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DYNAMICS OF ALCOHOLIC FERMENTATION AND THE QUALITY OF WHITE ORGANIC WINES PRODUCED WITH SELECTED YEASTS

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Abstract

The dynamics, duration and specificity of alcoholic fermentation are among the factors determining the quality of white wines. These features depend mostly on technological parameters such as temperature (16°C, 20°C) and amount of total sugars (180 g/dm³, 220 g/dm³). The aim of the current study was to assess the fermentation activity of yeast *Saccharomyces cerevisiae* from EXCELLENCE® line, intended for production of wines under Organic and National Organic Program (NOP) standards. The used yeasts have a high fermentation activity and are characterized with relatively fast alcoholic fermentation. The result showed that there was no difference in the dynamics of alcoholic fermentation of yeast strains from the used lines. The quick fermentation of sugars was observed in the initial (lag phase) and in the final stage (silent fermentation). However, the experimental variants with different sugar contents completed the process at the same time. A straightforward relationship between the fermentation of sugars and the changes in pH was not observed. According to the mass of the obtained yeast lees, there was a clear difference between all experimental variants. Nevertheless, the mass of the obtained yeast lees for all variants was lower than the normatively allowed.

Keywords: yeast, alcoholic fermentation, dynamics, sugars, relative density, pH

INTRODUCTION

The dynamics of alcoholic fermentation is greatly influenced by the temperature at which the process occurs. Yeast have a major role in winemaking by carring out the biochemical process of sugar transformation into alcohol and carbon dioxide (Bambalov, 1981), and in the production of a number of aromatic compounds. *Saccharomyces cerevisiae* is the main type of yeast used in winemaking, with currently over 200 different strains available for commercial purposes (Sablayrolles, 2019). The main difference between the strains is in kinetics and duration of fermentation (Colombie et al., 2005). The use of different fermentation temperature regimes results in different characteristics of the produced wine (Shi at al., 2022). Presently, the alcoholic fermentation at a low temperature (12-16°C) is still the dominant technology in the production of white wines. The grape variety and the yeast strains used for fermentation are of decisive importance for the aroma of young wines (Graham, 2003, Shi et al., 2022). Additionally, it is believed that alcoholic fermentation at a low temperature preserves the typical varietal and fermentation aromas, while balancing the fruity and herbal notes effectively (Deet at al., 2017). As an advantage of the low-temperature alcoholic fermentation, the production of increased amounts of terpene aromas, emphasizing varietal specificity, was also considered (Pérez et al., 2018). Wines, fermented at 10°C show an increased intensity and a good balance of aromas with sensory accents on fruity ones (Shi et al., 2022). With fermentation of such type, it is also possible to affect the microbial metabolism of *Saccharomyces cerevisiae* and to stimulate the

synthesis of volatile compounds (Molina et al., 2007). As a result, diverse series of flavor-active esters can be found in wine (Ortiz-Tovar et al., 2019). Additionally, at a low fermentation temperature, yeasts are less sensitive to the toxic effects of ethanol concentration. The cell growth is slowed down, as is the rate of fermentation, but the cell viability is improved (Shener et al., 2007).

On the other hand, alcoholic fermentation carried out at a higher temperature (>15°C) possibly reduces thiol aromas due to the increased content of ester compounds (Shi et al., 2022, McKay et al., 2020). The higher fermentation temperature negatively affects yeast cells, which is especially evident in their reduced viability at the end of fermentation (Shener et al., 2007). Although the rapid initiation and completion of fermentation has advantages, the preferred temperature for vinification is often lower than the optimum for ethanol production or for yeast growth (Shener et al., 2007).

The advantages of the fermentation carried out with pure cultures of wine yeast is almost undisputable (Andorrà, et al., 2010; Gardner, et al., 2023; Gonzalez, 2022; Gerald, 1988; Holešinský, et al., 2020; Pretorius, 2000). The utilization of pure cultures of wine yeasts leads to a production of wines with predictable qualities – a low content of residual sugar, desirable taste and aroma, and facilitated further processing (Georgiev, 2024). The most noticeable change during wine fermentation is the decrease in the fermentable sugars and the rapid increase in ethanol concentration that act as stress factors for the yeast cells. Marks et al., (2008) suggested that the yeast cell has a unique mechanism to respond to the presence of ethanol independently of glucose concentration. In addition, the high sugar concentration (over 21.4%) in the grape`s must is a source of osmotic stress for yeast cells that is partially relieved during fermentation due to the conversion of sugar into ethanol and CO_2 (Marks et al., 2008). The strains of *Saccharomyces cerevisiae* used in winemaking are well adapted to the conditions of the production environment, which is characterized by a high osmotic pressure, hypoxia, high sugar concentrations and low nitrogen levels (Ashalou, 2019, Alexandre et al., 2001; Ortiz et al., 2013). However, the consumer demand for typical and healthier wines has given rise to some alternative winemaking practices that involve utilization of wild or native yeasts. Among these practices is the use of selected yeasts, intended for the production of Organic and NOP category wines. One of the main requirements for the selected wine yeast is its resistance to ethanol and osmotic pressure. Improving the control of the alcoholic fermentation in using Organic and NOP yeasts can be challenging due to the necessity to optimize the technological parameters: reduction of sugars and duration of fermentation, which depends on the temperature of fermentation (Sablayrolles, 2019). The successful control of the process by pH requires more studies and design of models, since the available ones are incomplete and only partially predict pH changes during fermentation (Huberson et al., 2008).

The aim of the present study is to estimate the effect of the grape must`s sugar content and temperature on the fermentation activity of the yeast from EXCELLENCE® line during a production of white wine.

MATERIALS AND METHODS

Grape must. Grape must from the Dimyat vintage 2023 variety was used (the must was used 18 hours after its extraction). The turbidity of the must was 50 NTU (Nephelometric Turbidity unit).

Yeast. In the study, the yeast from line Excellence® B2, Excellence® STR, and Excellence® FTH was used kindly provided by Lamothe-Abiet, France. The specific characteristics of the yeast are shown in Table 1.

Table 1. The main characteristic of the yeast lines used in the study.

Specific features	Yeast line		
	Excellence® B2	**Excellence® STR**	**Excellence® FTH**
Resistance to difficult fermentation conditions	Yes	Yes	Yes
Fast integration into must	Yes	Yes	Yes
Fast and clean fermentation	Yes	Yes	Yes
Alcohol tolerance, in vol%	up to 14	up to 15	up to 15
Resistance to low temperatures, in °C	up to 14	up to 12	up to 12
Turbidity tolerance, in NTU	≥ 50	up to 50	up to 50
Need for nitrogen sources	Average	Low	Low
Profile of the wines produced	Typical	Esterene	Thiolov

To reduce the contamination a dry yeast patented product was utilized in the experiments provided by Lamothe-Abiet, France. Twenty grams of OenoStim® were used per 100 kg grape must. Initially, the yeasts were rehydrated for 15 min in water at a temperature of 36-40°C and a hydromodule of 1:10, which resulted in 25 g/hl of starter and 20 g/hl of sugar. Adaptation was done by dilution to a final hydromodulus of 1:25. It was carried out for 2 hours, with gradual cooling to 16°C (the temperature of the grape must). The rehydrated and adapted yeasts were added in predetermined quantities to the experimental variants.

Preliminary preparation of solutions

For the needs of the experiment, specially prepared solutions with final concentrations were used: a sugar solution (SS) – 180 and 220 g/dm^3 and a water-alcohol mixture (WAM) – 10, 12 and 78%.

Methods of analysis

The average samples from the grape must were taken according to BDS 6036-86. The analysis of the samples was carried out in the physico-chemical laboratory of the company Vinar BG Ltd – Haskovo. A hydrometric method was applied for specific gravity (Ivanov at al., 1978). The sugar content was estimated with a digital refractometer (ATAGO WM-7) and the Schoorl method for reducing sugar content was utilized according to BDS 6410-85. The titratable acidity (TC) and pH values were measured potentiometrically according to BDS 6409-86 and Ivanov et al., (1978), respectively. The sulfur dioxide content was estimated by the aspiration method according to the International Organisation of Vine and Wine (OIV) and the alcohol content was measured with an electronic ebuliometer (model AlkW001).

In order to carry out a comparative study of the dynamics of alcoholic fermentation of the indicated three yeast strains from the EXCELLENCE® series (B2, STR, FTH) at different sugar contents 180 and 220 g/dm3 and under different temperature regimes – 16 and 20°C, four series of experimental variants were done. They ware marked respectively - first series (A), second series (B), third series (C), fourth series (D). Within each separate series, three variants have been developed - one variant for each tested yeast strain. The variants of series A and B reproduced the process of alcoholic fermentation at 16°C and with the corresponding sugar content for series A – 180 g/dm3, and for series B – 220 g/dm3. The variants of series C and D reproduced the process of alcoholic fermentation at 20°C and with the corresponding sugar content for series C – 180 g/dm3, and for series D – 220 g/dm3. The general scheme of all variants, temperature regimes and initial sugar contents are presented in Table 2.

Table 2. General description of of the experimental variants.

Yeast line	Experimental series			
	A	**B**	**C**	**D**
Excellence® B2	B2-A	B2-B	B2-C	B2-D
Excellence® STR	STR-A	STR-B	STR-C	STR-D
Excellence® FTH	FTH-A	FTH-B	FTH-C	FTH-D
Fermentation temperature, °C	16	16	20	20
Initial sugar content, g/dm³	180	220	180	220

The two grape concentrations were prepared and sulfited in advance. With 1000 cm3 volumetric flasks, 1000 cm^3 were measured and placed in new PET (polyethylene terephthalate) bottles with a capacity of 1,5 dm^3. Immediately afterwards, each sample was inoculated with the corresponding strain of the wine yeast. Every day, until the end of the experiment, the samples were homogenized.

The characteristics of the must/wine in the beginning and at the end of the experiment for all series are shown in Tables 3, 4, 5 and 6.

Table 3. Characteristics of must/wine in the beginning and at the end of the experiment for series A.

№	Parameter	Abbreviation	Unit	Initial value series A	Final value series A		
					B2-A	**STR-A**	**FTH-A**
1	Specific gravity	D_R	g/dm³	1,079	0,998	0,998	0,998
2	Total sugars	TS	g/dm³	180,00	5,41	5,38	5,19
3	Alcohol	A	vol%	0	10,66	10,86	10,85
4	Titratable acids	TA	g/dm³	4,46	6,03	5,51	6,38
5	Actual acidity	pH	1	3,38	3,39	3,41	3,37
6	Volatile acids	VA	g/dm³	0,18	0,32	0,38	0,38
7	Free SO_2	L(SO_2)	mg/dm³	20,8	0	0	0
8	Total SO_2	T(SO_2)	mg/dm³	76,8	70,4	73,6	72

Table 4. Characteristics of must/wine in the beginning and at the end of the experiment for series B.

№	Parameter	Abbreviation	Unit	Initial values series B	Final values series B		
					B2-B	**STR-B**	**FTH-B**
1	Specific gravity	D_R	g/dm³	1,094	0,998	0,998	0,998
2	Total sugars	TS	g/dm³	220,00	5,66	5,63	5,81
3	Alcohol	A	vol%	0	13,10	13,26	13,18
4	Titratable acids	TA	g/dm³	5,81	6,82	6,75	7,31
5	Actual acidity	pH	1	3,35	3,40	3,44	3,40
6	Volatile acids	VA	g/dm³	0,20	0,32	0,42	0,42
7	Free SO_2	L(SO_2)	mg/dm³	20,8	0	0	0
8	Total SO_2	T(SO_2)	mg/dm³	91,2	89,6	86,4	88,0

Table 5. Characteristics of must/wine in the beginning and at the end of the experiment for series C.

№	Parameter	Abbreviation	Unit	Initial values series C	Final values series C		
					B2-C	STR-C	FTH-C
1	Specific gravity	D_R	g/dm³	1,078	0,999	0,999	0,999
2	Total sugars	TS	g/dm³	180,00	5,09	4,96	4,86
3	Alcohol	A	vol%	0	10,71	11,16	10,84
4	Titratable acids	TA	g/dm³	5,10	6,71	6,45	7,2
5	Actual acidity	pH	1	3,29	3,30	3,31	3,30
6	Volatile acids	VA	g/dm³	0,18	0,32	0,36	0,36
7	Free SO_2	L(SO_2)	mg/dm³	20,8	0	0	0
8	Total SO_2	T(SO_2)	mg/dm³	85,6	83,2	80,8	81,6

Table 6. Characteristics of must/wine in the beginning and at the end of the experiment for series D.

№	Parameter	Abbreviation	Unit	initial value series D	Final values series D		
					B2-D	STR-D	FTH-D
1	Specific gravity	D_R	g/dm³	1,093	0,999	0,999	0,999
2	Total sugars	TS	g/dm³	220,00	5,23	4,65	5,74
3	Alcohol	A	vol%	0	13,28	13,39	13,26
4	Titratable acids	TA	g/dm³	6,03	7,99	7,16	7,87
5	Actual acidity	pH	1	3,23	3,29	3,37	3,28
6	Volatile acids	VA	g/dm³	0,20	0,32	0,36	0,38
7	Free SO_2	L(SO_2)	mg/dm³	16,0	0	0	0
8	Total SO_2	T(SO_2)	mg/dm³	93,6	92,0	89,6	88,8

The experiment was repeated twice. For the first time, the experiment was conducted in the physico-chemical laboratory of the company Vinar BG Ltd – Haskovo in vessels of 1.5 dm3, while the volume of must was 1 dm3. For the second time the experiment was conducted in the wine cellar of the company Vinodar EOOD in the village of Polyanovo, Haskovo region, with a vessel volume of 220 dm3, while the must volume was 180 dm3. All experimental results, presented in the tables and graphs, are the average of the values, obtained from the two experiments.

Sensory analysis

The organoleptic characteristics of the obtained experimental variants were evaluated by seven wine professionals and quality experts (five men and two women within the age range of 40 to 52 years old, all with higher education (a minimum master's degree)). Five of them were oenologists with extensive practical experience in the production of wine; two had experience in the production of quality control wine. All participants in the tasting commission had extensive production and testing experience and were well aware of the requirements and standards for this analysis (ISO 13299:2016–ISO 6658:2017, ISO 3972:2011, ISO 5496:2006). The tasting committee perfectly recognized aromas, flavors and their intensity and balance. The jury performed a tasting of the made wines and evaluated them descriptively. The wines were also subjected to a triangle test to provide a good evaluation of the differences between the wines fermented by the different strains of the yeast at different temperatures and under different sugar contents (ISO 4120:2021 – Sensory analysis – Methodology – Triangle test). All assessments were performed from 10:00 a.m. to 12:00 p.m. in an individual booth, and the averaged data are presented.

RESULTS AND DISCUSSION

The changes in the sugar content (g/dm³) during alcoholic fermentation for all batches are shown in Tables 7, 8, 9, 10, and 11. All yeast strains fermented sugars to the level required for wine production and corresponding to the category of dry wines.

Table 7. Changes in the sugar content during the alcoholic fermentation in series A (g/dm³).

Time	Temperature	Experimental variants		
τ, d	t, °C	B2-A	STR-A	FTH-A
0	16	180,00	180,00	180,00
1	16	176,33	176,89	177,63
2	16	173,84	173,99	176,35
3	16	162,77	164,13	173,55
4	16	153,69	152,39	158,72
5	16	134,28	132,56	135,58
6	16	112,35	113,06	119,84
7	16	91,64	92,36	94,18
8	16	77,39	77,69	78,56
9	16	63,01	62,83	64,57
10	16	51,78	49,02	53,23
11	16	40,79	36,90	40,99
12	16	27,51	25,89	28,33
13	16	22,49	17,54	22,87
14	20	18,76	15,67	17,59
15	20	14,90	13,12	14,56
16	20	12,63	12,01	12,63
17	20	10,45	10,32	11,01
18	20	8,50	8,50	8,50
19	22	7,99	7,83	8,11
20	22	6,27	6,44	6,39
21	22	5,41	5,38	5,19

The dynamics of alcoholic fermentation was dependent on the fermentation temperature and the initial sugar content of the grape must. The main factor for the duration of the fermentation was the series temperature irrespective of the yeast strains and sugar content. The fermentation temperature and sugar content did not affect the amount of alcohol obtained per unit of sugars during alcoholic fermentation. This amount was dependent on the yeast strain. All used yeast strains have had an increased yield of alcohol per sugar unit. According to their alcoholic yield per sugar unit, the yeast strains of the EXCELLENCE® line can be arranged in the following descending order: STR, FTH, and B2.

Table 8. Changes in the content of sugar in g/dm³ during the alcoholic fermentation of the variants of series B.

Time	Temperature	Experimental variants		
τ, d	t, °C	B2-B	STR-B	FTH-B
0	16	220,00	220,00	220,00
1	16	219,39	218,81	219,84
2	16	216,56	217,13	218,42
3	16	208,27	208,96	213,68
4	16	196,75	197,48	199,87
5	16	175,06	172,25	183,69
6	16	157,87	153,42	163,28
7	16	136,45	138,91	151,26
8	16	117,23	112,19	129,53
9	16	100,18	97,23	105,12
10	16	89,52	85,92	90,06
11	16	74,00	72,05	78,43
12	16	63,94	61,79	64,56
13	16	53,29	46,11	53,76
14	16	45,76	32,39	46,55
15	16	30,11	24,72	33,19
16	16	21,79	18,12	22,23
17	20	16,41	12,09	14,19
18	20	10,50	10,50	10,50
19	20	9,95	8,89	9,73
20	20	7,16	7,06	6,94
21	22	5,66	5,63	5,81

The initial and final values of acidity (pH) for the variants with an initial sugar content of 180 g/dm³, regardless of the fermentation temperature (16°C, 20°C), remained unchanged (the differences fell within the error limits of the method of analysis). The final values of the active acidity (pH) for the

variants with an initial sugar content of 220 g/dm³, regardless of the fermentation temperature (16°C, 20°C), were slightly higher. At the initial sugar contents (180 g/dm³ and 220 g/dm³), the higher final titratable acids (as a difference with the initial titratable acids) were observed in the variants fermented at a higher temperature (20°C). In the variants fermented at temperatures (16°C, 20°C), the higher final titratable acids (as a difference with the initial titratable acids) were observed in the variants with lower initial sugar content (180 g/dm³). According to the obtained final titratable acid, the yeast of EXCELLENCE® line can be arranged in the following descending order: FTH, B2, STR.

Table 9. Changes in the content of sugar in g/dm³ during the alcoholic fermentation of the variants of series C.

Time	Temperature	Experimental variants		
τ, d	t, °C	B2-C	STR-C	FTH-C
0	20	180,00	180,00	180,00
1	20	179,13	174,98	175,88
2	20	163,75	157,79	156,23
3	20	152,09	139,48	146,76
4	20	127,54	119,12	126,99
5	20	97,20	92,49	96,89
6	20	79,50	74,46	77,19
7	20	61,80	61,82	61,09
8	20	47,64	41,97	46,76
9	20	35,25	25,72	34,22
10	22	29,94	18,52	25,27
11	22	22,86	16,70	18,11
12	24	15,78	14,89	14,53
13	24	12,90	12,14	11,87
14	24	10,26	9,68	8,92
15	24	8,49	7,82	6,99
16	24	6,75	5,64	5,39
17	24	5,09	4,96	4,86

Table 10. Changes in the content of sugar in g/dm³ during the alcoholic fermentation of the variants of series D.

Time	Temperature	Experimental variants		
τ, d	t, °C	B2-D	STR-D	FTH-D
0	20	220,00	220,00	220,00
1	20	212,59	212,78	212,26
2	20	199,90	191,39	202,16
3	20	182,63	179,27	186,44
4	20	167,20	155,69	164,17
5	20	139,97	124,86	138,82
6	20	111,83	99,68	107,89
7	20	95,09	81,11	85,95
8	20	80,22	62,54	73,15
9	20	65,34	43,97	56,70
10	20	54,19	30,96	45,73
11	20	44,89	21,68	38,42
12	22	31,87	17,17	27,45
13	22	22,58	14,25	21,36
14	24	18,76	12,27	16,48
15	24	11,65	8,96	10,33
16	24	7,32	6,46	7,78
17	24	5,23	4,65	5,74

The composition of wine lees is complex and directly depends on the type, terroir of cultivated grape, and other biotic and abiotic factors (Pérez-Bibbins et al., 2015). The variations in the composition of wine lees were explained by the presence of microorganisms and their autolysate products, as well as organic and inorganic residues (Antón-Díaz et al., 2016). At this stage, the wine lees consisted mainly of dead or residual yeast cells, which often seriestle to the bottom of the winemaking vessels (Barcia et al., 2014). The mass of the precipitate obtained for all series showed that the higher amount corresponded to a higher sugar content (220 g/dm³), and that the fermentation temperature did not affect the amount of precipitates (Table 11). The mass of the yeast sediment for all batches was less than the allowed technology limit of 2%.

Table 11. Lees mass.

№	Series and variants	Mass of lees at the first removing, gr	Mass of lees at the second removing, gr	Total mass of the removed lees, gr
	Series A			
1	B2-A	6	3	9
2	STR-A	9	3	12
3	FTH-A	5	2	7
	Series B			
4	B2-B	5	4	9
5	STR-B	6	5	11
6	FTH-B	3	3	6
	Series C			
7	B2-C	8	4	12
8	STR-C	11	6	17
9	FTH-C	10	7	17
	Series D			
10	B2-D	9	7	16
11	STR-D	8	6	14
12	FTH-D	6	6	12

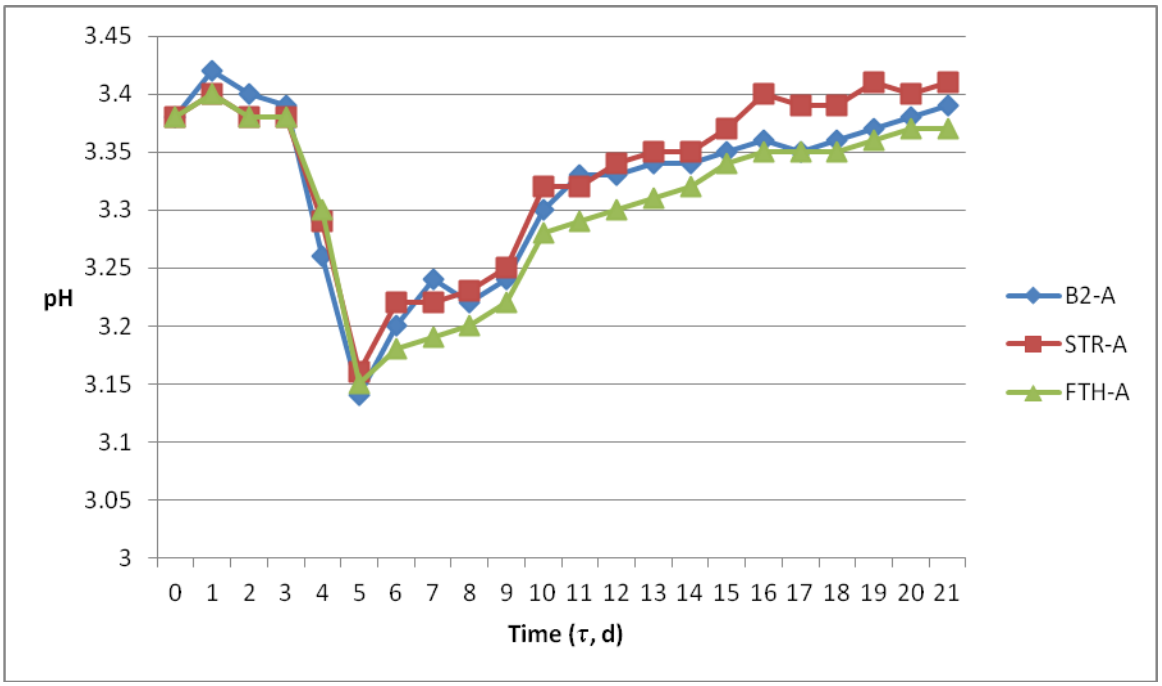

Figure 1. Changes in pH during the alcoholic fermentation of the variants of the series A.

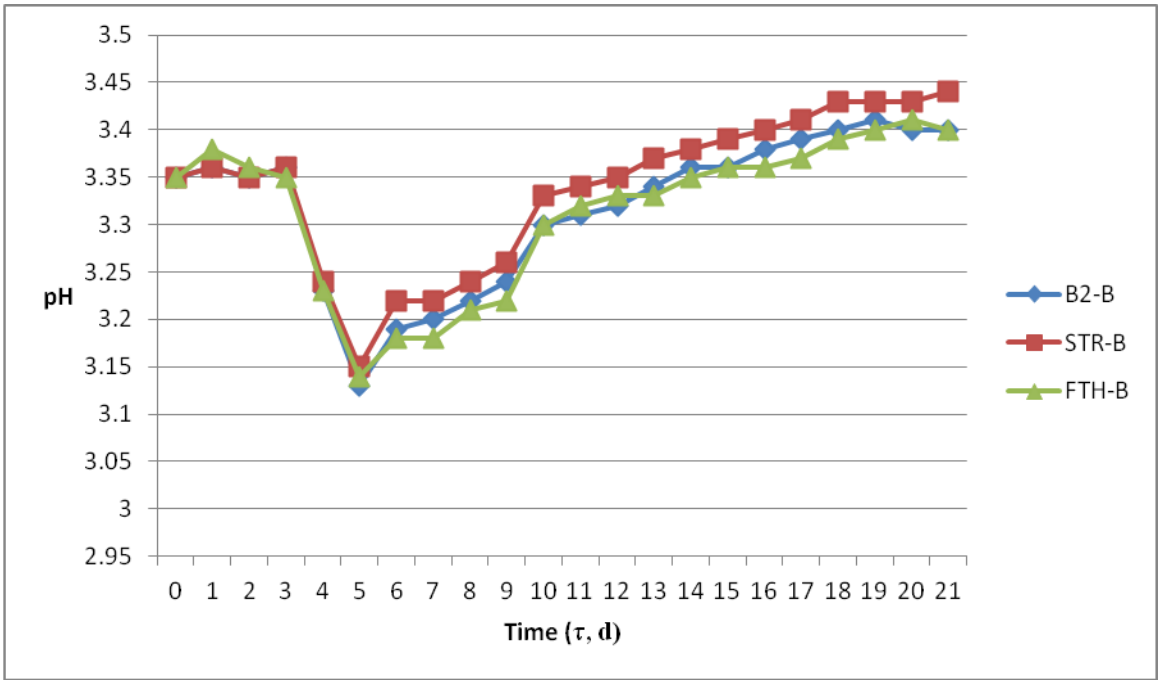

Figure 2. Changes in pH during the alcoholic fermentation of the variants of series B.

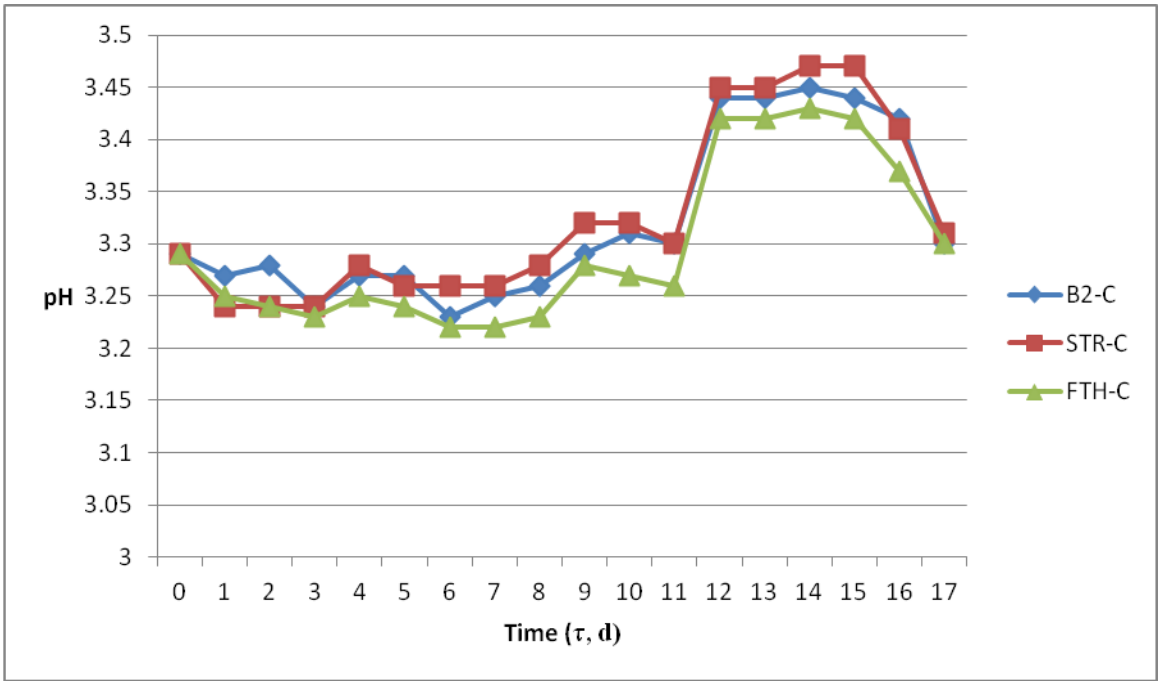

Figure 3. Changes in pH during the alcoholic fermentation of the variants of series C.

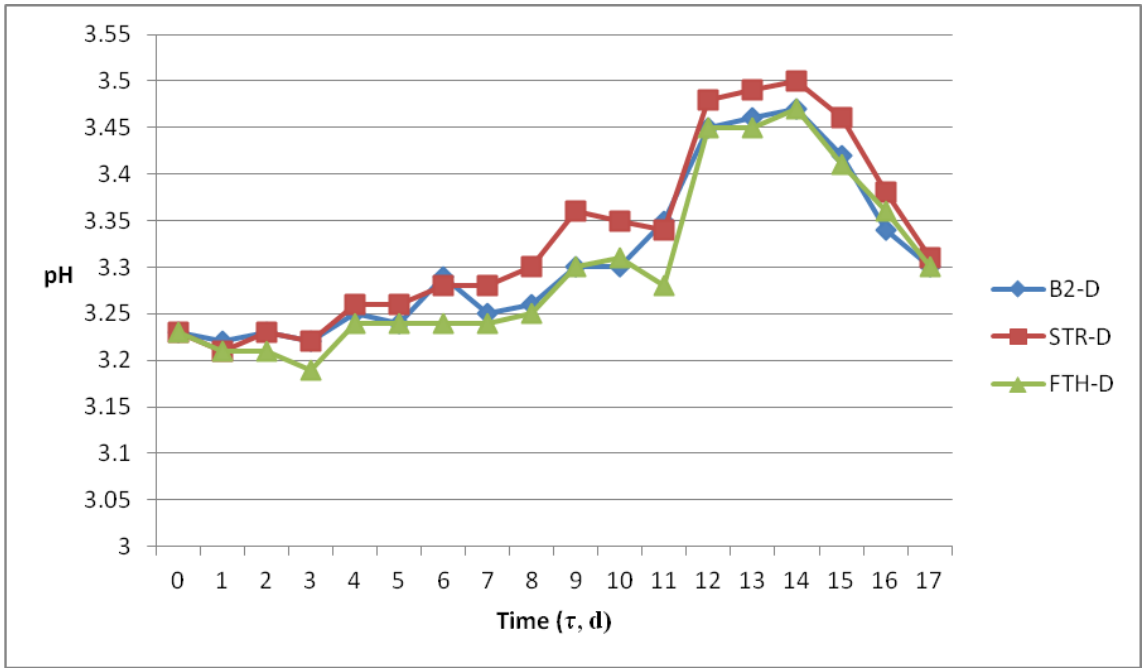

Figure 4. Changes in pH during the alcoholic fermentation of the variants of series D.

Sensory analysis

The overall aroma intensity and balance for all used strains were different and dependant on the type of yeast and the fermentation temperature. The wines variety fermented at 20°C were dominated by thiol and the typical fermentation aromas of ripe fruits. In terms of density, the wines fermented at 20°C were denser and balanced in taste, while the wines fermented at 16°C were fresher and lighter in taste. The aftertaste of the wines fermented at 20°C was voluminous, round with delicate notes of fruit, and those fermented at 16°C were light, delicate, with fruity and green notes. The wines with a higher initial sugar content were more voluminous with a fruity character, while those with a lower initial sugar were light, airy, with a strong freshness and fruity character. The wines produced with EXCELLENCE® B2 yeast were full-bodied, rounded and have a varietal profile which was preserved and strengthened to the maximum extent. They produced delicate fruit (floral) aromas and, in general, the resulting wines had a typical aroma profile.

The wines, produced with EXCELLENCE® STR yeast, were moderately dense and rounded, with an explosion of fresh and complex ester aromas. As in the wines fermented at 16°C, the leading aromas were rose (phenyl-ethyl acetate), hyacinth (phenyl-2-ethanol) and pear (hexyl acetate), while in the wines fermented at 20°C, the leading aromas were banana (isoamyl acetate) and apple. The result of using EXCELLENCE® FTH yeast was in the production of wines with roundness and sweetness and a significant sense of thiol aromas (olfactory and gustatory). Among the volatile thiols, the aromas of – boxwood (4-mercapto-4-methylpentan-2-one), citrus fruits (3-mercaptohexan-1-ol), exotic fruits, passion fruit (3-mercaptohexyl acetate), an empyreumatic aroma reminiscent of smoke (benzenemethanethiol), stood out, giving the necessary character and complexity of the wines. In general, the fermentation at low temperatures (16°C) provided more ester aromas - fresh fruit, "green" aromas, and the higher temperatures (20°C) for thiol aromas and also for fermentation tones, which partially "masked" the "green" aromas and gave the taste aromatic tones of ripe fruits.

Tracking the dynamics (kinetics) of the alcoholic fermentation for the different yeast strains has had an important scientific and

practical significance. From a scientific point of view, this is the creation of optimal conditions for its study, control and optimization, as well as the possibility of creating the so called "smart" vessels. In winemaking, the main goal is achieving the optimization of product quality (Francis et al., 2005). The basic technological control that is carried out is focused on the sugar reduction, and duration of fermentation (Sablayrolles, 2019). Nutrients affect winemaking in two directions: the first one is the rate of fermentation and the second one is the quality, the aroma of the wine. There is a direct relationship between the rate of fermentation and the concentration of absorbable nitrogen in the must (Nicolini et al., 2004). Adding ammonium salts effectively increases the rate of fermentation and decreases its duration (Agenbach, 1977), but the timing the adding is done is essential. The production of fermentation aromas is affected by the amount of nitrogen added (Bell et al., 2005), by the nature of the added nitrogen (inorganic or organic) (Torrea et al., 2011; Barbosa et al., 2012) and by the time of its addition (Barbosa et al., 2009). For balanced experimental results, a combined feed for yeasts was used and the moment of its introduction was carefully selected. It has been observed that the rate of fermentation doubled when the temperature is increased by approximately 8°C (from 15°C to 25°C) (Bely et al., 1990). A typical temperature for the fermentation of white wines is within the range of 15°C to 22°C, and the duration of fermentation is: 15°C – 22 days; 22°C – 11 days (Goelzer et al., 2009). In the current experiment, the duration of fermentation was 21 days at 16°C and 17 days at 20°C. An increase in the temperature by 4°C has resulted in approximately ¼ reduction in its duration. Low temperatures increase the production of volatile compounds (esters, etc.) by yeast during alcoholic fermentation (Torija et al., 2003; Beltran et al., 2008; Shi et al., 2022). Lower fermentation temperatures (10–15°C) can be used in order to improve the aromatic profile of wines. The results from the current study indicate that the EXCELLENCE® STR series have had a markedly more intense aroma at a fermentation temperature of 16°C in contrast to the wine fermented at 20°C. Howell et al. (2004) and Masneuf-Pomarede et al. (2006) reported that the fermentation temperature of 20°C (in Sauvignon Blanc must) resulted in significantly higher concentrations of all volatile thiols compared to the lower fermentation temperatures of 13°C, regardless of the yeast strain. The experimental results show that the samples with EXCELLENCE® FTH yeast have had a more intensive taste and olfactory aroma at a fermentation temperature of 20°C, in contrast to their equivalents fermented at 16°C. On the contrary, the wines produced with EXCELLENCE® B2 yeast retained their neutral aroma at both temperature regimes of fermentation.

In general, *Saccharomyces cerevisiae* have the ability to adapt to changes in osmotic pressure (Ingram et al., 1984). The sugar contents of 180 g/dm^3 and 220 g/dm^3 of the grape must have the greatest importance for industrial practice. From the conducted experiments, it was established that the initial sugar content of the grape must affected the dynamics of alcoholic fermentation, but not the fermentation time.

The actual acidity affects the quality of wine. It is considered that pH is strongly influenced by the presence of tartaric acid in the medium. Even though information on how pH changes affect alcoholic fermentation is available, the data is not sufficiently precise (Huberson et al., 2008). In the current experiment, the sugar content and temperature had a minimal effect on the initial and final pH of the medium, but the dynamics of the process was significantly affected by the temperature. Additional research is recommended.

CONCLUSION

The current experiment utilized the yeast from Excellence® line. It was established that the amount of sugar in the medium has had an effect only during the initial stage of alcoholic fermentation. For the variants with higher initial sugar content there was an observed delay. In the variants with a lower initial sugar content, the quiet fermentation was longer than in the variants with a higher initial sugar content. For both series of experimental variants, the alcoholic fermentation was done at the same time. The higher initial sugar content did not slow down the dynamics of alcoholic fermentation, on the contrary. At initial sugar contents (180 g/dm³ and 220 g/dm³), higher amounts of alcohol were formed in the variants at a higher fermentation temperature (20°C). The variants fermented at temperature (20°C) completed alcoholic fermentation faster than the variants fermented at temperature (16°C). The mass of the yeast lees of the variants fermented at 20°C was also higher than that of 16°C. A future research could focus on the comparison of yeasts obtained from different manufacturers. By doing simultaneous fermentation their differences can be assessed.

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