

Effect of pre-fermentative addition of oenological tannins on the volatile composition and colour characteristics of white wines

Negin Seif zadeh^{1,*}, Maria Alessandra Paissoni^{1,2}, Micaela Boido¹, Giorgia Botta^{1,} Domen Škrab¹, Carlo Montanini³, Simone Giacosa^{1,2}, Luca Rolle^{1,2}, Susana Río Segade^{1,2} 1. Department of Agricultural, Forest and Food Sciences, University of Turin, Corso Enotria 2/C, 12051 Alba, Italy 2. Interdepartmental Centre for Grapevines and Wine Sciences, University of Turin, Corso Enotria 2/C, 12051 Alba, Italy 3. AEB S.p.A., Via Vittorio Arici 104, 25134 Brescia, Italy * Corresponding author. Email:negin.seifzadeh@unito.it

Introduction

In wine, aroma perception is shaped by complex interactions between volatile and non-volatile components. Among the latter, oenological tannins (OETs) are commonly added during winemaking for their antioxidant and stabilizing properties, making them an interesting alternative to traditional chemical preservatives such as SO₂. Furthermore, OETs can modulate the volatility of aroma compounds. Therefore, this study investigates whether the prefermentative addition of OETs can influence the color characteristics and volatile



- Total polyphenols (TPI) and antioxidant activity (DPPH method)
- Color (CIELab and Abs 420 nm) (De Paolis et al., 2025)
- Volatile composition by HS-SPME-GC-MS (Slaghenaufi et al., 2018)

Results

Table 1_Physico-Chemical parameters of Favorita juice after OETs addition (PO) and at the end of alcoholic fermentation (P3). Sign: ***, p<0.001. Samples were grouped according Tukey HSD (Latin letters). EC: (-) epicatechine

P0	TPI	DPPH	т *	*	L*	Also 420mm	неу
Treatment	(mg EC/L)	(mMol Trolox/L)	L	a	D.,	ADS 4201M	ПЕЛ
СТ	399 ± 10 d	0.68 ± 0.07 d	96.22 ± 0.27 b	0.16 ± 0.10 c	9.57 ± 0.27d	$0.145 \pm 0.005 \text{ c}$	
GL	571 ± 5 a	$1.23 \pm 0.07 \text{ bc}$	96.78 ± 0.15 a	-0.47 ± 0.12 e	9.88 ± 0.42 d	0.146 ± 0.005 c	
EL	547 ± 4 bc	1.38 ± 0.10 ab	95.5 ± 0.08 cd	-0.20 ± 0.01 d	12.09 ± 0.03 c	$0.191 \pm 0.001 \text{ b}$	
AC	542 ± 1bc	1.55 ± 0.05 a	94.28 ± 0.23 f	0.55 ± 0.04 a	14.94 ± 0.44 a	0.218 ± 0.007 a	
QB	540 ± 3 c	1.06 ± 0.10 c	95.04 ± 0.11 de	0.49 ± 0.01 ab	13.43 ± 0.12 b	0.193 ± 0.003 b	
SK	564 ± 12 ab	1.45 ± 0.09 ab	94.94 ± 0.04 e	0.20 ± 0.03 c	14.45 ± 0.04 a	0.206 ± 0.001 a	
SD	564 ± 10 ab	1.47 ± 0.10 a	95.75 ± 0.20 c	$0.30 \pm 0.07 \text{ bc}$	13.04 ± 0.34 b	$0.185 \pm 0.003 \text{ b}$	
	***	***	***	***	***	***	

P3	TPI	DPPH	L*	a*	b*	Abs 420nm	HEX
Treatment	(mg EC/L)	(mMol Trolox/L)					
СТ	424 ± 5 d	$0.62 \pm 0.03 \text{ e}$	97.91 ± 0.14 a	-0.65 ± 0.13 b	6.42 ± 0.36 d	0.093 ± 0.005 c	
GL	488 ± 1 c	0.93 ± 0.03 cd	97.87 ± 0.09 ab	-0.57 ± 0.09 ab	6.52 ± 0.05 cd	$0.094 \pm 0.002 \text{ bc}$	
EL	502 ± 1 bc	0.98 ± 0.01 bc	97.57 ± 0.24 ab	-0.74 ± 0.09 b	7.40 ± 0.21 ab	$0.111 \pm 0.004 \text{ b}$	
AC	$505 \pm 9 b$	1.02 ± 0.03 ab	97.02 ± 0.34 c	-0.37 ± 0.17 a	8.11 ± 0.63 a	0.120 ± 0.012 a	
QB	515±7 b	0.87 ± 0.02 d	97.40 ± 0.17 bc	-0.66 ± 0.10 b	7.29 ± 0.23 abc	0.109 ± 0.006 ab	
SK	501 ± 2 bc	1.09 ± 0.02 a	97.64 ± 0.14 ab	-0.50 ± 0.05 ab	6.94 ± 0.10 bcd	$0.100 \pm 0.003 \text{ bc}$	
SD	532 ± 9 a	1.11 ± 0.07 a	97.55 ± 0.08 ab	-0.46 ± 0.11 ab	7.46 ± 0.16 ab	0.108 ± 0.003 ab	
	***	***	***	***	***	***	

After the addition, OETs increased uniformly the juice TPI values according to the dose used, while DPPH values varied depending on the tannin formulation. After fermentation, SK and SD samples exhibited the highest antioxidant activity in both varieties. In terms of colour, AC induced the most pronounced shift at PO, with a decrease in lightness (L*) and a notable increase in yellow/blue component (b*). However, colour differences among treatments became visually less marked at the end of fermentation (P3) (Tables 1 and 2). Table 2_Physico-Chemical parameters of Erbaluce juice after OETs addition (PO) and at the end of alcoholic fermentation (P3). Sign: ***, p<0.001. Samples were grouped according Tukey HSD (Latin letters). EC: (-) epicatechine

P0	TPI	DPPH	Т *	-*	1.*	Also 120mm	LIEV
Treatment	(mg EC/L)	(mMol Trolox/L)	L.	a	D	ADS 420nm	пел
СТ	756 ± 5 c	$1.11 \pm 0.04 \text{ d}$	95.19 ± 0.08 a	-0.27 ± 0.05 d	17.63 ± 0.10 d	0.261 ± 0.001 d	
GL	901 ± 1 ab	$1.47 \pm 0.04 \text{ c}$	95.07 ± 0.18 a	-0.25 ± 0.08 d	17.53 ± 0.13 d	0.262 ± 0.003 d	
EL	909 ± 2 a	$1.62 \pm 0.01 \text{ b}$	93.92 ± 0.03 b	-0.23 ± 0.02 d	20.34 ± 0.10 b	0.321 ± 0.002 abc	
AC	890 ± 20 ab	1.75 ± 0.08 a	92.72 ± 0.43 c	0.77 ± 0.19 a	21.09 ± 0.59 a	0.331 ± 0.012 a	
QB	880 ± 5 b	$1.62 \pm 0.01 \text{ b}$	93.08 ± 0.10 c	$0.30 \pm 0.06 \text{ c}$	19.72 ± 0.08 c	0.311 ± 0.002 c	
SK	907 ± 2 a	1.86 ± 0.03 a	93.78 ± 0.09 b	$0.34 \pm 0.07 \text{ bc}$	20.78 ± 0.03 ab	0.314 ± 0.002 ab	
SD	899 ± 6 ab	1.80 ± 0.04 a	92.80 ± 0.16 c	$0.52 \pm 0.02 \text{ b}$	20.53 ± 0.12 ab	0.324 ± 0.002 ab	
	***	***	***	***	***	***	

P3	TPI	DPPH	L*	a*	b*	Abs 420nm	HEX
Treatment	(mg EC/L)	(mMol Trolox/L)					
СТ	643 ± 2 d	0.90 ± 0.03 c	96.84 ± 0.12 a	-1.15 ± 0.13 cd	9.27 ± 0.19 f	0.146 ± 0.003 f	
GL	702 ± 3 c	$1.23 \pm 0.02 \text{ b}$	96.70 ± 0.12 a	-1.32 ± 0.10 d	9.66 ± 0.11 e	$0.155 \pm 0.002 \text{ e}$	
EL	715 ± 2 b	$1.23 \pm 0.06 \text{ b}$	94.97 ± 0.10 bc	-0.94 ± 0.11 bc	11.66 ± 0.07 bc	$0.199 \pm 0.002 \text{ bc}$	
AC	722 ± 2 ab	$1.21 \pm 0.01 \text{ b}$	94.61 ± 0.11 c	-0.81 ± 0.18 b	11.84 ± 0.27 b	$0.205 \pm 0.007 \text{ b}$	
QB	717 ± 3 b	$1.23 \pm 0.02 \text{ b}$	95.11 ± 0.16 b	-0.97 ± 0.15 bcd	11.36 ± 0.15 cd	0.194 ± 0.005 cd	
SK	727 ± 4 a	1.39 ± 0.02 a	95.29 ± 0.19 b	-0.74 ± 0.10 b	10.94 ± 0.12 d	0.183 ± 0.005 a	
SD	727 ± 7 a	1.35 ± 0.03 a	92.27 ± 0.15 d	-0.35 ± 0.16 a	14.00 ± 0.04 a	0.261 ± 0.003 b	
	***	***	***	***	***	***	







Figure 1_ Free VOCs of Favorita wine during fermentation, expressed as µg/L 2-octanol Sign: *** p<0.001, ** p<0.01, * p<0.05. Samples were grouped according Tukey HSD among treatments.

Terpenes α -Terpinolene

Hotrienol Nerol Geraniol β-Citronellol Norisoprenoids Farnesol β-Damascenone Vitispirane Alcohols 2-Methyl-1-propanol (Isobutanol) 3-Methyl-1-butanol (Isoamyl alcohol 3-Methyl-1-pentanol* 1-Hexanol 2-Phenylethanol (Phenylethyl alcohol) 2-Ethyl-1-hexanol* Esters Ethyl butanoate Ethyl 4-hydroxybutanoate Ethyl hexanoate (Ethyl caproate) Ethyl (E)-2-octenoate Ethyl octanoate (Ethyl caprylate) Ethyl nonanoate Ethyl 9-decenoate Ethyl decanoate (Ethyl caprate) Ethyl dodecanoate (Ethyl laurate) Ethyl 3-hydroxydodecanoate Ethyl tetradecanoate 3-Methylbutyl hexanoate (Isoamyl hexanoate) 3-Methylbutyl octanoate (Isoamyl octanoate) 2-Phenylethyl 2-methylpropanoate 2-Phenylethyl hexanoate (Phenethyl hexanoate) 2-Phenylethyl octanoate (Phenethyl octanoate) Ethyl acetate 3-Methylbutyl acetate (Isoamyl acetate) Hexyl acetate 2-Phenylethyl acetate (Phenethyl acetate) Octyl acetate 2-Ethylhexyl acetate Acids Hexanoic acid (Caproic acid) Octanoic acid (Caprylic acid) Nonanoic acid 9-Decenoic acid Decanoic acid (Capric acid) Dodecanoic acid (Lauric acid) Ketones 2-Octanone Higher Lower



With respect to the volatile composition, Favorita was more responsive to tannin addition. QB increased total VOCs at the end of fermentation (P3), particularly esters, higher alcohols and volatile acids compared to control, and helped to better preserve norisoprenoids (Figure 1 and 3). In Erbaluce, the effects of OETs addition were less pronounced and significant differences were not found for total VOCs. (Figure 2 and 4). These findings demonstrate that aroma modulation is both tannin and grape variety dependent.

Figure 2_Free VOCs of Erbaluce wine during fermentation, expressed as µg/L 2-octanol Sign: *** p<0.001, ** p<0.01, * p<0.05. Samples were grouped according Tukey HSD among treatments.

> Benzenoids Benzyl alcohol Methyl 2-hydroxybenzoate (Methyl salicylate) Alcohols 2-Methyl-1-propanol (Isobutanol) 3-Methyl-1-butanol (Isoamyl alcohol) 1-Hexanol 2-Phenylethanol (Phenylethyl alcohol) 2-Ethyl-1-hexanol Esters Ethyl butanoate Ethyl hexanoate (Ethyl caproate) Ethyl octanoate (Ethyl caprylate) Ethyl nonanoate Ethyl 9-decenoate Ethyl decanoate (Ethyl caprate)* 3-Methylbutyl decanoate (Isoamyl decanoate) 2-Phenylethyl hexanoate (Phenethyl hexanoate) Ethyl acetate 3-Methylbutyl acetate (Isoamyl acetate) Hexyl acetate 2-Phenylethyl acetate (Phenethyl acetate) Acids Hexanoic acid (Caproic acid) Octanoic acid (Caprylic acid) Nonanoic acid 9-Decenoic acid Decanoic acid (Capric acid) Dodecanoic acid (Lauric acid)









Figure 3_ Heatmap visualisation of free volatile compounds of Favorita wine at P3 (µg/L). Sign: *** p<0.001, ** p<0.01, * p<0.05. Samples were grouped according Tukey HSD (Latin letters) among treatments.

Conclusion

The pre-fermentative addition of oenological tannins modulated the volatile profile of white wines, particularly in Favorita variety. The effect was influenced by both the tannin type and the grape variety. Certain tannin formulations, such as QB, showed promising potential for enhancing aromatic complexity without significantly affecting wine colour. These findings suggest that the aroma modulation is not only influenced by antioxidant capacity and further support the use of oenological tannins as a valuable enological tool.

Figure 4_ Heatmap visualisation of free volatilecompounds of Erbaluce wine at P3 (μg/L).Sign: ** p<0.01, * p<0.05. Samples were grouped according Tukey</td>HSD (Latin letters) among treatments .

References

Higher Lower

OIV . (2021). Organisation Internationale de la Vigne et du Vin, Dijon, France.

De Paolis, et al. (2025). Food Chemistry, 465, 142058. Morakul, et al. (2010). J. Agric. Food Chem., 58, 10219–10225. Slaghenaufi et al. (2018). Frontiers in Chemistry, 6, 66.