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THE INFLUENCE OF INDIGENOUS YEAST STRAINS ON THE CONCENTRATION OF PHENOLIC SUBSTANCES AND COLOR INDICES IN RED WINE CABERNET SAUVIGNON

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Abstract: This study investigates the influence of nine indigenous yeast strains on the quality of dry red wines, focusing specifically on their effect on the concentration of phenolic compounds and color indices from 2 winemaking centers in Moldova. Yeast strains isolated '21-C-S-120-P-2', '24-R-NNP-2', '29-R-N-120-P-4', and '30-R-N-120-P-5', were selected in the Purcari winemaking center and '27 -MTr-4', '32-M100Tr-1', '35-M100Tr-4', 41-C-S60Tr-2', and '43-C-S60Tr-4' were selected in the Trifeshti winemaking center significantly used in the fermentation of 'Cabernet-Sauvignon' grape must improve phenolic extraction. The results of the study showed that 2 strains significantly improved the content of phenolic compounds, in the case of strain '30-R-N-120-P-5' a concentration of 1542 $mg \cdot L^{-1}$ of total phenolic compounds and 298 $mg \cdot L^{-1}$ of anthocyanins was obtained, while strain '41-C-S60Tr-2' produced 1520 $mg \cdot L^{-1}$ phenolic compounds and 302 $mg \cdot L^{-1}$ of anthocyanins. Wines fermented with these indigenous strains were compared to a commercial control strain, 'Oenoferm Be-Red'. Both strains showed a significant increase in total phenolic compounds and color intensity, with strain '41-C-S60Tr-2' reaching the highest color intensity at 15.4. Research highlights the potential of indigenous yeast strains to increase the concentration of phenolic compounds and improve the color indices of dry red wines.

Keywords: *Cabernet Sauvignon, fermentation, marketability, phenolic extraction, sensory evaluation, wine quality*

INTRODUCTION

The fermentation process in winemaking is critical for developing the desired sensory and physicochemical attributes of the final wine. Yeast strains, particularly from the *Saccharomyces* genus, are responsible for not only the conversion of sugars into alcohol but also for influencing secondary metabolites that contribute to the wine's aroma, flavor, and stability [1, 2]. In red wine production, yeast-driven fermentation enhances the extraction and stabilization of phenolic compounds, such as anthocyanins and tannins, which are responsible for the color and astringency of the wine [3]. The enzymatic activity of yeast strains during fermentation directly catalyzes the extraction of these compounds from grape skins, contributing to the wine's structure, mouthfeel, and aging potential [4]. Research has demonstrated that specific *Saccharomyces* yeast strains not only enhance the extraction of phenolic compounds but also influence the rate and efficiency of fermentation, the production of glycerol, and the reduction of undesirable by-products such as acetic acid and acetaldehyde [5]. A key component of red wine quality is the chromatic stability, which is primarily determined by anthocyanins and their interactions with tannins [6]. The condensation reactions catalyzed by yeast enzymes during fermentation and subsequent maturation lead to the formation of stable pigment-tannin complexes, which help preserve the color over time [7]. Given that phenolic content and color are major determinants of red wine's marketability, it is essential to understand how yeast selection influences these parameters.

This study aims to investigate the impact of various selected *Saccharomyces* yeast strains on the phenolic composition, color stability, and overall quality of dry red wines produced in the Republic of Moldova. Special attention will be given to comparing the performance of local *Saccharomyces* strains with commercial strains. The results of this research could lead to improved winemaking practices and contribute to the development of quality red wines with higher maturation potential and organoleptic qualities [8, 9].

MATERIALS AND METHODS

The research was carried out in the Laboratory of Biotechnology and Wine Microbiology at the Scientific-Practical Institute of Horticulture and Food Technologies (Republic of Moldova).

Of the 9 strains, 4 yeast strains analyzed were isolated in the Purcari winemaking center ('21-C-S-120-P-2', '24-R-NNP-2', '29-R-N-120-P-4' and '30-R-N-120-P-5') and 5 others belong to the winemaking center of Trifeshti ('27-MTr-4', '32-M100Tr-1', '35-M100Tr-4', '41-C-S60Tr-2', and '43-C-S60Tr-4'). The 4 strains were used to ferment the must from the 'Cabernet-Sauvignon' variety, harvested in 2017 from the wine Cellar Purcari SRL vineyards with a technological reserve from grapes of 2916 $mg \cdot L^{-1}$ of phenolic compounds and 516 $mg \cdot L^{-1}$ of anthocyanins. The must had the following physicochemical characteristics: sugar content of 225.0 $g \cdot L^{-1}$, total acidity of 7.8 $g \cdot L^{-1}$. Similarly, 5 strains were used to ferment the must from the 'Cabernet-Sauvignon' variety, harvested in 2018 from the wine Cellar Vierul-Vin SRL vineyards with a technological reserve from grapes of 2988 $mg \cdot L^{-1}$ of phenolic compounds and 532 $mg \cdot L^{-1}$ of anthocyanins. The must had the following physicochemical characteristics: sugar content of 255.0 $g \cdot L^{-1}$, total acidity of 5.9 $g \cdot L^{-1}$. The commercial yeast strain

'Oenoferm Be-Red' (Germany), specially designed for the production of dry red wine, was used as a control.

The fermentation-maceration processes were conducted following classical technology under controlled conditions to achieve optimal extraction of phenolic compounds and anthocyanins. Analysis was then performed to determine the concentration of phenolic compounds, anthocyanins, and color indices. The fermentation temperature was maintained at approximately 28 - 30 °C, an ideal range for enhancing phenolic extraction without compromising the wine's aromatic profile. The fermentation-maceration process lasted for 10 days, ensuring the gradual extraction of phenolics and anthocyanins. The fermentation-maceration process was carried out with stirring five times daily. For experimental accuracy, no material adjuvants were added. The must yield after pressing was 70 %. The wine was left for post-fermentation at 20 °C. Upon the completion of alcoholic fermentation, analyses were performed. Non-fermented sugars after fermentation in all samples were below 4 $g \cdot L^{-1}$.

Total sugars content in the musts was determined using the areometric method according to GOST 27198-87 [10]. The mass concentration of non-fermented sugars ($g \cdot L^{-1}$) in wines was determined by the indirect titration method specified in SM GOST 13192-73 [11]. Total acidity was determined by titration with bromthymol blue as an indicator, in accordance with OIV method [12].

The technological reserve from grapes of phenolic substances and anthocyanins was determined by [13]

The phenolic compounds were quantified using the colorimetric method with the Folin-Ciocalteu reagent, as outlined by the OIV [14]. Anthocyanins were determined using a spectrophotometric method, which measures absorbance at 520 nm, following the *p*H-differentiation technique to account for changes in color under different *p*H conditions [15]. Additionally, the intensity and color hue were measured at wavelengths of 420 nm, 520 nm, and 620 nm, according to OIV standards for chromatic characteristics [16]. These methods provide a comprehensive analysis of the wine's phenolic content and color properties.

Statistical analyses were performed using a one-way analysis of variance (ANOVA) to assess the content of phenolic compounds, anthocyanins, and color indices in the wines. This analysis utilized GraphPad Prism 5.0 software and was supplemented with an online statistical calculator available at math.semestr.ru. All experiments were conducted in triplicate.

RESULTS AND DISCUSSION

The analysis of the results presented in Table 1 found that the yeast strains used during must fermentation have a significant impact on the color indices of red wines. In the case of the yeasts obtained at the winemaking center of Purcari, the highest color intensity was observed in the wine fermented with the reference strain Oenoferm Be-Red (15.0), followed by wines fermented with strains '21-C-S-120-P-2' and '30-R-N-120-P-5'. This aligns with findings by Swiegers *et al*. (2005), who highlighted that yeast selection can significantly affect wine color through its influence on anthocyanin extraction and stability [2].

Yeast strain '30-R-N-120-P-5' notably promoted the extraction of phenolic compounds, with a maximum content of phenols at 1542 mg·L^{-1} and anthocyanins at 298 mg·L^{-1}. In comparison, the red wine produced using the yeast strain 'Oenoferm Be-Red' also showed an advanced phenolic content (1513 mg·L^{-1}), but had a lower anthocyanin content (266 mg·L^{-1}) due to significant adsorption during fermentation-maceration. This phenomenon of anthocyanin adsorption is well-documented, with Ribéreau-Gayon *et al*. (2006) highlighting the critical role of yeast cell walls in retaining these color compounds throughout fermentation [3].

Wines obtained with the strains selected at Purcari '21-C-S-120-P-2', '24-R-NNP-2', and '29-R-N-120-P-4' exhibited lower phenolic content (1385-1420 mg·L^{-1}) and anthocyanins (Table 1).

Table 1. *The influence of yeast strains obtained from the two Purcari and Trifeshti winemaking centers on the content of phenolic compounds and color indices of Cabernet Sauvignon wines*

№	Yeast Strain, No.	Total Phenolic Compounds Concentration, [mg·L^{-1}]	Anthocyanin Concentration, [mg·L^{-1}]	Color Intensity, ($I=A_{420}+A_{520}+A_{620}$)	Color hue, ($N=A_{420}nm/A_{520}nm$)
Yeast strains of Purcari winemaking center					
1	Oenoferm Be-Red (control)	1513±7	266±2	15.0±0.8	0.61±0.02
2	1-C-S-120-P-2	1406±5	278±4	14.2±0.5	0.50±0.02
3	24-R-NNP-2	1385±8	284±2	13.9±0.9	0.48±0.03
4	29-R-N-120-P-4	1420±4	276±1	13.7±0.5	0.54±0.02
5	30-R-N-120-P-5	1542±3	298±3	14.6±1.1	0.57±0.05
Yeast strains of Trifeshti winemaking center					
6	Oenoferm Be-Red (control)	1496±5	275±2	14.8±0.5	0.60±0.05
7	27-MTr-4	1439±4	287±3	13.6±0.4	0.47±0.03
8	32-M100Tr-1	1442±5	292±2	13.8±0.4	0.48±0.03
0	35-M100Tr-4	1436±2	284±4	13.3±0.3	0.45±0.04
10	41-C-S60Tr-2	1520±7	302±7	15.4±0.6	0.62±0.05
11	43-C-S60Tr-4	1466±5	310±8	13.9±0.4	0.55±0.02

The analysis of the results regarding the use of selected yeasts from Trifeshti viticultural center further indicates that the yeast strains used in the fermentation of must have a significant impact on the chromatic indices of red wines.

The maximum color intensity was determined in the wine fermented using the yeast strain '41-C-S60Tr-2' (15.4), followed by the wine fermented with the control strain Oenoferm Be-Red. This result is comparable to the observations of Carew, A. et al. (2015) [17], who noted that specific yeast strains could significantly improve wine color through an increased extraction of anthocyanin.

To determine the influence of yeast strains on the phenolic and anthocyanin content in red wines, the extraction yield of these compounds was calculated relative to the technological reserve from grapes, which is 2916 mg·L^{-1} of phenolic compounds and

516 mg·L^{-1} of anthocyanins. The data obtained in the case of the strains selected from the Purcari viticultural center are presented in Figure 1.

The findings indicate that yeast strains exert a substantial impact on the phenolic content in wines. The extraction yield of phenolic compounds during the fermentation-maceration process of red wines varied between 47.5 % (strain '21-C-S-120-P-2') and 52.9 % (strain '30-R-N-120-P-5'). The highest extraction yield of anthocyanins in wine (η = 57.6 %) was found in the wine fermented with strain '30-R-N-120-P-5'. This is consistent with the findings of Jolly *et al*. (2014) [18], who reported that specific yeast strains could enhance both phenolic extraction and anthocyanin stability, significantly impacting the overall quality of the wine.

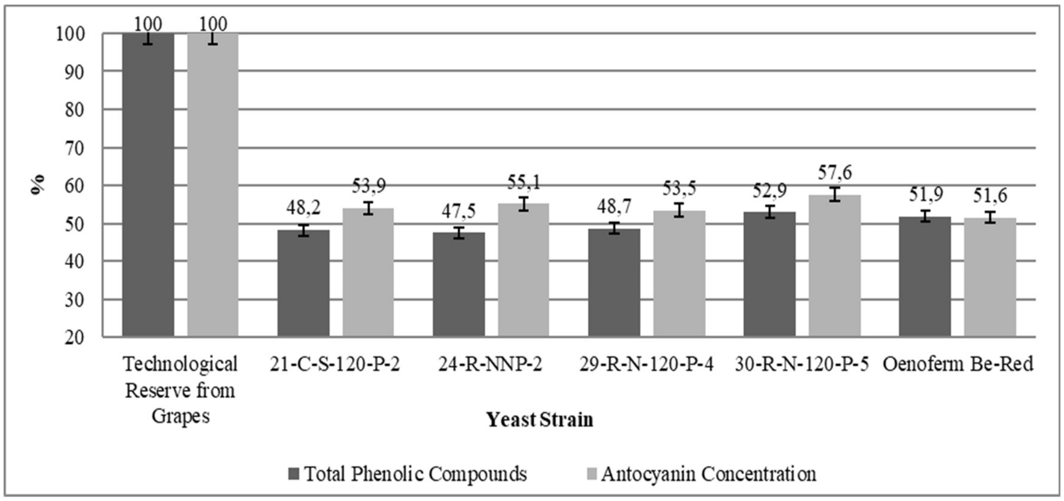

Figure 1. *Yield of phenolic compounds and anthocyanins from grapes in dry red Cabernet Sauvignon wines obtained by using selected yeast strains from the Purcari winemaking center*

The results of the yeasts selected from the Trifeshti winemaking center used in the fermentation of 'Cabernet-Sauvignon' wine show that the yeast strain '41-C-S60Tr-2' significantly enhanced the extraction of phenolic compounds, with a maximum phenolic content of 1520 mg·L^{-1}and anthocyanins of 302 mg·L^{-1}. The red wine produced using the yeast strain 'Oenoferm Be-Red' also showed an advanced content of phenolic compounds (1496 mg·L^{-1}), but had the lowest content of anthocyanins (275 mg·L^{-1}) due to significant absorption during fermentation-maceration process. This confirms findings from previous studies indicating that different strains influence the phenolic profile of wines (Belda *et al*., 2015) [19].

Wines obtained using yeast strains '27-MTr-4', '32-M100Tr-1', '35-M100Tr-4', and '43-C-S60Tr-4' exhibited approximately identical results with a lower content of phenolic compounds (1436 - 1466 mg·L^{-1}) and a moderate content of anthocyanins. To establish the influence of the yeast strain on the content of phenolic compounds and anthocyanins in red wines, the extraction yield of these compounds was calculated compared to the technological reserve from grapes, which is 2988 mg·L^{-1} of phenolic compounds and 532 mg·L^{-1} of anthocyanins. The obtained data are presented in Figure 2.

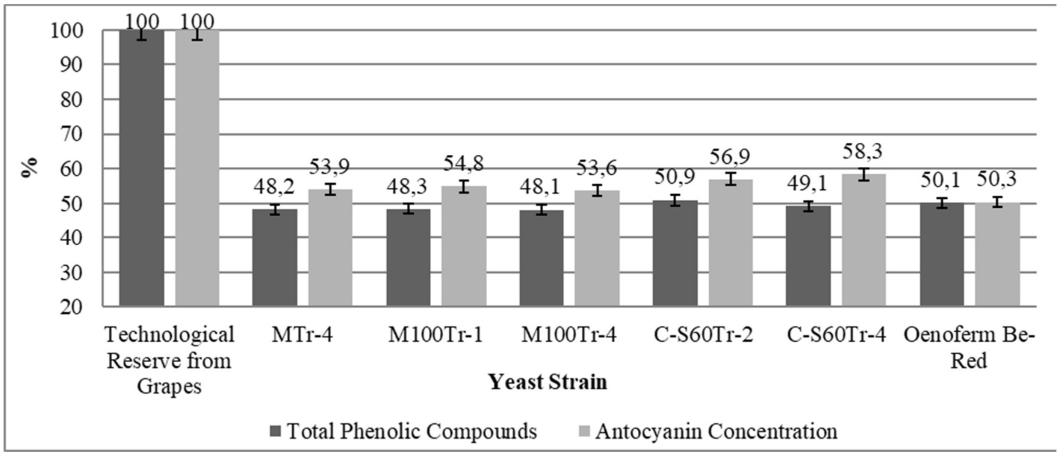

Figure 2. *Yield of phenolic compounds and anthocyanins from grapes in dry red Cabernet Sauvignon wines obtained by using selected yeast strains from the Trifeshti winemaking center*

CONCLUSIONS

The findings of this research underscore the critical role of indigenous yeast strains in enhancing the phenolic content and color stability of dry red wines. Yeast strains isolated from both Purcari and Trifeshti exhibited distinct effects on phenolic extraction, with certain strains demonstrating superior performance in increasing anthocyanin concentration and overall color intensity. The capacity of these indigenous strains to influence the wine's organoleptic qualities suggests that they can be effectively integrated into modern winemaking practices. As the wine industry seeks to produce high-quality wines that stand out in the market, leveraging local yeast diversity offers a promising avenue for enhancing both the sensory experience and the commercial value of dry red wines. Future studies should explore the broader applications of these indigenous yeast strains and their potential synergies with other winemaking techniques to further improve wine quality.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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