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ENSURING THE STABILITY OF WHITE GRAPE WINES TASTE CHARACTERISTICS WITH USE OF PRODUCTS BASED ON POLYVINYLPOLYPYRROLIDONE

Abstract. The aim of the study was to establish the optimal modes of industrial forms application of PVPP preparations (Polyclar 10, Polyclar VT and Polyclar V) for white wines treatment. The samples of oxidized white grape wines were used to determine: the total content of phenolic substances and the relative optical density at a wavelength of 420 nm. To establish the effect of the drugs on the wine materials, a three-factor quadratic regression model of dependence of the content of phenolic substances on the dose of the preparation, temperature and time of exposure was constructed for Polyclar 10, Polyclar VT and Polyclar V according to the data obtained. The result of the regression analysis are the equations linking the content of phenolic substances in the product with time, temperature and doses of injected preparations. The analysis of the obtained results allowed to establish, that the use of preparations has a statistically significant effect on the decrease in the content of phenolic substances in wine material; an increase in the exposure time has a significant effect when extrapolating the obtained dependence by up to 100 min; a decrease in the content of phenolic substances is achieved over the entire range of studied temperatures, and in order to achieve optimal results, the dosage of preparations should be reduced with temperature increasing.

Key words: white grape wines, oxidative browning, condensed forms of phenolic compounds, polyvinylpolypyrrolidone.

In countries with favorable climatic conditions, one of the leading sectors of agriculture is viticulture, more than 80% of whose production is used to produce grape wines. In 2017, the world wine production amounted to 246 million hl, while Russia ranks 12th with a volume of about 5 million hl [1].

A steady trend is the increase in the proportion of high-quality wines (reserve, branded, protected geographical indications, etc.), to which they have special requirements for sensory characteristics [2-4]. If a few decades ago, the consumer gave preference to aged wines, now, great interest is taken to light wines, in particular white wines with pronounced aroma, delicate taste with no oxidation tones, associated with the presence of condensed polyphenol forms [5-7]. In the process of wine production and storage, their quality indicators may deteriorate [8, 9].

A similar challenge is in the brewing industry, where for many years preparations, based on polyvinylpolypyrrolidone (PVPP) have been successfully used [10, 11]. There are preparations based on PVPP of various degrees of polymerization, proposed for white wines treatment, however, recommendations on the modes of their use are of a general nature [12, 13]. In addition, there are practically no scientific data on the effect of their use effectiveness, depending on the dosage, treatment duration, temperature and other factors.

In this regard, the purpose of this study was to find the optimal modes of PVPP preparations industrial forms application for the white wine treatment.

Studies, that previously were conducted at All-Russian Scientific Research Institute of Brewing, Beverage and Wine Industry, showed high efficiency of preventive treatment of grape must with new-generation preparations, based on PVPP (Polyclar 10, Polyclar V and Polyclar VT) in order to prevent oxidation of wines phenolic compounds [14, 15]. Therefore, in the present work, studies of these preparations were continued. For each preparation, in accordance with the recommendations of the manufacturer, three doses for wine treating were selected (minimum, maximum and average); treating temperature - 0 °C, 12.5 °C, 25 °C; treating time - 5 min; 27.5 minutes and 50 minutes.

In industrial samples of oxidized white grape wines, the total content of phenolic substances was determined according to the methods, recommended by the International Organisation of Vine and Wine (OIV), and the relative optical density at 420 nm using a photoelectric concentration colorimeter KFK-2. The research results are presented in tables 1-3.

Table 1 – Temperature at 25 °C

Preparation	Dose, g/dm^3	Time, min	D_{420}	Total Phenolic Content, mg/dm^3
Control	–	–	0.33	740
Temperature 25 °C				
Polyclar 10	0.1	5	0.29	710
	0.7	5	0.20	560
	0.4	27.5	0.28	730
	0.1	50	0.31	580
	0.7	50	0.22	660
Polyclar VT	0.15	5	0.30	620
	0.7	5	0.24	730
	0.43	27.5	0.25	560
	0.15	50	0.30	720
	0.7	50	0.21	580
Polyclar V	0.1	5	0.32	650
	0.6	5	0.24	590
	0.35	27.5	0.26	580
	0.1	50	0.33	640
	0.6	50	0.23	590

Table 2 – Temperature at 12.5 °C

Preparation	Dose, g/dm^3	Time, min	D_{420}	Total Phenolic Content, mg/dm^3
Control	–	–	0.33	740
Temperature 12,5 °C				
Polyclar 10	0.4	5	0.29	580
	0.4	50	0.29	590
	0.1	27.5	0.38	680
	0.7	27.5	0.26	540
Polyclar VT	0.43	5	0.31	600
	0.43	50	0.31	590
	0.15	27.5	0.40	630
	0.7	27.5	0.33	540
Polyclar V	0.35	5	0.31	580
	0.35	50	0.30	530
	0.1	27.5	0.40	650
	0.6	27.5	0.29	520

Table 3 – Temperature at 0 °C

Preparation	Dose, g/dm^3	Time, min	D_{420}	Total Phenolic Content, mg/dm^3
Control	–	–	0.33	740
Temperature 0 °C				
Polyclar 10	0.1	5	0.34	550
	0.7	5	0.24	540
	0.4	27.5	0.26	540
	0.1	50	0.31	730
	0.7	50	0.22	590
Polyclar VT	0.15	5	0.37	650
	0.7	5	0.27	770
	0.43	27.5	0.27	630
	0.15	50	0.30	650
	0.7	50	0.24	580
Polyclar V	0.1	5	0.36	630
	0.6	5	0.27	560
	0.35	27.5	0.26	600
	0.1	50	0.30	560
	0.6	50	0.23	660

Analysis of the results showed, that the total content of phenolic substances in the samples, treated with the studied preparations, regularly decreases by 20-30%, compared with the control. The largest decrease in this indicator was observed in samples, obtained at a temperature of 12.5 °C, the smallest - at a temperature of 25 °C.

At the same time, when treating white grape wine at a temperature of 25 °C, the maximum decrease in the relative optical density at a wavelength of 420 nm, which characterizes the presence of polymerized phenolic compounds, was observed from 0.33 in control to 0.20-0.23 in test samples. And when treating at a temperature of 12.5 °C, this indicator decreases minimally.

The treatment at the temperature of 25 °C turned out to be the most effective, as it allowed the color to be corrected as much as possible, getting rid of oxidation tones, while retaining the fullness of taste of the test samples.

Regarding the duration of experimental samples contact with preparations and the doses of these preparations, the following pattern is noted here - the greatest effect was obtained when using the maximum dose of preparations with the minimum contact time.

In order to study the preparations effect on wine materials, was constructed a three-factor quadratic regression model [16] based on phenolic substances content on the dose of the preparation, temperature and time of exposure for Polyclar 10, Polyclar VT and Polyclar V according to the obtained data.

The sample of white wine at the zero point of control contained 740 mg/dm3 of phenolic substances, had a relative optical density indicator D_{420} equal to 0.33. To construct the regression equations, were taken working intervals of exposure equal to 5–50 min for time and 0–25 °C for temperature.

The obtained experimental data were processed by the methods of mathematical statistics to achieve an acceptable level of significance [17-21], the uniformity of all experiments meets the Bartlett criterion with a confidence probability of 0.9. In the construction of dependencies, control values for zero dosage were also considered.

The result of the regression analysis are the equations, linking the content of phenolic substances in the product with time, temperature and doses of injected preparations:

$$f_{pol10}(d, t, T)=723-52{,}9d+3{,}13d^2+1{,}84t+0{,}15dt-0{,}034t^2-3{,}8T+0{,}12dT-0{,}06tT+0{,}013dtT+0{,}2T^2; \quad (1)$$

$$f_{polVT}(d, t, T)=735-28{,}22d+5{,}21d^2-3{,}53t-0{,}6dt+0{,}07t^2-6{,}8T-0{,}24dT+0{,}03tT+0{,}24T^2; \quad (2)$$

$$f_{polV}(d, t, T)=721-72{,}2d+7{,}84d^2+1{,}5t-0{,}28dt-0{,}04t^2-2{,}54T+0{,}03dT+0{,}02tT+0{,}01dtT+ 0{,}1T^2; \quad (3)$$

where d – preparation dosage (g/dm^3), t – time (min), T – temperature (°C). The functions correspond to the results for Polyclar 10, Polyclar VT and Polyclar V, respectively.

Due to the presence in the equations of three incoming factors, a visual interpretation of the resulting dependencies is possible with the transition to a two-factor hyperplane with fixation of the third (figure 1).

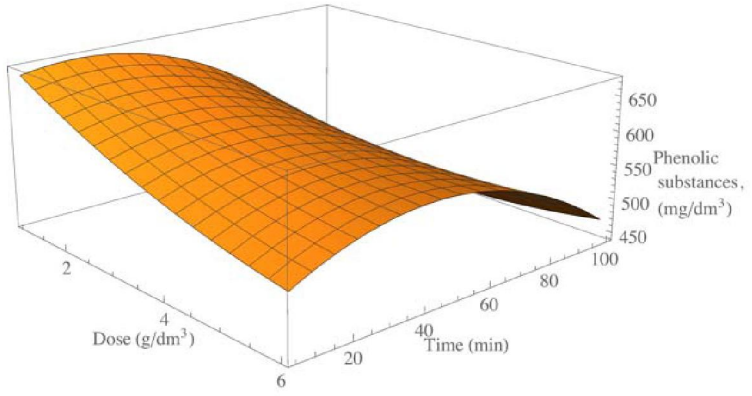

Figure 1 – The projection of the regression equation on the hyperplane with a fixed temperature parameter (preparation - Polyclar 10; T = 12 °C)

Analysis of the results and further study of the equations on the influence of incoming factors made it possible to establish that:

- the preparations presence has a statistically significant effect on the reduction of phenolic substances content in wine materials. This is clearly demonstrated in figure 2;

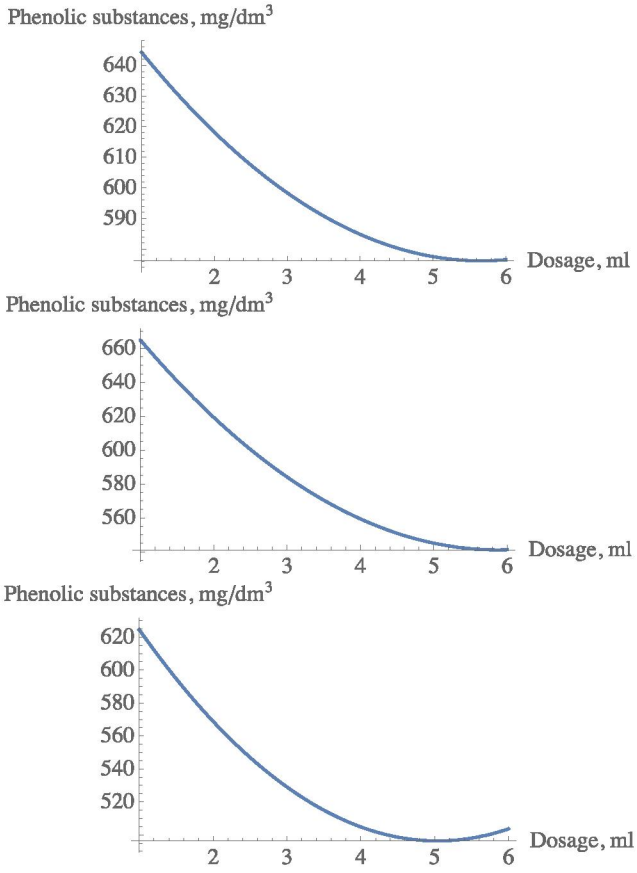

Figure 2 – Dependence of phenolic substances content on the preparation dosage (temperature and time are fixed: t = 50 min, T = 12 °C)

- an increase in the exposure time has a significant effect when extrapolating the obtained dependence for a range up to 100 min;

- a decrease of phenolic substances content is achieved over the entire range of studied temperatures, while in order to achieve optimal results, with increasing temperature, the preparations dosage should be reduced;

- statistically, it is possible to distinguish the preparation Polyclar V as the most effective.

Recommended in terms of built regression models dosage regimes, exposure time at room temperature (20 °C) for all preparations: Polyclar 10 - dose 3.2 g/dm^3, time 70 min; Polyclar VT - dose of 4.6 g/dm^3, time 25 min; Polyclar V - dose of 4.6 g/dm^3, time 25 min. The order and factors of influence can be varied in dependence of production needs, using data of the obtained equations.

Using the equations, the optimum temperature for wine materials treatment was calculated for the manufacturer's recommended minimum and maximum dosages for each of the preparation, as well as the recommended treating time for wine materials - 5 minutes. The calculated range of optimal treating temperatures was varied within fairly wide limits, from 6.6 to 17.2 °C. The technological requirements for the production premises of wineries consist in the creation of certain temperatures, humidity, etc. The temperature of the production premises depends on its functional purpose and type of wine. An important technological requirement is the constancy of temperature, temperature fluctuations are disrupting the normal course of wine materials clarification, and they adversely affect on the wine ripening. It is obvious, that for industry enterprises the wines treatment at calculated temperatures is not advisable.

In rooms, intended for wines aging and treatment, the temperature is maintained at 8-10 °C and does not allow it to rise above 15 °C. In the ground premises in the summer period, the wine is kept at a temperature of 16-20 °C. Therefore, using the obtained equations, optimal doses of preparations were calculated at a treatment temperature of 12 and 20 °C, as well as treatment times of 5, 30 and 60 minutes. The obtained calculated data are presented in table 4.

Table 4 – Recommended dosage and treatment time

Preparation	Temperature, °C	Time, min	Dose, g/dm^3
Polyclar 10	12	5	7.00
		30	6.60
		60	5.10
	20	5	7.00
		30	6.00
		60	3.95
Polyclar V	12	5	4.6
		30	4.8
		60	5.1
	20	5	3.45
		30	4.88
		60	6.00
Polyclar VT	12	5	3.2
		30	4.7
		60	6.0
	20	5	4.50
		30	4.66
		60	4.75

Studies have shown that the treatment of white grape wines with new generation products based on PVPP is effective for eliminating oxidative browning, as it helps to reduce the content of condensed forms of phenolic substances and allows you to get rid of oxidation tones in taste. Treatment of experimental data using mathematical statistics allows choose the optimal modes of wine treatment, depending on the physicochemical indicators of a particular wine, as well as the capabilities and needs of a particular production.

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ПВПП-ҒА НЕГІЗДЕЛГЕН ПРЕПАРАТТАРДЫҢ КӨМЕГІМЕН АҚ ЖҮЗІМ ШАРАПТАРЫНЫҢ ДӘМДІК ҚАСИЕТТЕРІНІҢ ТҰРАҚТЫЛЫҒЫН ҚАМТАМАСЫЗ ЕТУ

Аннотация. Зерттеудің мақсаты ақ шараптарды өңдеуге арналған ПВПП препараттарының (Поликлар 10, Поликлар ВТ и Поликлар В) өнеркәсіптік түрлерін қолданудың оңтайлы режимдерін құру болып табылады. Тотыққан ақ жүзім шарапының үлгілерінен келесі көрсеткіштер анықталды: фенолдық заттардың жалпы мөлшері және 420 нм толқын ұзындығындағы салыстырмалы оптикалық тығыздық. Препараттардың шарап материалдарына әсерін анықтау үшін фенолдық заттардың құрамының препараттың дозасына тәуелділігі, температурасы мен уақытына байланысты үш факторлы регрессиялық моделі Поликлар 10, Поликлар ВТ және Поликлар үшін құрастырылған. Регрессиялық талдаудың нәтижесі - өнімдегі фенолдық заттардың уақытын, температурасын және енгізілетін препараттардың дозаларын байланыстыратын теңдеулер. Алынған нәтижелерді талдау препараттарды қолдану фенолды заттардың құрамында шарап материалының азаюына статистикалық маңызды әсер ететінін анықтауға мүмкіндік берді; экспозиция уақытының ұлғаюы алынған тәуелділікті 100 минутқа дейін экстраполяциялау кезінде айтарлықтай әсер етеді; фенолдық заттардың құрамының төмендеуі зерттелген температуралардың бүкіл ауқымында қол жеткізіледі және оңтайлы нәтижелерге қол жеткізу үшін препараттың дозасын жоғарылату керек.

Түйін сөздер: ақ жүзім шарабы; тотықтырушы қызару; фенолдық қосылыстардың конденсирленген формалары; поливинилполипирролидон.

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ОБЕСПЕЧЕНИЕ СТАБИЛЬНОСТИ ВКУСОВЫХ ХАРАКТЕРИСТИК БЕЛЫХ ВИНОГРАДНЫХ ВИН С ПОМОЩЬЮ ПРЕПАРАТОВ НА ОСНОВЕ ПВПП

Аннотация. Целью исследования явилось установление оптимальных режимов применения промышленных форм препаратов ПВПП (Поликлар 10, Поликлар ВТ и Поликлар В) для обработки белых вин. В образцах окисленных белых виноградных вин определяли: общее содержание фенольных веществ и показатель относительной оптической плотности при длине волны 420 нм. Для установления влияния воздействия препаратов на виноматериал по полученным данным для Поликлар 10, Поликлар ВТ и Поликлар В была построена трехфакторная квадратичная регрессионная модель зависимости содержания фенольных веществ от дозы препарата, температуры и времени экспозиции. Результатом регрессионного анализа стали уравнения, связывающие содержание фенольных веществ в продукте со временем, температурой и дозами вводимых препаратов. Анализ полученных результатов позволил установить, что использование препаратов оказывает статистически значимое влияние на снижение содержания фенольных веществ в виноматериале; увеличение времени экспозиции имеет значимый эффект при экстраполяции полученной зависимости на диапазон до 100 мин; снижение содержания фенольных веществ достигается на всем диапазоне исследуемых температур, при этом для достижения оптимальных результатов, при повышении температуры следует снижать дозировку препаратов.

Ключевые слова: белые виноградные вина; окислительное покоричневение; конденсированные формы фенольных соединений; поливинилполипирролидон.

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