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Effect of fermentation temperature on polyphenolic composition and sensory properties of red Vranac wines

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Abstract: Vranac is a prevailing red wine grape variety indigenous to Montenegro accounting for 80% of the country's vineyard area. Vranac grapes are exceptionally rich in colouring matter contained mostly in the skin, flesh and juice of the berry. To date, no detailed research has been conducted to examine the technological factors that affect the polyphenolic potential of this variety. This paper presents the results of a study on the effect of three different fermentation temperatures ($T_1=22-24^\circ\text{C}$, $T_2=24-27^\circ\text{C}$ and $T_3=28-31^\circ\text{C}$) on the chemical composition, polyphenol compounds and sensory properties of Vranac wines. The test Vranac wines were prepared from the grape grown at the experimental vineyard of the Biotechnical Institute, Podgorica, in 2005. Winemaking was carried out using the traditional method. The main objective of the study was to identify the optimum temperature of fermentation to match the desired style of Vranac wine by achieving appropriate phenolic composition and typical sensory properties. In terms of both sensory and chemical characteristics, the best properties (colour, clarity, flavour and taste) were obtained in the wine produced at a fermentation temperature of 24-27°C. The wine achieved optimum sensory characteristics typical of the red wine Vranac produced in Montenegro.

Key words: Vranac wine, fermentation temperature, polyphenol compounds, sensory properties

Introduction

Polyphenol extraction during maceration gives wine its sensory properties – colour, astringency and bitterness. The phenolic compounds extracted during maceration are responsible for the characteristics of young red wines, and they play an important role during the wine maturation and ageing period. Temperature is among factors significantly affecting the extinction, colour, and the content of anthocyanins and other polyphenols released into the wine.

Red wines are fermented at temperatures ranging from 20-32°C. An optimum temperature should be adapted to both the type-style of wine to be produced and the grapevine variety used to make wine. In order to create fresh fruit aromatic wines while preventing the undesirable loss of alcohol, a relatively low temperature of 20 to 25°C is required. Higher temperatures of about 30°C enhance fermentation and facilitate the extraction of polyphenolic compounds, ensuring better flavour, taste and harmony of the wine – the typical tannic type of wines suitable for wine ageing (Ough, 1991).

In traditional wine making, Vranac is generally produced at temperatures of about 30°C, with the wine obtained being characterised by marked astringency and acerbity. Modern wine production trends involve the enhancement of the cultivar-specific aroma reflected through the fresh fruit character of the wine.

The main objective of this study was to identify the optimum temperature of fermentation to match the desired style of the Vranac red wine. The study was conducted at the Biotechnical Institute, Podgorica during 2005.

Material and methods

The experiment included grape variety Vranac. Grape harvest was conducted at the vineyard located in the trial field of the Biotechnical Institute, Podgorica, at the Lješkopolje site, in the Podgorica subregion (Region –Skadar Lake Basin, Montenegro).

The standard microvinification process was employed at the Winery of the Biotechnical Institute. Grape harvest conducted at technological maturity was followed by grape pressing and stem separation. Then, 25 l vessels were filled with pomace which was treated with 10 mg/dm³ SO₂ and inoculated with selected yeast in order to start the fermentation process. The traditional method was used. Maceration lasted 7 days. Three groups, each containing 5 samples, were prepared at different fermentation temperatures which were within the range recommended for red wine production, viz. lowest temperature T₁ (22-24°C), medium temperature T₂ (24-27°C) and highest temperature T₃ (28-31°C). Average results for the three groups of samples are presented.

The wine was racked off after a month, the second racking was performed in December, and the third in February when the wine was bottled and subjected, thereafter, to chemical analysis and tasting.

The chemical analysis of both the must and the wine i.e. determination of sugars, alcohol, extracts, pH, and total and volatile acids was performed using official enological methods (Daničić, 1988). Spectrophotometric examination involved analysis of the following polyphenolic composition of the wines: total phenolics, anthocyanins, catechins, and colour intensity and hue using the methodology described by P. Ribereau-Gayon et al. 2001. Anthocyanin content was assessed by a method described by Stonestreet (1965) and further developed by Ribereau-Gayon et al. (1972). Total phenolic content was estimated using the Folin-Ciocalteu reagent promoted by Ought and Emerine (1987). Colour intensity and hue were determined by absorbance measurement at 420, 520 and 620nm. Total catechins were determined by preparation of 3 groups of samples containing wine, HCl and vanillin; a control sample with water and a sample without vanillin, with absorbance read at 500nm.

The wines were subjected to sensory evaluation by the scoring and sensory description method. The 20-point Buxbaum method was administered by a five-member panel to evaluate wine properties. OIV Wine Descriptor Codes were used for the sensory description of the wines (O.I.V., 1983).

Results and discussion

1. Chemical composition of the grape must

Grape harvest for the analysis of the effect of the temperature factor was conducted during mid-September. The harvest was followed by grape pressing, pomace homogenisation and classification of samples into three groups. The results of the analysis of the chemical composition of the must are presented in Table 1.

Table 1: Chemical composition of the must

	Sugar g/dm ³	Total acids g/dm ³	pH	Sugar index
T ₁	193.9	5.90	3.45	32.86
T ₂	193.9	5.90	3.45	32.86
T ₃	199.8	5.90	3.45	33.86
x	195.8	5.90	3.45	33.19

Table 1 shows that the must sugar content was 193.9 g/dm³ in T₁ and T₂ and 198.9 g/dm³ in T₃. The content of total acids was 5.9 g/l in all samples. pH also showed uniform values of 3.45. The sweetness index was 32.86 in T₁ and T₂

and 33.18 in T₃. The values for the test parameters of the must chemical composition were within the expected range for Vranac grapes harvested under unfavourable weather conditions (Pajović et al. 2002).

2. Chemical composition of wine at different fermentation temperatures

Higher fermentation temperatures during the experiment enabled increased synthesis of glycerol which gives wine its specific body, and conferred a greater complexity and tannic character upon the wine. The undesirable effects of higher temperatures included lower alcohol amounts, a higher remaining sugar content, higher amounts of acetic acid, acetaldehyde and acetone, and lower ester concentrations in the wine, this being in agreement with the results of Ružić (1991).

The results on the chemical analysis of the wines obtained at different fermentation temperatures are outlined in Tab. 2. Fermentation temperature has the largest effect on the alcohol, extract and glycerol content, as clearly presented in Fig. 1.

Table. 2.: Chemical composition of Vranac wines produced at different fermentation temperatures

	Relative density	Alcohol vol%	Reduc. sugars g/l	Sugar-free extract g/l	Total acids g/l	Volatile acids	pH	Glycerol g/l	Ash g/l
T ₁	0.9948	10.6	3.5	19.05	4.83	0.40	3.36	8.67	2.192
T ₂	0.9943	11.3	2.3	21.5	4.95	0.40	3.44	9.42	2.308
T ₃	0.9977	9.60	5.5	21.7	4.79	0.65	3.36	9.52	2.656

The table shows that the alcohol content increased from 10.6 to 11.3 vol%. with increasing fermentation temperature from T₁ to T₂. The increase in fermentation temperature to T₃ induced a substantial decrease in alcohol content to 9.60 vol%, being the result of both a higher loss of alcohol due to evaporation, as reported by Ought (1990), and yeast metabolism, as described by Ružić (1991).

The sugar-free extract increased with increasing temperature, from 19.0 in T₁ to 21.5 in T₂ to 21.7 gr/l in T₃. The content of unfermented sugars was highest in T₃ samples (5.5 g/l) and within the range for dry wines of 3.5 and 2.3 g/l in T₁ and T₂ samples, respectively. The glycerol content of the wine also increased with increasing fermentation temperature, the values being 8.67 in T₁, 9.42 in T₂ and 9.52 in T₃. All parameters tested in the wines produced at different fermentation temperatures comply with the results reported by Jackson (1994) on the behaviour of these components during fermentation at increased

temperatures: a reduction in alcohol content, and an increase in glycerol and extract content. The ash content of the wines was in agreement with the extract and glycerol content, and ranged from 2.19 in T₁, 2.31 in T₂ to 2.65 g/l in T₃. The test wines were fairly uniform in total acids, their values being 4.83 in T₁, 4.95 in T₂ and 4.79 g/l in T₃. The content of volatile acids was 0.40 g/l in T₁ and T₂, and somewhat higher in T₃ – 0.65 g/l, although far below the upper limit for volatile acids in wine. As reported by Zoecklin (1990), this temperature most likely induced termination of the fermentation (due to a substantially high amount of sugar remaining in the wine) without increasing the content of volatile acids.

3. Polyphenolic composition of wines at different fermentation temperatures

A detailed knowledge of the behaviour of the colouring and tannic matter at different temperatures is an important requirement in the determination of an optimum fermentation temperature. The content of major polyphenols (anthocyanins, total polyphenols and catechins) in the wine is given in Figure 1.

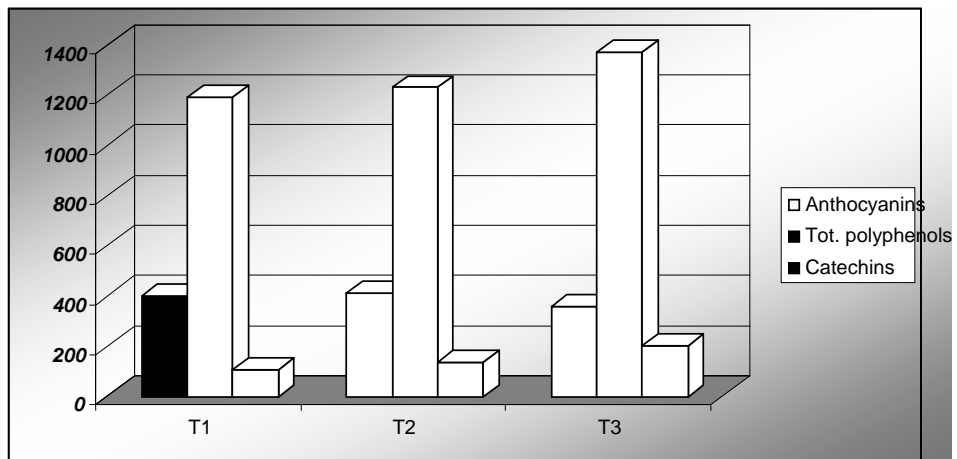


Figure 1.: Anthocyanins, total polyphenols and catechins in wines

The graph in Figure 1 shows an increase in anthocyanin content with increasing temperature, i.e. from 398.4 at T₁ to 412.2 mg/l at T₂. The anthocyanin content decreased to 356.1 mg/l at T₃. The temperature conditions during vinification at T₃ ensured rapid extraction of anthocyanins during the first two or three days. The constant temperature during the seven days of maceration most likely caused anthocyanin degradation.

Total polyphenols increased from 1,190.2 at T₁ to 1,231.0 at T₂ and 1,370.1 mg/l at T₃. Kennedy and Peynot (2003) suggest that the increase in temperature as the major parameter determining the wine polyphenol content

necessarily leads to an increase in the tannin and total polyphenol content. This complies with the results of the present study. The graph also shows that the catechin content in the wines increased from 108.0 (T₁) and 138.4 (T₂) to 200 mg/l (T₃). Since catechins are observed as potential proanthocyanidins in this study, our results are in complete agreement with the results obtained by Budić-Leto et al. (2003), who reported increased proanthocyanidin content with increasing fermentation temperature. The colour intensity to hue ratio in the test wines is graphically presented in Figure 2.

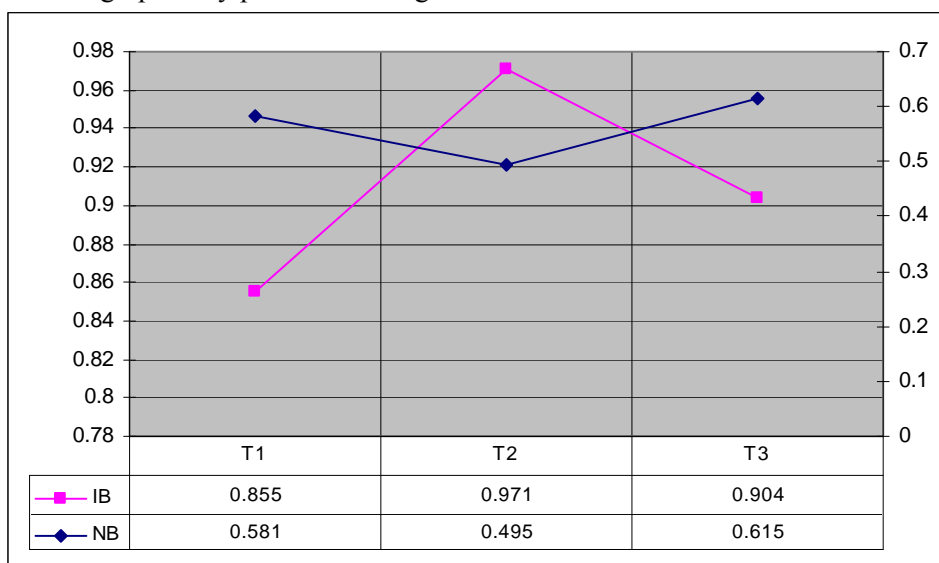


Figure. 2.: Colour intensity and hue in the test wines

The graph in Fig. 2. shows that colour intensity in the test wines increased from 0.855 (T₁) to 0.971 (T₂) with increasing fermentation temperature, but decreased with the further temperature increase to 0.904 (T₃) due to anthocyanin degradation. The colour hue of the test wines was inversely proportional to the colour intensity values: 0.495 in T₂, 0.581 in T₁ and 0.615 in T₃.

4. Sensory properties of the test wines at different fermentation temperatures

The analysis of the effect of temperature on wine quality requires evaluation of the sensory profile of the test wines. The results on the sensory properties of the wines produced at different temperatures are presented in Table 3.

Table 3.: Effect of fermentation temperature on the sensory properties of the test wines

	Colour			Clarity			Flavour			Taste			Total		
	min	max	x	min	max	x	min	max	x	min	max	x	min	max	x
T ₁	1.8	1.8	1.8	2.0	2.0	2.0	3.0	3.2	3.1	9.4	10.4	9.7	16.4	17.3	16.6
T ₂	1.8	1.8	1.8	2.0	2.0	2.0	3.0	3.3	3.3	9.7	10.8	10.2	16.6	17.8	17.3
T ₃	1.8	1.8	1.8	2.0	2.0	2.0	3.2	3.4	3.2	9.0	10.7	9.8	16.0	17.9	16.8

Table 3 shows the following wine sensory scores: the wines scored 1.8 points for colour and 2.0 points for clarity; flavour had the highest score of 3.3 in T₂ wines, and the lowest of 3.1 in T₁ wines. The highest scores for taste were obtained in T₂ wines (10.2), followed by T₁ and T₃ wines (9.8 and 9.7, respectively). The highest total score of 17.3 points was recorded for the wine that was fermented at T₂ (24-27°C), somewhat lower for T₁ wine (22-24°C) and lowest (16.6) for T₃ (28-31°C).

The test wines that underwent fermentation at different temperatures differed in their sensory properties. The wines that were fermented at T₁ were clear and red-coloured, with a medium-intensity, open, simple, fruity flavour, and light, open, simple, medium-lasting taste. The final impression: pleasant harmonious wine that loses its quality when stored. The wines that were fermented at T₂ were intensively red in colour, clear and medium aromatic, had an open fruity aroma, and balanced harmonious taste. The wines that underwent fermentation at T₃ were intensively red in colour and had a closed flavour, and tannic sweetish taste.

The results on the chemical analysis and sensory evaluation of the test wines are in agreement with the weather conditions during the year but in disagreement with the high quality commonly reached by the Vranac variety under the Podgorica Subregion conditions.

Overall, these results, along with the results on the chemical composition of the test wines, show the highest compliance with the findings of Pajović et al. (2003) who also studied the Vranac variety grown in the same subregion. The temperature observed by the authors as being the most optimum in terms of the chemical composition and polyphenolic composition of the wines ranged from 22 to 27 C°, the range being very close to the optimum temperature range of 24 to 27 C° in the present study. Budić-Leto et al. (2003) also reported an optimum fermentation temperature of 19 to 27 C° for the polyphenolic composition of the autochthonous Croatian variety Babić grown in the Primošten vine-growing region.

Conclusions

The present results on the study of the effect of fermentation temperature on the colouring matter content in the Montenegrin Vranac wine suggest the following:

An increase in fermentation temperature induced an increase in total extract, glycerol, ash and volatile acids content, and a decrease in alcohol content.

The increased fermentation temperature resulted in enhanced polyphenol extraction. The content of total polyphenols and catechins increased with increasing fermentation temperature, whereas that of total anthocyanins decreased in wine samples subjected to the highest fermentation temperature. The colour intensity and hue of wines were proportional to the wine anthocyanin content.

The results on the sensory assessment of wines produced at different temperatures show that higher scores for all wine properties (colour, clarity, flavour and taste) were obtained for samples that were fermented at medium temperature T₂ which resulted in an optimum harmony of smell, taste and aroma.

Based on the above results, the recommendation for the winemaking practice is to use the fermentation temperature of 24-27 C° for Vranac grapes. The Vranac wine produced under these temperature conditions shows the highest quality in terms of chemical composition, polyphenolic composition and sensory properties.

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UTICAJ TEMPERATURE FERMENTACIJE NA POLIFENOLNI SASTAV I SENZORNA SVOJSTVA VINA VRANAC

- originalni naučni rad -

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Rezime

U Crnoj Gori autohtona sorta vranac dominira među vinskim sortama i učestvuje u vinogradima sa oko 80%. Grožđe ove sorte je izuzetno bogato bojenim materijama. Osim u pokožici, bojene materije se nalaze i u mesu i soku bobice. Do sada nijesu detaljno istraženi tehnološki faktori koji utiču na polifenolni potencijal ove sorte.

U ovom radu su prikazani rezultati ispitivanja uticaja temperature fermentacije na sadržaj bojenih materija u vinu vranac, izvršenih u toku 2005 godine u Podgoričkom vinogorju, vinifikacijom grožđa ove sorte na različitim temperaturama. Cilj ovog istraživanja bio je utvrđivanje optimalne temperature fermentacije za proizvodnju vina vranac. Ispitivanje je rađeno sa temperaturama fermentacije koje su u opsegu preporučenih za proizvodnju crvenih vina. To su: najniža temperatura (22-24°C) označena sa T_1 , srednja temperatura (24-27°C) označena sa T_2 i najviša temperatura (28-31°C) označena sa T_3 .

Rezultati istraživanja su pokazali da su najbolja svojstva vina, sa aspekta postizanja odgovarajućeg polifenolnog sastava i njegovih tipičnih senzornih svojstava, bili kod uzoraka koji su fermentisali na temperaturi fermentacije (24-27°C).

Ključne riječi: vino vranac, temperatura fermentacije, polifenolne materije, senzorna svojstva