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Article

CHANGES IN ANTIOXIDANT ACTIVITY, PHENOLIC CONTENT AND COLOUR CHARACTERISTICS OF RED WINES FOLLOWING DEALCOHOLISATION

Claudia MURESAN[1◆], Flavia BORTES[2,3◆], Alexandru GANCEA[1], Sergiu PALCU[1], Dana Maria COPOLOVICI[1], Lucian COPOLOVICI[1,2], Andreea LUPITU[2], Cristian MOISA[2*]

[1]*Faculty of Food Engineering, Tourism and Environmental Protection, "Aurel Vlaicu" University of Arad, Romania, 2 Elena Dragoi, Arad 310330, Romania*
[2]*Institute for Interdisciplinary Research, "Aurel Vlaicu" University of Arad, Elena Dragoi St. 2, Arad, 310330, Romania*
[3]*Interdisciplinary Doctoral School of "Aurel Vlaicu" University of Arad, Elena Dragoi St. 2, Arad, 310330, Romania*
◆These authors have contributed equally.
Corresponding author email: moisa.cristian@yahoo.com

Abstract: *The increasing interest and demand for low-alcohol and alcohol-free beverages has encouraged wine producers to invest in the development of processes able to reduce ethanol content while preserving the main characteristics of wine. This study evaluated the effect of dealcoholisation by rotary evaporation under reduced pressure on the antioxidant, phenolic and chromatic properties of two experimental red wine blends, designated as Rubra Nova and Armony. Antioxidant activity was determined by the DPPH assay, total phenolic content by the Folin–Ciocâlteu method, while colour characteristics and visible absorption profiles were evaluated by UV–Vis spectrophotometry. Dealcoholisation caused only a slight decrease in DPPH radical inhibition in both wines, while total phenolic content showed a small increase. More evident changes were observed in the chromatic parameters, particularly in colour intensity and hue. However, the overall shape of the UV–Vis spectra remained similar before and after treatment. These results indicate that rotary evaporation under reduced pressure largely preserved the antioxidant and phenolic characteristics of the analysed wines, although some minor changes in their colour properties were observed.*

Keywords: dealcoholised wine; rotary evaporation; antioxidant activity; total phenolic content; chromatic characteristics.

INTRODUCTION

Wine is conventionally defined as the product obtained exclusively through the partial or complete alcoholic fermentation of fresh grapes, either crushed or not, or grape must. Both the International Organisation of Vine and Wine and the European Union regulatory framework establish a minimum actual alcoholic strength of 8.5% vol. for products classified as wine (EU Regulation No 1308/2013, 2013; Kumar et al., 2024; Wine, 2026).

Wine, and particularly red wine is known for being a complex mixture of phenolic compounds, flavonoids, anthocyanins (El Rayess et al., 2024; Muñoz-Bernal et al., 2023), all which contribute to its antioxidant properties, colour and flavour, while several studies associate light-moderate drinking of red wine with the possibility of reducing the risk of cardiovascular diseases (Baxevanis and Kanellos, 2024; Cândido et al., 2026; Castaldo et al., 2019; Monagas et al., 2005).

In recent years, interest in low-alcohol and alcohol-free beverages (beer, wine) has increased considerably, mainly due to changing consumer preferences toward products perceived as more compatible with a healthy lifestyle and moderate alcohol consumption (Catarino and Mendes, 2011; Desk, 2026; Oshima et al., 2022). In Great Britain an increase in the consumption of alcohol-free drinks was observed from 35.0% to 43.9% during 2020 and 2024, and from 25.5% to 38.8% in the attempt to cut down on overall alcohol consumption (Buss et al., 2025).

Demand for these products is also supported by consumers who try to limit or avoid alcohol for health, safety, religious, or other lifestyle reasons, as well as by the need for responsible behaviour in situations such as driving (Kumar et al., 2024; Piornos et al., 2020;

Ruggeri et al., 2026). In this context, dealcoholised wines represent a growing product category aimed at preserving, as closely as possible, the sensory and compositional characteristics of conventional wine while reducing its ethanol content. Some alternatives available to wine producers for obtaining low-alcohol wines include pre-fermentation strategies, such as using grapes with a lower sugar content or reducing the concentration of fermentable sugars in the must by dilution, as well as fermentation-stage approaches, such as interrupting fermentation or using selected or modified yeast strains. Although these methods can effectively reduce ethanol formation, they may negatively affect the sensory characteristics of the final product. Consequently, post-fermentation techniques, including reverse osmosis, osmotic distillation, vacuum distillation, spinning cone column, pervaporation, and diafiltration, are often preferred when the aim is to obtain dealcoholised wines while preserving overall product quality (Akhtar et al., 2025).

In parallel with these consumer-driven trends, recent climate changes and overall increase of annually temperatures, especially during grape ripening season, can result in a higher sugar accumulation in grapes and therefore lead to wines with a higher alcohol content (Parker et al., 2020), further increasing the interest in alcohol-reduction technologies.

In this context, evaluating the effect of dealcoholisation on wines produced from traditional Romanian grape varieties may provide useful information on the preservation of their phenolic and chromatic characteristics.

Therefore, the aim of this study was to investigate the effect of dealcoholisation by rotary evaporation under reduced pressure on the antioxidant activity, total phenolic content, and chromatic characteristics of red wines, with particular emphasis on the preservation of these properties after ethanol removal.

MATERIALS AND METHODS

Wine samples and abbreviations

Two experimental red wine blends, designated as Armony and Rubra Nova, were prepared for this study from local commercially available wines. They were produced as a blend of Cadarcă and Fetească Neagră grapes in the following proportions: 50-50 for Armony and 20-80 for Rubra Nova.

Cadarcă is a traditional red grape variety strongly associated with the Miniș wine-growing region, producing wines typically characterized by a ruby-red colour and distinctive aroma and flavour (Geza et al., 2023), while Fetească Neagră is an autochthonous Romanian variety known for producing deeply coloured wines with a rich phenolic profile and good anthocyanin content (Yao et al., 2026).

Each blend was analysed both in its original form and after dealcoholisation by rotary evaporation under reduced pressure.

Table 1. Abbreviations

Wine name	Original wine	Dealcoholised wines
Rubra Nova	RN	RND
Armony	A	AD

Dealcoholisation by rotary evaporation

Dealcoholisation of both wine blends was performed using a rotary evaporator equipment IKA RV 10 controller and HB 10 heating bath (IKA-Werke GmbH & Co. KG, Staufen, Germany). The samples were processed using the automatic distillation mode with ethanol selected as solvent, a rotation speed of 100 rpm, a heating bath temperature of 60 °C, and an automatically regulated vacuum. The distillation was continued until the automatic endpoint was reached. After dealcoholisation, the samples were restored to their initial volume using distilled water.

Antioxidant activity

The antioxidant activity of the samples was determined using the DPPH radical scavenging assay, according to the method described by (Moisă et al., 2018), with minor modifications. Briefly, 100 μL of wine sample was mixed with 3 mL of freshly prepared 0.2 mM DPPH solution in ethanol and incubated in the dark for 30 minutes at room temperature. Absorbance was measured at 517 nm using a Specord 200 UV-Vis spectrophotometer (Analytik Jena, Germany). The antioxidant activity was expressed as DPPH radical inhibition (%) and was calculated as follows:

$$\text{DPPH inhibition (\%)} = [(A_0-A_s)/A_0] \times 100$$

Where A_0 is the absorbance of the DPPH solution and A_s is the absorbance of the sample.

Total phenolic content

The total phenolic content (TPC) of the wine samples was determined using the Folin-Ciocâlteu method described by (Moisă et al., 2018), with minor modifications. Briefly, 1 mL diluted wine sample 1:25 with distilled water, was mixed with 0.5 mL Folin-Ciocâlteu reagent, 2 mL of 20% Na_2CO_3 solution, and 5 mL of distilled water. The mixture was incubated for 45 minutes at room temperature in the dark, and the absorbance was measured at 765 nm using a Specord 200 UV-Vis spectrophotometer (Analytik Jena, Germany). Total phenolic content was calculated using a gallic acid calibration curve and expressed as mg gallic acid equivalents per liter (mg GAE/L).

UV-Vis spectral and chromatic characteristics of wine

The UV-Vis spectra of the original and dealcoholised wine samples were recorded in the 400-650 nm range using a Specord 200 UV-Vis spectrophotometer (Analytik Jena, Germany). The resulting spectra were overlaid to evaluate changes in the absorption profile following dealcoholisation.

The chromatic characteristics were determined spectrophotometrically according to the method described by (Glories, 1984) and subsequently applied in wine colour studies (Gambuti et al., 2022). The absorbance was measured at 420, 520 and 620 nm using a UV-Vis spectrophotometer. Colour intensity (CI) was calculated as the sum of the absorbance values at the three wavelengths (A420 + A520 + A620), while hue was expressed as the A420/A520 ratio. The relative contributions of the yellow, red and blue components were calculated as percentages of the total colour intensity. The dA% parameter that represents the contribution of the red component associated with flavylium forms of free and combined anthocyanins, was calculated according to Glories method.

RESULTS AND DISCUSSIONS

The impact of dealcoholisation by rotary evaporation was assessed by comparing each dealcoholised wine with its corresponding original sample in terms of antioxidant activity, total phenolic content and chromatic characteristics (Figure 1).

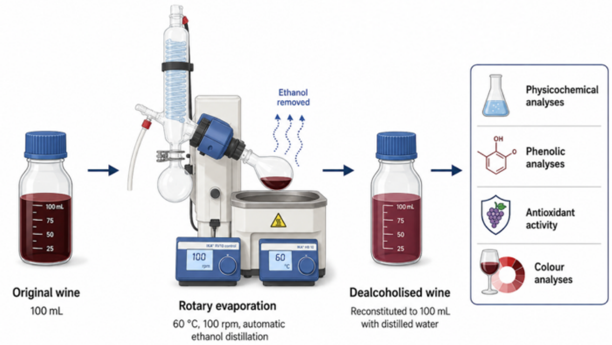

Figure 1. Schematic representation of the experimental workflow used for wine dealcoholisation and analysis (image generated using AI)

Antioxidant activity and phenolic content

Antioxidant activity, expressed as DPPH radical inhibition, remained high in all analysed samples, with values ranging from 83.04 to 87.08% (Table 2). Following dealcoholisation, only a slight decrease was observed for both wines, from 87.08% to 86.40% in Rubra Nova and from 83.77% to 83.04% in Armony. In contrast, total phenolic content showed a slight increase after treatment, from 1723.40 to 1743.59 mg GAE/L for Rubra Nova and from 2373.78 to 2425.80 mg GAE/L for Armony (Table 2). Overall, Armony exhibited a higher phenolic content than Rubra Nova, whereas Rubra Nova showed slightly higher DPPH radical inhibition.

Table 2. DPPH radical inhibition and total phenolic content of original and dealcoholised wines

Sample	DPPH Inhibition (%)	TPC (mg GAE/L)
RN	87.08 ± 0.14	1723.40 ± 7.24
RND	86.40 ± 0.10	1743.59 ± 5.58
A	83.77 ± 0.36	2373.78 ± 27.74
AD	83.04 ± 0.34	2425.80 ± 3.12

Values are expressed as mean ± SEM (n = 3).

According to (Belisario-Sánchez et al., 2009) the antioxidant activity expressed as DPPH radical inhibition remained high and was similar after dealcoholisation with minor decreases observed for the analysed samples. In the present study, the same variations were observed after rotary evaporation: both wine blends preserved their antioxidant capacity with minor decreases under 1%. In the case of phenolic compounds, several studies (Belisario-Sánchez et al., 2009; Motta et al., 2017) present a slight increase in total phenolic content after dealcoholisation, an effect associated with ethanol removal and a part of the volatile fraction.

These results suggest that rotary evaporation had only a limited effect on the antioxidant capacity of the wines, while the small increase in total phenolic content (20-50 mg GAE/L) may be related to changes in sample concentration or matrix composition during dealcoholisation or even variations of the Folin–Ciocâlteu assay.

UV-Vis spectral and chromatic characteristics of wine

The chromatic parameters showed clear differences between the two wines and between the original and dealcoholised samples (Figure 2). Armony exhibited a higher colour intensity than Rubra Nova both before and after dealcoholisation. Following rotary evaporation, colour intensity increased from 1.6342 to 2.0281 in Rubra Nova and from 3.3222 to 3.9553 in Armony, corresponding to increases of approximately 24% and 19%, respectively (Table 3). Changes were also observed in the relative contribution of the individual colour components. In Rubra Nova, dealcoholisation slightly increased the red component from 44.55% to 45.61% and dA from 61.89% to 66.15%, while hue decreased from 1.0032 to 0.9348 (Table 3). In contrast, Armony showed a decrease in the relative red contribution from 48.22% to 44.51% and in dA from 69.53% to 65.36%, accompanied by an increase in hue from 0.8417 to 0.9696. The blue component increased slightly after dealcoholisation in both wines.

Previous studies on dealcoholised wines observed a colour increase for red wines subjected to vacuum distillation, literature data indicating an increase ranging between 17 to 98%, depending on the type of wine and processing conditions. This behaviour was mainly attributed to concentration effect associated with ethanol removal (Motta et al., 2017; Sam et al., 2021). More recently, (Kumar et al., 2025) reported an increased colour intensity in red dealcoholised wine. The increases observed in the present study, approximately 24% for Rubra Nova and 19% for Armony fall within the range previously reported for dealcoholised wines.

For hue differences, a slight decrease is reported (Kumar et al., 2024), Rubra Nova has a similar trend while Armony presented the opposite behaviour. These differences indicate that the initial pigment composition and wine matrix are important.

Table 3. Chromatic characteristics of original and dealcoholised red wines determined by the Glories method.

Sample	Colour intensity	Hue	Yellow (%)	Red (%)	Blue (%)	dA (%)
RN	1.6342	1.0032	44.70	44.55	10.75	61.89
RND	2.0281	0.9348	42.64	45.61	11.75	66.15
A	3.3222	0.8417	40.58	48.22	11.20	69.53
AD	3.9553	0.9696	43.16	44.51	12.32	65.36

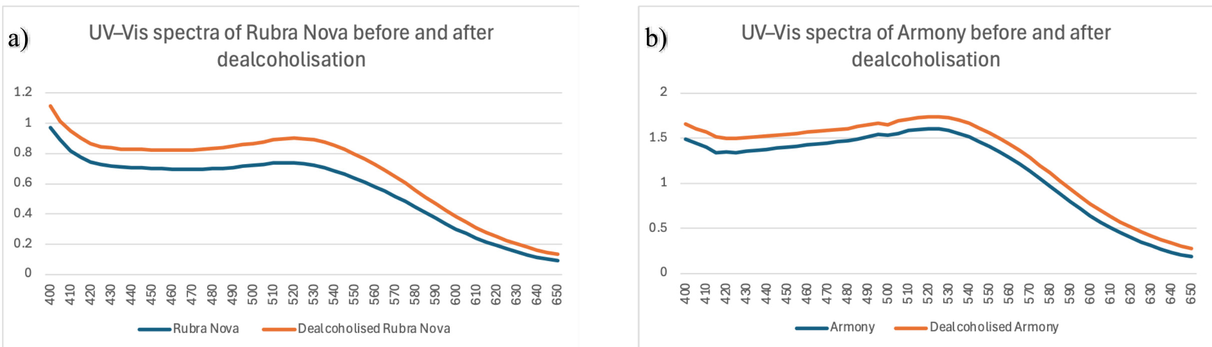

Figure 2. UV–Vis absorption spectra of red wines before and after dealcoholisation: (a) Rubra Nova; (b) Armony

The chromatic changes observed after dealcoholisation were also reflected in the UV–Vis spectral profiles (Figure 2). In both wines, the dealcoholised samples showed higher absorbance over most of the 400–650 nm range, while the overall shape of the spectra remained similar to that of the corresponding original wines. This behaviour is consistent with the increase in colour intensity calculated using the Glories parameters and suggests that dealcoholisation mainly affected the scale of visible absorption rather than producing major changes in the overall spectral profile.

CONCLUSIONS

Dealcoholisation by rotary evaporation under reduced pressure had a limited effect on the antioxidant properties of the analysed red wine blends. DPPH inhibition showed only a slight decrease, while total phenolic content slightly increased after treatment. More evident changes were observed in the chromatic parameters, particularly in colour intensity and hue, with the magnitude and direction of some changes depending on the wine blend. Nevertheless, the overall UV–Vis spectral profiles remained similar before and after dealcoholisation. Overall, within the parameters evaluated in this study, rotary evaporation under reduced pressure largely preserved the antioxidant and phenolic characteristics of the wines, while inducing moderate and wine-dependent changes in their colour properties.

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