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

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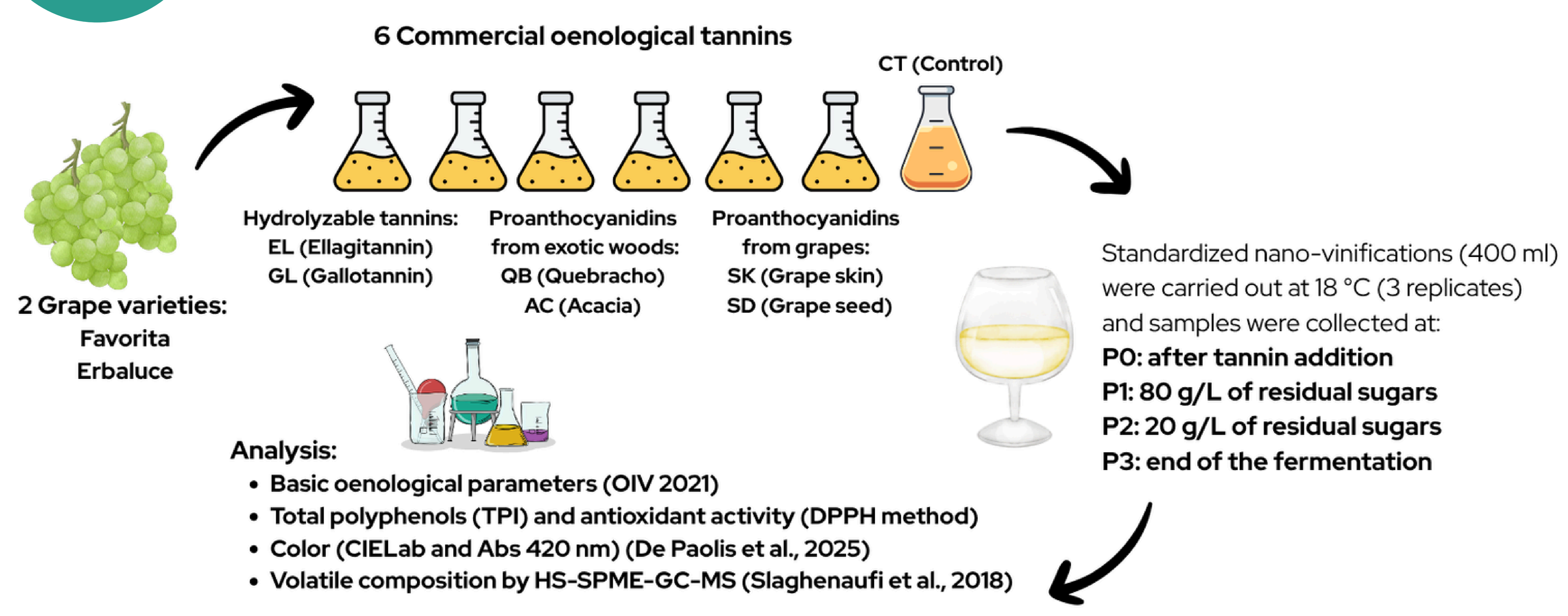
Introduction

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 SO_2. Furthermore, OETs can modulate the volatility of aroma compounds. Therefore, this study investigates whether the pre-fermentative addition of OETs can influence the color characteristics and volatile organic compounds (VOCs) of white wines, thereby enhancing aroma complexity.

Methodology



Results

Table 1_Physico-Chemical parameters of Favorita juice after OETs addition (P0) and at the end of alcoholic fermentation (P3). Sign: ***, p<0.001. Samples were grouped according Tukey HSD (Latin letters). EC: (-) epicatechine

P0 Treatment	TPI (mg EC/L)	DPPH (mMol Trolox/L)	L*	a*	b*	Abs 420nm	HEX
CT	399 ± 10 d	0.68 ± 0.07 d	96.22 ± 0.27 b	0.16 ± 0.10 c	9.57 ± 0.27d	0.145 ± 0.005 c	
GL	571 ± 5 a	1.23 ± 0.07 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 ± 0.01d	12.09 ± 0.03 c	0.191 ± 0.001 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 ± 0.07 bc	13.04 ± 0.34 b	0.185 ± 0.003 b	
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P3 Treatment	TPI (mg EC/L)	DPPH (mMol Trolox/L)	L*	a*	b*	Abs 420nm	HEX
CT	424 ± 5 d	0.62 ± 0.03 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 ± 0.002 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 ± 0.004 b	
AC	505 ± 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 ± 0.003 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	
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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 P0, 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 (P0) and at the end of alcoholic fermentation (P3). Sign: ***, p<0.001. Samples were grouped according Tukey HSD (Latin letters). EC: (-) epicatechine

P0 Treatment	TPI (mg EC/L)	DPPH (mMol Trolox/L)	L*	a*	b*	Abs 420nm	HEX
CT	756 ± 5 c	1.11 ± 0.04 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 ± 0.04 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 ± 0.01 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 ± 0.01 b	93.08 ± 0.10 c	0.30 ± 0.06 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 ± 0.07 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 ± 0.02 b	20.53 ± 0.12 ab	0.324 ± 0.002 ab	
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P3 Treatment	TPI (mg EC/L)	DPPH (mMol Trolox/L)	L*	a*	b*	Abs 420nm	HEX
CT	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 ± 0.02 b	96.70 ± 0.12 a	-1.32 ± 0.10 d	9.66 ± 0.11 e	0.155 ± 0.002 e	
EL	715 ± 2 b	1.23 ± 0.06 b	94.97 ± 0.10 bc	-0.94 ± 0.11 bc	11.66 ± 0.07 bc	0.199 ± 0.002 bc	
AC	722 ± 2 ab	1.21 ± 0.01 b	94.61 ± 0.11 c	-0.81 ± 0.18 b	11.84 ± 0.27 b	0.205 ± 0.007 b	
QB	717 ± 3 b	1.23 ± 0.02 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	
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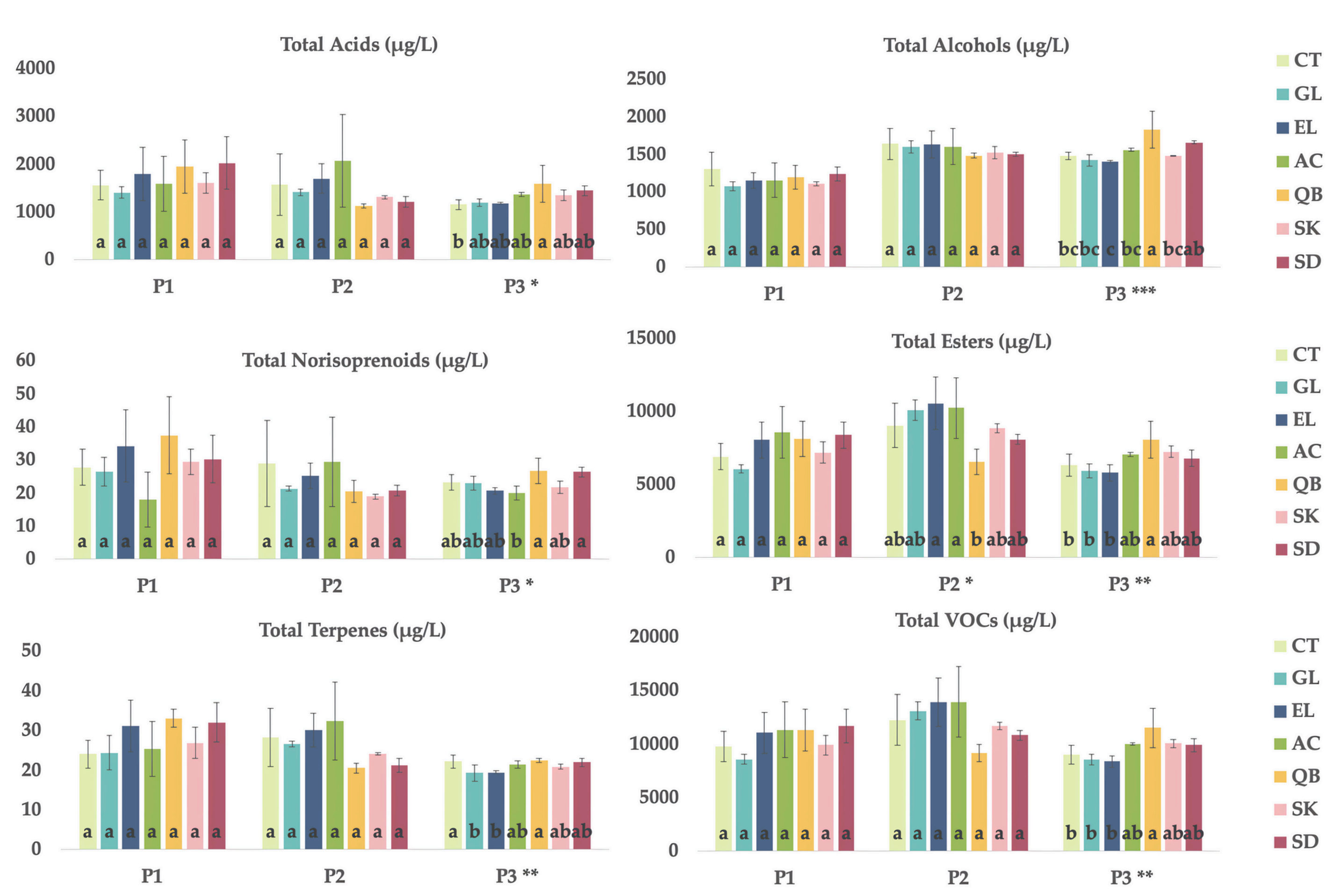

Figure 1_ Free VOCs of Favorita wine during fermentation, expressed as µg/L 2-octanol
Sign: *** p<0.001, ** p<0.01, * p<0.05. Samples were grouped according Tukey HSD among treatments.

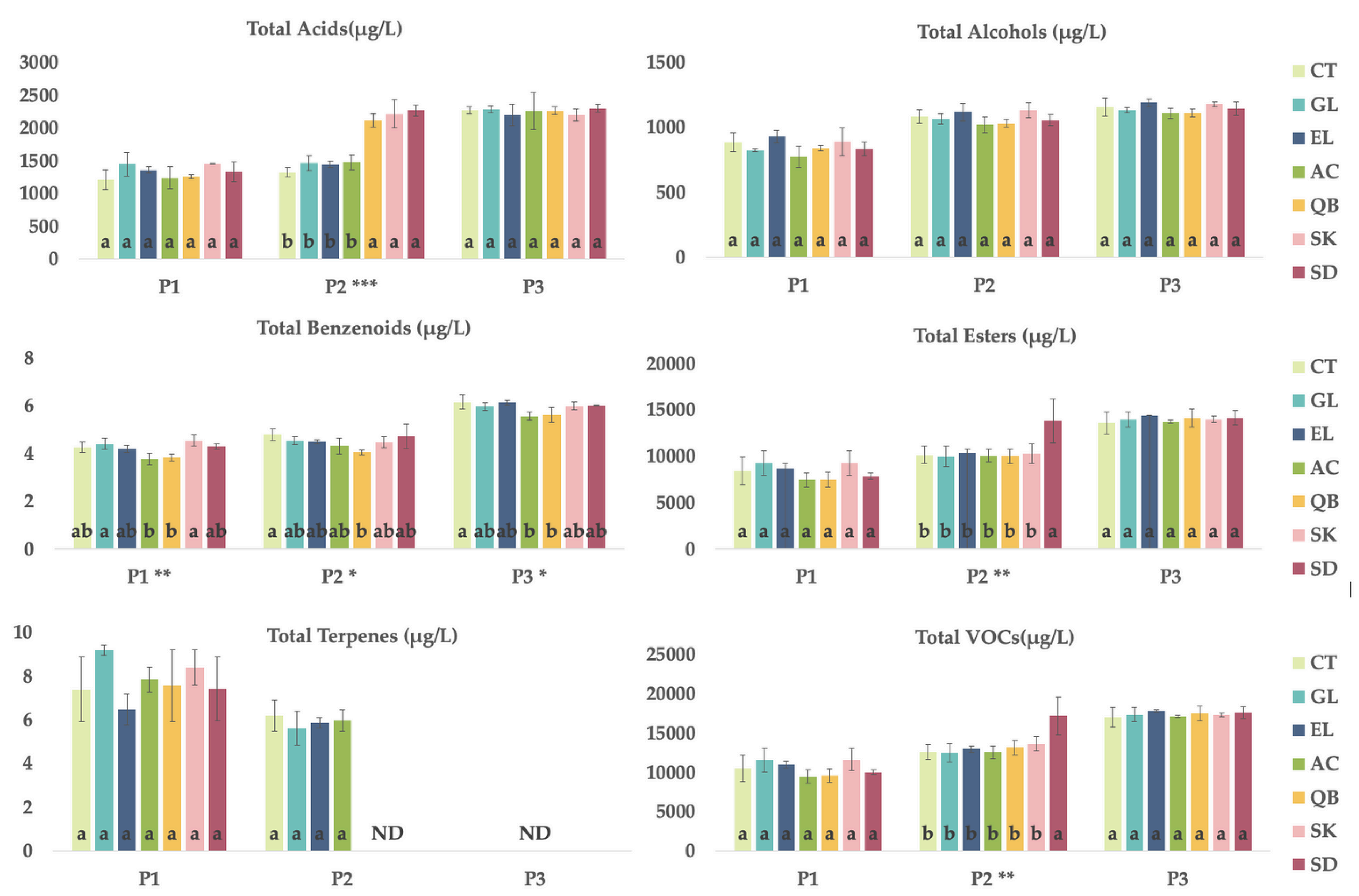

Figure 2_ Free VOCs of Erbaluce wine during fermentation, expressed as µg/L 2-octanol
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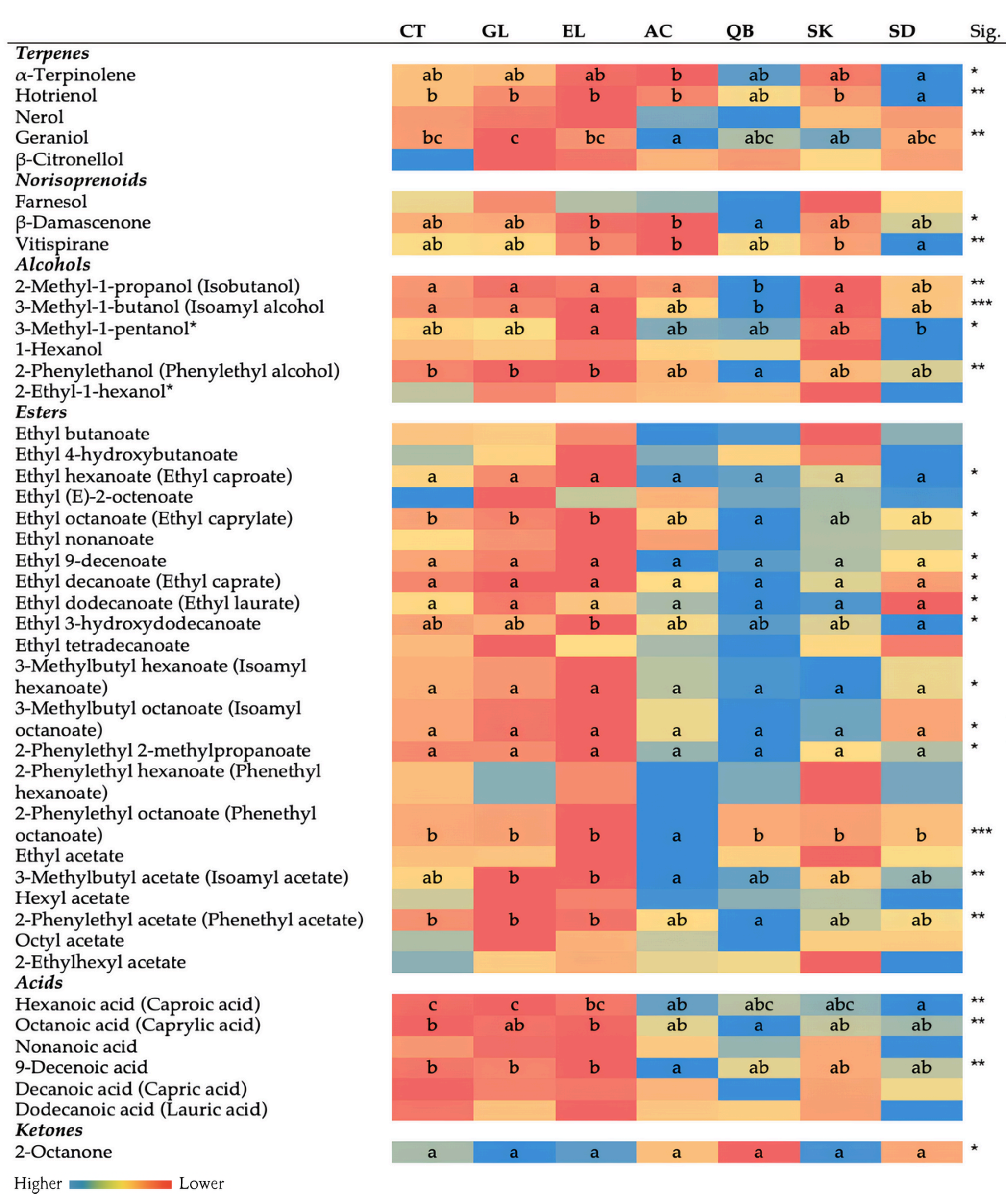

Figure 3_ Heatmap visualisation of free volatile compounds of Favorita wine at P3 (µg/L).
Sign: *** p<0.001, ** p<0.01, * p<0.05. Samples were grouped according Tukey HSD (Latin letters) among treatments.

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.

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.

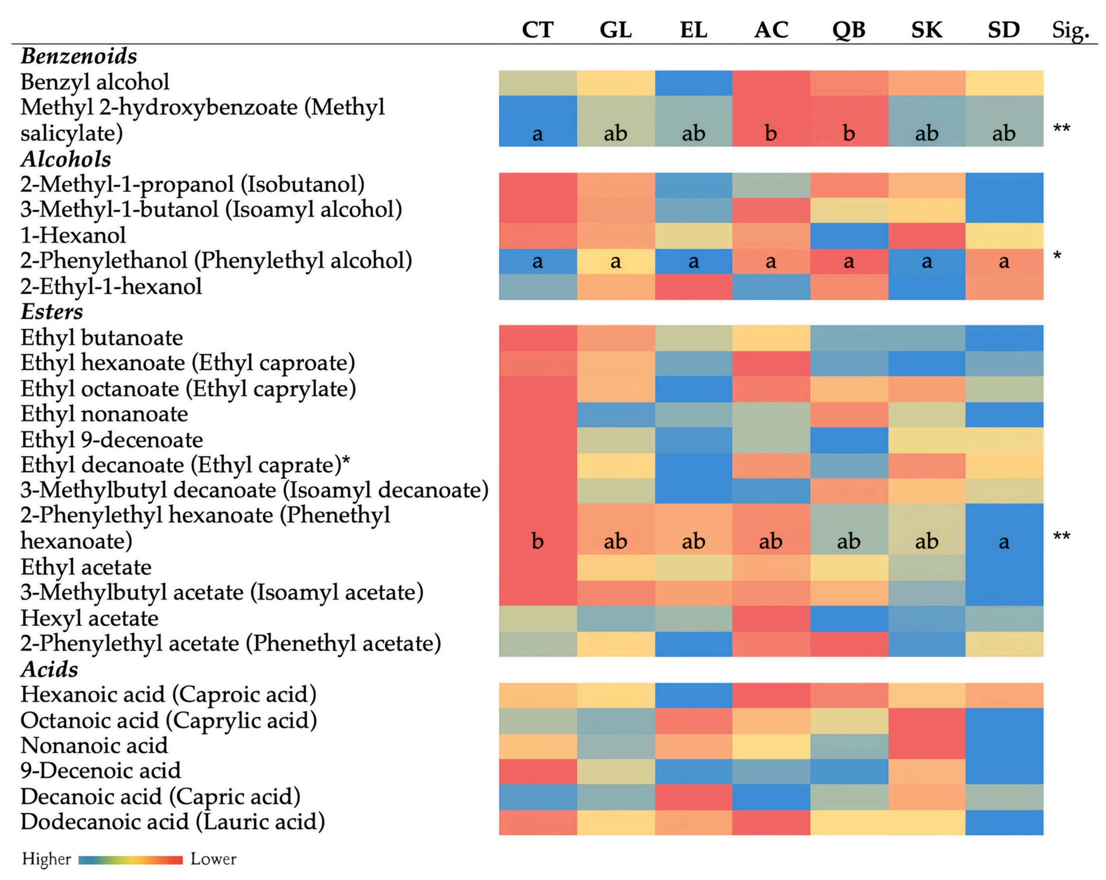

Figure 4_ Heatmap visualisation of free volatile compounds of Erbaluce wine at P3 (µg/L).
Sign: ** p<0.01, * p<0.05. Samples were grouped according Tukey HSD (Latin letters) among treatments .

References

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