonols and luteolin glucoside at 360 nm, and anthocyanin glycosides at 520 nm (Fig. 1). Retention times and spectra were compared to that of pure standards and total polyphenols content was expressed as mg per 100 g fruit tissue. Standards of anthocyanidin glycosides were obtained from Polyphenols Laboratories (Norway), while, for phenolic acids, flavonols and luteolin glucoside from Extrasynthese (France).

Fruit, pulp and wine color were measured in a transmitted mode through Konica Minolta CM-700 d spectrophotometer in 1 cm-thick glass trays. Measurements were conducted in CIE L*a*b* system **[**L* white (100) black (0), a* green (-100) red (+100), b* blue (-100) yellow (+100)**]**, through a 10 ° observer type and D65 illuminant.

The chemical composition of fruits was examined in the juice collected from the must immediately after fragmenting fruits. After harvest, fruits from the species under analysis were divided into 5 kg portions, which were then crushed using a crusher destemmer and the pulp obtained was put into fermentation tubs. Potassium pyrosulfite was added to the must (0.5 gram per 5 litres of must), which destroyed strains of wild yeasts. It was assumed that wines should have a 13 % alcohol content, i.e. all should contain 220 g of sugar per 1 litre of must blend. It was also adopted, based on the literature, that the extract contains 4 % of compounds which are not sugars. On this basis, the amount of sugar to be added to the must was calculated. After 24 hours, the extract content was examined, sugar was added to the must to reach 23 % and it was inoculated with premium yeast cultures ICV K1W-1116. The must was mixed during fermentation to remove carbon dioxide. After 7 or 14 days (depending on the maceration time defined in the methodology), the must was filtered using a pleated filter (the juice efficiency of the individual products was determined at that time) and it was poured into fermentation bottles. Afterwards, sugar was added to the must again, thus raising the extract level by 4 % (on the 7th day after the beginning of fermentation; the drained must blend and the must blend are intended for 14-day maceration). During the fermentation process, the tubs were placed in rooms where the air temperature was kept within the range of 16-18 °C and the must temperature did not exceed 20 °C.

The values were evaluated by the Tukey test and the differences at $P<0.05$ were considered significant. The statistical analyses were performed using the Statistica 10.0 software (Statsoft, Poland).

Results and discussion. The fruits used for wine production had a different chemical composition, size and the colour of skin and pulp. The lowest pH and the highest acidity amounting to 4.12 g·100 mL^{-1} was found in black currant fruits (Table 1). In the authors' opinion (Markowski and Pluta 2003; Siksnianas et al. 2006; Giongo et al. 2008), the organic acid content in these fruits can range from 2.12 to 4.23 %. The high acidity of black currant fruits translated into the highest acid content in the wine made from these fruits (Table 1 and 5), which on average amounted to 7.4 g·L^{-1}, including 3.0 g·L^{-1} of lactic acid. As shown by research (Czech et al. 2009), the average value of general acidity of red wines made in France was 4.94 g·L^{-1}, and of Bulgarian wines was 5.74 g·L^{-1}. Highbush blueberry fruits were characterised by the lowest acidity, as little as 0.53 g·100 mL^{-1}, and the acid content in blueberry fruits was nearly 8 times lower than in black currant fruits. They were characterised by the highest extract content, on the other hand. The acidity of highbush blueberry can be higher and it may range from 0.83 (Ochmian *et al.* 2009 a and b) up to even 1.47 g·100 g^{-1} and is expressed as citric acid (Giovanelli and Buratti 2009). In the author's own research, the wine made of highbush blueberry was characterised by the low acidity amounting only 2.4 g·L^{-1}, including 1 g·L^{-1} of lactic acid, where, according to PN-90A-79120/07, the acidity of grape wines should fall within the range of 3.5 to 9.0 g L^{-1}. After analysing the results of the tasting (the results are not placed in this study), which was conducted according to the formula for grape wines, the highbush blueberry notes received the lowest ratings due to its low acidity affecting the indistinct taste. The juice of redcurrant and blueberried honeysuckle fruits had the similar acidity and pH; however, they differed in the extract content, which was the lowest of only 11.2 % in the redcurrant. Redcurrant fruits were also the smallest; the weight of 100 fruits was 77 g, which is also confirmed by research by other authors (Giongo et al. 2008; Clever 2010). The highbush blueberry was characterised by the largest fruit (197 g).

Table 1. Characteristics of fruits of four species used to make the wines

Berry plant	Red currant			Black currant			Blue honeysuckle			Highbush blueberry		
Mass of 100 fruits (g)	77 a[1]			116 b			144 c			197 d		
Volume of 100 fruit (cm^3)	81 a			104 b			158 c			233 d		
Soluble solids (%)	11,2 a			16,4 c			14,7 b			17,1 d		
Titratable acidity (g·100 mL^{-1})	2,65 b			4,12 c			2,75 b			0,53 a		
Juice pH	3,51 b			3,12 a			3,46 b			3,65 b		
Fruit color – CIE	L*	a*	b*	L*	a*	b*	L*	a*	b*	L*	a*	b*
	34,56	28,88	22,36	25,27	0,42	-0,69	22,38	2,33	-5,47	28,39	5,17	-8,82
The color of the pulp immediately after crushing fruit – CIE	32,93	19,30	16,45	23,82	19,42	-5,44	22,55	12,52	-11,09	31,66	0,68	-1,23

[1]Explanation: the means signed the same letter not differ significantly at the 5 % level of significance, Tukey test

On the basis of colour measurements performed in the CIE L*a*b* system, it was found that the a* (28.88) and b* (22.36) parameters, only redcurrant fruits had positive values, which indicates the red colour (Table 1). In the fruit skin of the other species, compounds responsible for the blue colour were present (a* from 0.42 to 5.17; b* from -0.69 to -8.82), and these results are reflected in the chemical analyses performed. The redcurrant fruits had the lowest amount of anthocyanins giving the characteristic dark colour to the fruits (Table 2). The a* parameter of the blue honeysuckle fruits was at a similar level, while b* was considerably different from values obtained in the experiment described in Ochmian *et al.* (2012 b), a* 22.49; b* 25.40. Redcurrant fruits were characterised by the lowest colour, both of the skin and the pulp (Table 1). The pulp made from highbush blueberry fruits was equally light (L* 31.66) and it was lighter than the fruit surface (L*28.39). The blue honeysuckle fruits were the darkest, but its pulp was as dark as the pulp made from black currant bushes. Those were values similar to those in the pulp made from the chokeberry 'Galicjanka' fruits L* 24.90 (Ochmian et al. 2012 a). All tested fruits have flesh with a light, greenish colour, so the pulp colour and the wine owes its colour to the compounds contained in the skin. The content of antioxidant compounds, such as polyphenols, is higher in the skin than in the flesh (Chang et al. 2000; Fernandez-Pachon et al. 2004; Jakobek et al. 2007 a).

Table 2. The content of polyphenols in fruits and wines, made from them

Berry plant	Phenolic compounds (mg·100 g^{-1})					
	Anthocyanins	Flavonols	Luteolin-7-O-glucoside	Total flavonoids	Phenolic acids	Total polyphenol
fruits						
Red currant	34,1 a	3,2 a	-	37,3 a	1,2 a	38,5 a
Black currant	331,6 d	13,4 b	-	344,6 d	5,7 b	350,7 d
Blue honeysuckle	162,2 b	15,0 b	2,6	179,8 b	25,1 c	204,9 b
Highbush blueberry	211,0 c	18,6 c	-	229,8 c	46,7 d	276,3 c

wine												
Berry plant	Maceration days											
	7	14	7	14	7	14	7	14	7	14	7	14
Red currant	17,1 a	18,3 a	2,6 a	1,8 a	-	-	19,7 a	20,1 a	0,9 a	1,6 a	20,6 a	21,7 a
Black currant	82,8 c	85,1 c	8,0 b	8,6 b	-	-	90,8 c	93,7 c	0,9 a	1,7 a	91,7 c	95,4 d
Blue honeysuckle	24,3 a	25,0ab	2,2 a	3,3 a	2,2	1,7	28,7 b	30 a	3,8 b	3,3ab	32,5 b	33,3 b
Highbush blueberry	21,7 b	36,5 b	6,5 b	8,2 b	-	-	28,2 b	44,7 b	7,0 c	5,8 b	35,2 b	50,5 c

A wine's color depends on several parameters such as the grape variety, the vinification techniques used, and the numerous reactions that take place during storage (Auw et al. 1996).

The most rapid changes in color composition occur during the first year of storage (Sommers and Evans 1986). Storage temperature influences pigment degradation and polymerization and is, according to Sommers and Evans (1986) and Somers and Pocock (1990), the primary environmental factor that influences changes in the color characteristics of red wine. In the experiment, changes in the must colour, as well as in the wine colour, were observed depending on the maceration time. A 14-day maceration period made it possible to obtain a darker must (parameter L*), especially as far as the blueberried honeysuckle and highbush blueberry fruits are concerned (Table 3). Similar relationships were also observed in wines. After 10 months, all wines were darker than the must, from which they were made, and the greatest changes applied to redcurrant and highbush blueberry wines. Moreover, the colour of redcurrant wines was found to have changed over the period from maceration to bottling (10 months). The b* parameter took negative values, which correspond to blue colours. In other wines, changes in the values of this parameter were also observed. In all wines, especially ones made from blueberried honeysuckle and highbush blueberry, the values of the a* parameter, which define the red colour, were lower. The must darkened and compounds responsible for the wine colour were released also in grapes (Ochmian et al. 2012 c).

Table 3. The color and juice field of the must after maceration period and color of the wine before bottling

Berry plant		Red currant		Black currant		Blue honeysuckle		Highbush blueberry	
Maceration days		7	14	7	14	7	14	7	14
Fruit must									
Color CIE	L*	27,74	26,39	15,27	14,20	22,97	14,80	25,91	19,47
	a*	14,67	15,05	7,27	8,83	12,86	15,14	9,54	12,72
	b*	6,78	3,43	-12,36	-14,78	-7,41	-12,02	-5,63	-8,89
Juice field (%)		74,3 de	75,7 e	72,3 d	73,5 d	68,4 b	70,1 c	64,6 a	65,2 a
Wine after 10 months									
Color CIE	L*	19,42	19,13	14,80	13,96	14,44	13,83	16,39	13,57
	a*	12,76	14,56	4,21	4,11	4,07	3,42	3,12	3,83
	b*	-7,77	-6,08	-14,55	-15,23	-13,59	-14,99	-12,53	-15,23

To obtain the assumed amount of alcohol in wine (13 %) at the beginning of fermentation, sugar was added to all must blends to reach the level of 23 % extract content (Table 4). The largest amount of sugar was added to the redcurrant must (118 g per litre), due to the low extract content in fruits (Table 1). In a similar manner, sugar was added after a week to supplement all must blends with another 4 % of the extract content. The fermentation process was the quickest in the black currant and redcurrant must and this is indicated by the greatest changes in the extract content in the must. The extract content decreased most slowly in the highbush blueberry must. After 14 days after the beginning of fermentation, the extract content in the must prepared from highbush blueberry fruits were more than twice the extract in the musts prepared from redcurrant fruits and it amounted to approx. 12.2 %. No influence of fruit presence on the fermentation process was found. Fermentation occurred at a similar rate in the must filtered on the 7th day (7-day maceration) as in the must with fruits (14-day maceration). Highbush blueberry fruits are a very good material for producing red table wines; however, due to their low acidity, problems with must fermentation may occur (Kawecki et al. 2007).

Table 4. Changes in the content of the extract of must of tested cultivars during maceration

Berry plant	Red currant		Black currant		Blue honeysuckle		Highbush blueberry	
Days of measurement	maceration days							
	7	14	7	14	7	14	7	14
1 day – all attempts have been sweetened to 23 %	weight added sugar (g L^{-1})							
	118		66		83		59	
	soluble solids (%)							
3 days	19,1	19,3	18,6	18,9	21,1	20,0	22,3	22,4
5 days	14,5	14,7	11,3	13,5	17,8	16,6	19,9	20,1
7 days	8,2	8,6	5,7	7,4	12,3	11,5	16,1	16,3
7 days – the must sugar enriched by a further 4 %	12,2	12,6	9,7	11,4	16,3	15,5	20,1	20,3
10 days	7,0	6,8	8,3	8,5	13,7	12,9	17,4	17,8
12 days	5,5	5,2	5,7	5,3	10,2	9,3	14,5	15,1
14 days	4,0	3,7	3,9	3,5	7,7	6,5	11,8	12,2

Table 5. Acidity and a content of lactic acid in the wines before bottling

Maceration days		Red currant	Black currant	Blue honey-suckle	Highbush blueberry	mean
Total acids ($g \cdot L^{-1}$)	7	3,9 b	6,9 de	4,3 bc	2,3 a	4,4 a
	14	4,0 b	7,8 e	5,6 cd	2,4 a	5,0 a
mean		4,0 b	7,4 c	5,0 b	2,4 a	–
Lactic acid ($g \cdot L^{-1}$)	7	2,1 b	2,9 d	2,4 c	1,1 a	2,1 a
	14	2,2 bc	3,1 d	2,2 bc	1,0 a	2,1 a
mean		2,2 b	3,0 c	2,3 b	1,0 a	–

In many European regions, where grape wines are produced, the maximum wine production from a surface area unit is determined to increase the quality. If too great a force is used while crushing the pulp, the wine quality deteriorates as the so-called "green flavours" are released. When standard settings were used, redcurrant fruits (approx. 75 %) and black currant fruits (73 %) had the highest juice efficiency, while highbush blueberry fruits were characterised by the lower juice efficiency (approx. 65 %) – Table 3. In earlier experiments, juice efficiency at a level of 71 % was obtained from Regent cultivar grapes and at a level of 67 % from Cabernet Sauvignon 67 % (Ochmian et al. 2012 c)**.** The efficiency of other berry fruits ranged from 64 % (cranberries) to 72.2 % (strawberries) – (Szajdek et al. 2006).

The research conducted (Table 2) showed that black currant fruits were characterised by the largest quantity of polyphenolic compounds (350 $mg \cdot 100\ g^{-1}$). Redcurrant fruits contained the lowest quantity of phenolic compounds (38.5 $mg \cdot 100\ g^{-1}$), which constituted only 11 % of total polyphenolic compounds contained in black currant fruits. The concentrations of most of the compounds identified, diminished during the first 12 months ageing in barrel, possibly due to typical oxidation and condensation reactions (Moreno-Arribas et al. 2008).

Anthocyanins were the main group of compounds in all the species under analysis, their content ranged from 76 % (blueberried honeysuckle) up to 94 % (black currant) of all polyphenolic compounds determined (Table 2). This is confirmed by research by other authors (Ochmian et al. 2009 a; Giovanelli and Buratti 2009). Total phenolic contents of anthocyanins of the wines were highly correlated with the indices determined in the grapes and with the maximum anthocyanins and total polyphenols contents of the musts and skin extracts (González-Neves et al. 2004). The content of phenolic compounds in wines was distinctly lower than in fruits, from which they were made. The length of the maceration period had a considerable influence on the content of these compounds. In the wine made from redcurrant fruit macerated for 7 days, the amount of these compounds was 47 % lower and in wine made from redcurrant fruits macerated for 14 days, the amount of these compounds was 44 % lower (20.6 and 21.7 $mg \cdot 100\ g^{-1}$), and in wine made from blueberried honeysuckle fruits, it was 84 % lower. The largest content of phenolic compounds was found in black currant wine (91.7 and 95.4 mg). Those losses, however, were higher than those observed by Czyżowska and Pogorzelski (2002), which amounted to 25 % for redcurrant wine. According to Borowska (2003), red wines can contain from 30 to 750 mg anthocyanins per 100 g, which is also confirmed by research conducted by González-Neves *et al.* (2004).

The highest phenolic acid content was shown both in the highbush blueberry fruits and in the product obtained from them. The presence of luteolin was found only in blueberried honeysuckle fruits and wine (Table 2).

Conclusions:

1. Fruits of all the species tested were useful in the production of wines meeting Polish quality standards. The lower intensity of the fermentation process occurred in the must of highbush blueberry, due to its very low acidity. All fruits, especially, redcurrant fruits were characterised by a low extract content, and sugar had to be added to musts made from them to obtain the minimum alcohol content.
2. A longer maceration time resulted in stronger leaching of colouring compounds from the skin in all tested species, which resulted in darker must colours and in darker colours of wines obtained from these musts. Wines made of dark-skinned fruits had a higher content of anthocyanins, which are responsible for the blue colour (the b* parameter).
3. During wine maturation, their content changes and wines become darker. In all wines under analysis, the compounds giving the red colour to them were partially reduced (parameter a*), while compounds giving the blue colour to the wine (parameter b*) were revealed, especially in wines made of redcurrant fruits.
4. The level of acids in the wines obtained was different. The acidity level in the wine obtained from highbush blueberry fruits was too low. The acidity of the wine obtained from black currant fruits was high, but it still conformed to the standards. However, it is recommended that the acid content in this wine should be reduced to make its flavour more delicate.
5. Black currant fruits were characterised by the highest content of polyphenols, which were mostly anthocyanins. All wines obtained had a significantly lower polyphenol content than fruits. The length of the maceration process had little effect on the content of these compounds in wines.

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Добровольска А., Охмян І., Башуцька У. **Вплив якості фруктів чотирьох видів ягідних рослин та їх вимочування на якість вина**

Дослідження здійснено у 2010-2011 рр. на кафедрі садівництва Західнопоморського технологічного університету в Щеціні. Порівняно якість фруктів чотирьох чагарникових видів (смородина червона і чорна, камчатська ягода, борувка висока). Встановлено також вплив тривалості вимочування (7 чи 14 днів) на колір та хімічний склад виготовлених із них молодих вин. Фрукти борувки високої були найбільшими плодами (197 г) із найвищим вмістом екстракту (17.1 %) при одночасній найнижчій кислотності (0.53 g). Фрукти червоної смородини були найменшими (77 г), містили найменше екстракту (11.2 %) й поліфенолових зв'язків (38.5 мг). Вина, отримані із плодів борувки високої, мали низьку кислотність (2.4 g L^{-1}). Кислотність вина, отриманого з плодів чорної смородини, була дуже високою (7.4 g L^{-1}), також високим був рівень молочної кислоти (3.0 g L^{-1}). Найтемнішими були фрукти камчатської ягоди (L* 22.38), як і м'яка маса з них (L* 22.55), а найсвітлішою була м'яка маса із плодів червоної смородини (L* 34.56). Протягом процесу вимочування м'яка маса із плодів кожного виду ягідних рослин потемніла (L* параметр) і із шкірки вилуговувалися забарвлюючі пігменти (параметри a* і b*). Збільшення тривалості вимочування підсилювало цей процес. Також вина в процесі дозрівання темніли. Всі отримані вина містили значно менше поліфенолів, ніж фрукти. Тривалість процесу вимочування мала незначний вплив на кількість цих зв'язків у винах.

Ключові слова: кислотність, колір, фрукти, поліфеноли, молоде вино, вино.

Добровольская А., Охмян И., Башуцькая У. **Влияние качества фруктов четырех видов ягодных растений и их вымачивания на качество вина**

Исследования проведены в 2010-2011 гг. на кафедре садоводства Западнопоморского технологического университета в Щецине. Сравнено качество фруктов четырех кустарниковых видов (смородина красная и черная, камчатская ягода, борувка высокая). Установлено также влияние длительности вымачивания (7 или 14 дней) на цвет и химический состав изготовленных из них молодых вин. Фрукты борувки высокой были самыми крупными плодами (197 г) из самым высоким содержанием экстракта (17.1 %) при одновременно самой низкой кислотности (0.53 g). Фрукты красной смородины были самыми мелкими плодами (77 г), с наименьшим содержанием экстракта (11.2 %) и полифенольных связей (38.5 мг). Вина, полученные из плодов борувки высокой, имели самую низкую кислотность (2.4 g L^{-1}). Кислотность вина, полученного из плодов черной смородины, была очень высокой (7.4 g L^{-1}), также высоким был уровень молочной кислоты (3.0 g L^{-1}). Самыми темными были фрукты камчатской ягоды (L* 22.38), как и мягкая масса из них (L* 22.55), а самой светлой была мягкая масса из плодов красной смородины (L* 34.56). На протяжении процесса вымачивания мягкая масса из плодов каждого вида ягодных растений потемнела (L* параметр) и из шкурки выщелочились цветные пигменты (параметры a* і b*). Увеличение длительности вымачивания усиливало этот процесс. Также вина в процессе созревания темнели. Все полученные вина содержали значительно меньше полифенолов, чем фрукты. Длительность процесса вымачивания имела незначительное влияние на количество этих связей в винах.

Ключевые слова: кислотность, цвет, фрукты, полифенолы, молодое вино, вино.

УДК 621.[787+91]

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ЗАЛЕЖНІСТЬ МІКРОТВЕРДОСТІ ЗМІЦНЕНОГО ВИСОКОШВИДКІСНИМ ТЕРТЯМ ШАРУ СТАЛІ 45 ВІД РЕЖИМНИХ ФАКТОРІВ

Досліджено, з використанням планування експерименту за В-планом, вплив швидкості обертання зміцнювального інструмента-диска, швидкості подачі зразка та нормальної сили притискання інструмента-диска до поверхні зразка на мікротвердість зміцненого шару. Встановлено граничні значення мікротвердості зміцненого шару, яка достатня для виготовлення ножів зі сталі 45 для різання деревини.

Постановка проблеми. Працездатність ножів для різання деревини залежить від фізико-механічних властивостей їх лез, що безпосередньо беруть участь у різанні. Лезо ножа повинне мати високу протизношувальну тривкість, бути витривалим під дією корозії, мати високу твердість та достатню пластичність. У роботі [1] встановлено значення коефіцієнта питомої контактної твердості (Hμ/E*) та відносного позаконтактного напруження (σ_{es}) зміцненого високошвидкісним тертям шару сталі 45. Установлено, що відношення Hμ/E* найбільш повно показує сукупний вплив пружності, міцності та пластичності, як опір матеріалу механічній дії. Важливо знати залежність мікротвердості зміцненого високошвидкісним тертям шару від режимних факторів.

Аналіз останніх досліджень та публікацій. У роботі [2] проводили дослідження мікротвердості деталей помп зі сталі 40Х, зміцнених високошвидкісним тертям на токарному верстаті 1К62 сталевим диском діаметром 250 мм, який обертався з частотою 7000 $хв^{-1}$. Досліджували вплив питомого тиску та подачі на врізання диска на мікротвердість зміцненого шару. Максимальне значення мікротвердості становило 7 ГПа. Величину і розподіл мікротвердості сталі 45 після високошвидкісного зміцнення інструментом-диском з різних матеріалів установлено в [3]. Найбільша товщина та мікротвердість (10 ГПа) була під час зміцнення диском з титанового сплаву ВТ6. У роботі [4] встановлено вплив сили притискання інструмента-диска з титанового сплаву на мікротвердість та товщину зміцненого шару. Максимальне значення мікротвердості було 10,87 ГПа, а товщина – 1,3 мм. Комплексне дослідження впливу режимних факторів на мікротвердість зміцненого шару сталі 45 не проводили.

Метою роботи є встановлення впливу режимних факторів високошвидкісного тертя на мікротвердість зміцненого шару на зразках зі сталі 45.

Виклад основного матеріалу. Дослідження впливу режимів зміцнення високошвидкісним тертям новим способом [5] проводили на експериментальній установці [6]. Змінні фактори та області їх інтересу наведено в табл. 1.

Табл. 1. Змінні фактори та область їх інтересу

Назва фактора	Кодове позна-чення	Натуральне позначення	Значен-ня міні-мальне	Значення макси-мальне	Одиниця виміру
Швидкість обертання зміцнювального інструмента-диска	X_1	υ	40	75	м/с
Швидкість подачі зразка, що зміцнюється	X_2	$υ_S$	0,25	0,75	м/хв
Величина сили притискання зміцнювального інструмента-диска до оброблюваної поверхні	X_3	P	600	1000	Н

Під час проведення досліджень застосовували планування експерименту за В-планом. Матрицю В-плану експерименту наведено в табл. 2.

Табл. 2. Матриця В-плану експерименту

№ досліду	Кодові значення			Натуральні значення		
	X_1	X_2	X_3	V, м/с	Vs, м/хв	P, Н
1	-1	-1	-1	40	0,25	600
2	1	-1	-1	75	0,25	600
3	-1	1	-1	40	0,75	600
4	1	1	-1	75	0,75	600
5	-1	-1	1	40	0,25	1000
6	1	-1	1	75	0,25	1000
7	-1	1	1	40	0,75	1000
8	1	1	1	75	0,75	1000
9	-1	0	0	40	0,5	800
10	1	0	0	75	0,5	800
11	0	-1	0	57,5	0,25	800
12	0	1	0	57,5	0,75	800
13	0	0	-1	57,5	0,5	600
14	0	0	1	57,5	0,5	1000
15	0	0	0	57,5	0,5	800

Після проведення експериментів досліджували мікротвердість на шліфах, які виготовляли за відомою методикою [7]. Мікротвердість вимірювали на мікротвердомірі ПМТ-3 з навантаженням на індентор 2 Н. У кожній точці проводили по три заміри. У табл. 3 наведено результати експерименту залежності мікротвердості зразків зі сталі 45 на глибині 550 мкм від поверхні зразка.

Табл. 3. Результати експерименту

№ досліду	К1	К2	К3
1	11,0	10,1	9,6
2	9,6	10,3	11,7
3	10,4	11,3	11,7
4	11,7	10,4	10,7
5	6,8	7,4	8,2