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OPTIMIZE THE FERMENTATION PROCESS OF STRAWBERRY MUST FOR UNFORTIFIED WINE

A. Yu. TOKAR, Doctor of Agricultural Sciences, Professor
I. V. GAYDAY, Candidate of Technical Sciences, Associate Professor
O. Yu. YUSHINA, post-graduate student
Uman National University of Horticulture
O. M. LITOVCHENKO, Doctor of Technical Sciences, Professor
Institute of Horticulture of the National Academy of Agrarian Sciences of Ukraine
V. I. VOITSEKHIVSKYI, Candidate of Agricultural Sciences, Associate Professor
National University of Life and Environmental Sciences of Ukraine
E-mail: vinodel@i.ua

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Abstract. *The dynamics of the accumulation of ethyl alcohol in the must from the strawberry varieties of Skolka and Pegas harvested in 2016 and 2017 during the production of unfortified wine materials were investigated. In variants which have accumulated a sufficient volume fraction of ethyl alcohol for the preparation of non-fortified wine, the average content is determined depending on the duration of fermentation. It is advisable to use yeast races EU-1118, ENSIS-LE-5, ENSIS-LE-6 for the production of quality straw-based wines. A graphical representation of the average accumulation of alcohol for its optimal passage has been calculated and constructed. It is determined that the accumulation of ethyl alcohol in strawberry worms (y, %) can be calculated in any period of the process (x, day) by the equation of a quadratic parabola:* $y = -0{,}0038x^2 + 0{,}4666x + 2{,}6646$*, with to an accuracy of 1,5 %. The equation x = 0...90 days is applied. The intensity of the accumulation of ethyl alcohol (% vol.) is derived from the equation. The optimal process flow from 24 to31 days. The volumetric fraction of ethyl alcohol in a must have to be at least 13 %. The criteria for evaluating the fermentation process in a periodic way and taking measures for its regulation can be obtained.*

Key words: *strawberry berries, must, fermentation process, optimization, yeast, unfortified wines*

Introduction. Wine in Europe and around the world is a food product. In Ukraine, wine products are equated with alcoholic beverages. That is why in our country there is no proper culture of consumption of wine products. Information on the development of the National Program for the Development of Culture of Sport with real measures on the "state level of production", "the change of wine traditions". It is necessary to withdraw the wine from the excisable goods. The most important thing here is a healthy and good product. Innovations plus traditions, they must be handed over to winemaking in inheritance [1, 2].

In 2018, the Historical Bill "On Amendments to Certain Legislative Acts Concerning the Development of the Production of Original Wines and Natural Honey Beverages" was adopted in Ukraine. The document defines the legal status of small winemaking (up to 10 thousand decaliters per year), facilitates the introduction of new varieties into the market, and also provides a declaration of compliance of the material and technical base with the requirements of legislation instead of certification of production. For registration only a copy of the founding documents, a document on payment of a license and a declaration of material and technical condition are required. Innovative changes open the prospects for the revival of the national heritage - fruit and berry and honey drinks, reducing the monopolization of the industry, expanding the production of domestic high-quality competitive products, interest of agricultural enterprises in the renewal and extension of plantations. The law allows you to make only natural varieties or grape wines based on the fermentation of grapes, various fruits, berries or honey [3].

Almost all fruits and berries contain high concentrations of acids and less than desirable sugars to obtain conditioned wine. Therefore, it is necessary to use special technological techniques for making conditioned fruit and berry wines [4, 5]. The manufacture of table and unassembled fruit and berry wines is associated with a long process of fermentation [2]. **Relevance of the research** is determined by the lack of objective criteria for the optimality of its passage, assessment and adoption of measures to regulate the process.

Fermentation of must is a central technological process of winemaking. It can be carried out periodically and continuously [6]. In the process of alcoholic fermentation of glucose, two main products are formed - ethyl alcohol and carbon dioxide. Different sugars are fermented at different rates. The most easily fermented glucose and fructose, more slowly - mannose and galactose; pentoses with yeast are not fermented. Sugar is a good fermentation substrate, but after hydrolysis to mono-sugars [7,8].

There are a number of patents for automatic control methods performed at the temperature of a wand worn, for carbon dioxide isolated, or by the decomposition of sugars. Particularly in the period of rapid fermentation, yeast can be decomposed up to 15 ... 25 g of sugar in 1 dm^3 of wort [5, 9].

Wineries around the world are focusing on the regulation of the fermentation process. Low cost method for controlling the process of fermentation of cider in industrial conditions is offered. The method is based on the existence of a dependence between the temperature dynamics and the evolution of ethyl alcohol [10, 11, 12, 13].

The use of different models of alcohol fermentation can predict a process that is important from a technical and economic point of view. The principal physiological processes in fermentation and mathematical equations that can describe these processes are considered. In particular, the kinetics of yeast growth, taking into account various inhibitory factors, the kinetics of the formation of the product and the kinetics of the consumption of the substrate. Despite the high degree of consistency between model and process, not all models are suitable outside the experiment. Creating a global operating model is difficult, but for a number of factors taken into account, the creation of a practically useful model is possible [9, 12].

The aim of our research was to develop a mathematical model capable of objectively describing the accumulation of ethyl alcohol in a straw must for the preparation of unprocessed wine materials, which can be used to control and regulate the process for keeping the last periodic method for small production.

Materials and research methods. The research was conducted in the laboratory of the Department of technology of storage and processing of fruits and vegetables of Uman National Horticultural University in 2016 and 2017. Two varieties of strawberry straw were used for Salk and Pegasus, from which juices were obtained by pressing. After determining the mass concentration of sugars and titrated acids and other quality indicators in juices, they added a calculated amount of white sugar, pasteurized the must at a temperature of 80-85 °C. for 3-5 minutes. The must was cooled to a temperature of 18-20 °C., different races of active dry yeast were added and controlled by the passage of the fermentation process by changing the mass of the must due to the release of carbon dioxide and the accumulation of ethyl alcohol. After the fermentation process was completed, the amount of ethyl alcohol in the wine materials was determined by the isometric method and analyzed the dynamics of the accumulation of ethyl alcohol during fermentation. There were selected variants in which a sufficient volume fraction of ethyl alcohol has been accumulated for the production of fortified wines. According to the averaged data, the correlation equations were calculated, and the intensity of the accumulation of ethyl alcohol in different periods of the process was determined. Analysis of the correlation equation was carried out according methodology to V.O. Yeshchenko and others [14, 15].

Research results and discussion. Analyzing the content of physicochemical indicators of quality of non-fortified wines according to state standart 6036: 2008, it can be concluded that in order to ensure their conditionality, the volumetric fraction of ethyl alcohol in wine materials should be not less than 14.2% in Table 1.

As a result of the dispersion analysis, it turned out that the greatest impact on the accumulation of ethyl alcohol in the must was the duration of the process, the impact strength of 77-96%, the race of yeast 1-20%, and the interaction of factors 2-4%. Therefore, we concluded that it is expedient to optimize the process by its duration.

1. Physical and chemical indicators of quality of unfortified wines and wine materials

Type of wine	For wines according to the current standard SSU 6036: 2008 (mass concentration of titrated acids in terms of malic acid 5..8 g/dm^3		For wine materials (estimated)	
	Volume fraction of ethyl alcohol,%	Mass concentration of sugars in terms of invert g / dm^3	Volume fraction of ethyl alcohol,%	Mass concentration of titrated acids based on malic acid g / dm^3
Strong	14-15	20-80	14,2–15,7	5,1…8,4
Strong	14-15	90-130	14,8–16,2	5,3…8,6
Dessert	14-15	140-190	15,3–16,9	5,5…9,0
Liquor	13-15	200-300	14,7–18,2	5,7…9,7

In 2016, in strawberry must, which was digested with yeast races EU-1118, ENSIS -LE-5, ENSIS -LE-6 sufficient volume fraction of ethyl alcohol has accumulated at an average of 14.9% in Table 2.

2. Results of monitoring the dynamics of accumulation of ethyl alcohol in strawberry must, taken to optimize the process flow,% vol.

Sort	Yeast races	Day												
		0	3	5	7	11	13	18	24	31	46	62	77	90
		2016 year												
Polka	EC-1118	0	1,0	2,4	3,8	6,7	8,3	9,9	11,8	12,8	13,6	14,5	15,0	15,0
	ENSIS-LE-5	0	2,1	3,8	5,4	8,7	10,4	11,4	12,7	12,9	13,5	14,2	14,7	14,7
	ENSIS-LE-6	0	1,4	3,3	5,2	8,6	10,0	11,2	12,7	13,1	13,7	14,4	15,1	15,1
Pegas	ENSIS-LE-6	0	3,9	5,3	6,7	8,1	9,7	11,7	12,7	12,9	13,7	14,2	14,8	14,8
2017 year														
Polka	ENSIS-LE-1	0	1,2	3,9	5,5	8,4	9,1	10,9	11,7	12,6	14,5	15,4	16,2	16,9
	ENSIS-LE-5	0	2,3	5,3	6,8	9,4	10,2	12,3	13,0	13,8	15,4	16,1	16,7	17,2
	ENSIS-LE-6	0	1,6	4,6	6,6	10,0	11,0	13,6	14,3	15,1	16,8	17,0	17,2	17,4
Pegas	EC-1118	0	2,1	4,9	7,0	10,3	11,1	13,2	13,4	13,7	14,2	14,7	15,2	15,7
	ENSIS-LE-5	0	4,0	6,7	8,9	11,7	12,2	13,3	13,6	13,9	14,5	15,0	15,4	15,8
	ENSIS-LE-6	0	2,0	6,0	6,6	9,0	10,0	12,6	12,9	13,3	14,0	14,5	15,0	15,4
Median		0	2,2	4,6	6,2	9,1	10,2	12,0	12,9	13,4	14,4	15,0	15,5	15,8

In the must from the Pegas variety, which was fermented by the ENSIS-LE-6 race, it has accumulated 14.8% ethyl alcohol. In 2017, in three variants, depending on the yeast race: ENSIS -LE-1, ENSIS-LE-5, ENSIS-LE-6 in the must of the Polka variety on average accounted for 17.2% of the volume. Ethanol. In must from berry berries sort Pegas, enough ethyl alcohol has

accumulated for digestion of the yeast race EU-1118, ENSIS -LE-5, ENSIS-LE-6, at an average of 15.6%. To optimize the process of fermentation of strawberries, we took into account all the best options for two years in two varieties, given in Table 2.

Dynamics of accumulation of ethyl alcohol in strawberry worms for the optimal process flow in the figure. 1a. Correlation equation is derived which can be used to evaluate and regulate the process in practice.

For the analysis of the obtained correlation equation, the correlation ratio was calculated, $\eta_{yx} = 0,92$, and the error correlation ratio, $S\eta_{yx} = 0,12$. Determine the student's actual criterion, $t\eta = 7,7$. Student's theoretical criterion was found by the number of degrees of freedom: $t_{0,95} = 0,20$, and $t_{0,99} = 3,11$.

Since the Student's criterion is actually $t_\eta = 7,7$ greater than $t_{0,95}$ фтві $t_{0,99}$, the connection is reliable on both levels of reliable probability.

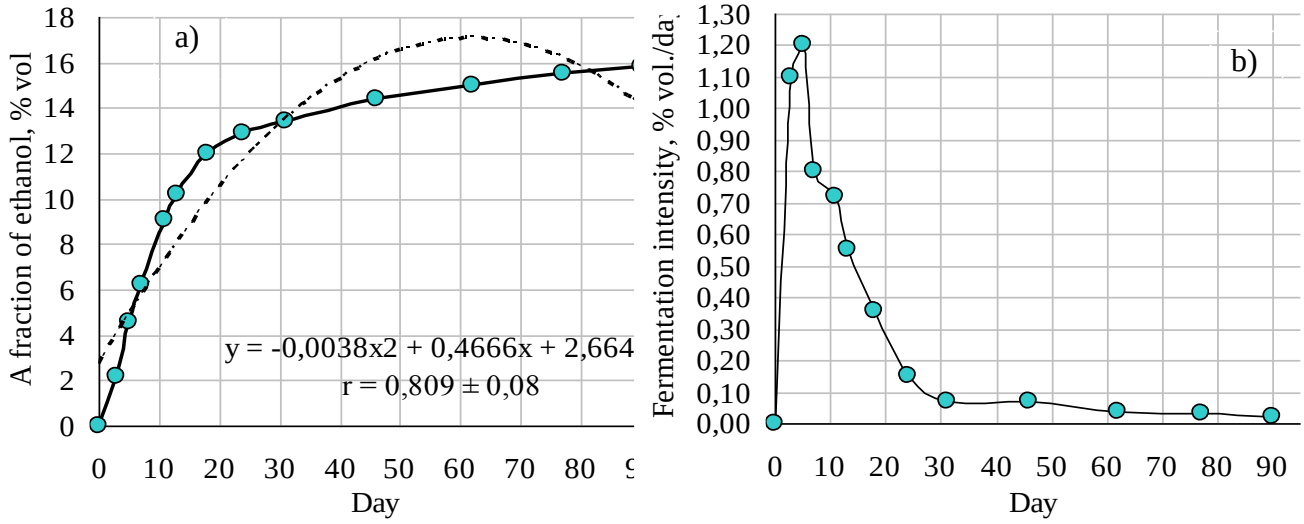

Figure 1. a) Dynamics of the accumulation of ethyl alcohol in strawberry must for optimal passage of the fermentation process depending on the length of the process; b) Intensity of accumulation of ethyl alcohol in strawberry must for optimal passage of the fermentation process.

Calculated deviation (y_x, % of vol.) from the optimal value was 1.48.

Consequently, using the equation: $y=-0,0038x^2 + 0,4666x+2,6646$, one can determine the volume fraction of ethyl alcohol in a strawberry on any day of the fermentation process for its optimal flow within 90 days with an accuracy of 1,5 % (figure. 1b). Compare the calculated indicator with the results obtained from the control of the wand, and make timely conclusions and take measures as needed to improve.

The dynamics of the accumulation of ethyl alcohol is described by the equation of a quadratic parabola, which has the general form: $y = Ax^2 + Bx + C$.

The velocity of the process (y ') is derived from the equation and can be

determined on any day (x) by the equation: y' = A2x + B + 0. In particular, in our case: y' = 0,4666 – 0,0076x.

Conclusions. To optimize the process of fermentation of straw berries, you can use the equation of a quadratic parabola: $y=-0,0038x^2 + 0,4666x+2,6646$, which can be used to control the fermentation of strawberries in the manufacture of unsold wine materials. The derived equation makes it possible to determine the content of ethyl alcohol in must in any given day with a precision of 1.5% v / v. and make timely decisions on the regulation of the fermentation process. For an optimal flow of the process to 24-31 days in must, the volume fraction of ethyl alcohol should reach at least 13%. It is advisable to use the yeast EU-1118, ENSIS-LE-5, ENSIS-LE-6 to effectively make straw-wine materials. The data obtained should be taken into account when producing quality and competitive strawberry wines. Further studies should focus on the study of aroma-forming compounds of wine materials for the fermentation of different races.

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ОПТИМІЗАЦІЯ ПРОЦЕСУ БРОДІННЯ СУНИЧНИХ СУСЕЛ ДЛЯ НЕКРІПЛЕНИХ ВИН

А. Ю. Токар, І. В. Гайдай, О. Ю. Юшина, О. М. Литовченко, В. І. Войцехівський

Анотація. *Досліджено динаміку накопичення етилового спирту в суслах з ягід суниці садової сортів Полка і Пегас врожаю 2016 і 2017 років під час виготовлення некріплених виноматеріалів. У варіантами, у яких накопичилась достатня об'ємна частка етилового спирту для приготування некріпленого вина, визначено середній вміст залежно від тривалості бродіння. Для виготовлення якісних суничних виноматеріалів доцільно застосовувати раси дріжджів EC-1118, ENSIS-LE-5, ENSIS-LE-6. Розраховано і побудовано графічне зображення усередненого процесу накопичення спирту за його оптимального проходження. Визначено, що накопичення етилового спирту в суничних суслах (у, %), може бути розрахованим у будь-який період процесу (х, доба) за рівнянням квадратичної параболи:* $y=-0{,}0038x^2+0{,}4666x+2{,}6646$*, з точністю 1,5%. Область застосування рівняння х=0…90 діб. Інтенсивність накопичення етилового спирту (%об./добу) є похідною від рівняння. За оптимального протікання процесу до 24–31 доби. Об'ємна частка етилового спирту у суслі повинна становити не менше 13 %. Отримано критерії, за якими можливо оцінити процес бродіння періодичним способом та прийняти заходи щодо його регулювання.*

Ключові слова: *ягоди суниці садової, сусло, процес бродіння, оптимізація, дріжджі, некріплені вина*

Токар А. Ю., Гайдай І. В., Юшина О. Ю., Литовченко О. М., Войцехівський В. І.

ОПТИМИЗАЦИЯ ПРОЦЕССА БРОЖЕНИЕ ЗЕМЛЯНИЧНЫЙ СУСЕЛ ДЛЯ НЕКРЕПЛЕНЫЕ ВИН

А. Е. Токарь, И. В. Гайдай, О. Ю. Юшина, А. М. Литовченко, В. И. Войцеховский

***Аннотация**. Исследовано динамику накопления этилового спирта в суслах с ягод земляники садовой сортов Полка и Пегас урожая 2016 и 2017 годов во время производства некрепленных виноматериалов. У вариантах, с достаточным накоплением этилового спирта определена интенсивность и длительность брожения. Для приготовления качественных земляничных виноматериалов целесообразно использовать расы дрожжей EC-1118, ENSIS-LE-5, ENSIS-LE-6. Рассчитана модель и подано графическая модель усредненного процесса его оптимального прохождения. Определено, что накопление этилового спирту в земляничных суслах (у, %), может быть рассчитано в любой период процесса (х, сутки) по уравнению квадратической параболы: $y=-0,0038x^2+0,4666x+2,6646$, с точностью 1,5%. Область использования уравнения х=0…90 суток. Интенсивность накопления этилового спирта (%об./сутки) является производной от уравнения. При оптимальном протекании процесса за 24-31 суток в сусле объемная доля этилового спирта должна достигать не менее 13%. Получены критерии, по которым можно оценить процесс брожения периодическим способом и принять меры к его регулированию.*

***Ключевые слова:** ягоды земляники садовой, сусло, процесс брожения, оптимизация, дрожжи, некрепленые вина*