Article

Enological Tannin Effect on Red Wine Color and Pigment Composition and Relevance of the Yeast Fermentation Products

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Grapes and wines

All wines studied were elaborated from the same "batch" of *Vitis vinifera L*. cv. Tempranillo grapes, which were collected the same day at technological maturity (24 ˚Brix) from a vineyard located in the D.O.Ca. Rioja. Grape juice showed 4.9 g/L of titrable acidity (expressed as tartaric acid equivalents), 3.4 g/L of malic acid, pH=3.93 and IPT=34. Fermentation was carried out with *S. cerevisiae* (*Zymaflore RJA64*, Laffort España, Rentería, Spain). Winemaking was performed in 100L stainless steel fermenters. Grape juice underwent cold macerations for 3 days, then it underwent alcoholic fermentation for 16 days and finally, wines underwent post-fermentative maceration for 3 days. SO_2 was added before (5g/hL) and after (4g/hL) alcoholic fermentation and temperature was controlled to be lower than 13 ºC, 23 ºC and 20ºC during cold maceration, fermentation process and post-fermentative maceration, respectively. Furthermore, during fermentation process the cap was punched down each two days. After post-fermentative maceration, malolactic fermentation was induced by inoculation with lactic acid bacteria (*Oenococcus oeni*).

R and C wines were elaborated following the same procedure but in the case of R wines, the enological tannin *C* was added at the start (10 g/hL), during the first *pumping over* (15 g/hL) and at the end of the alcoholic fermentation (10 g/hL) to reach a final concentration of 35 g/hL, as the manufacturer recommends.

Supplementary Materials

Table S1. Evolution of the percentage in relation to the initial content of the different anthocyanin 3-*O*-glucoside in the model systems prepared in standard wine.

Percentage in relation to initial content*

Day	Dp 3-glc**			Day	Cy 3-glc**		
	ATC	*ATS*	*A*		*ATC*	*ATS*	*A*
0	100.00^{a}	100.00^{a}	100.00^{a}	0	100.00^{a}	100.00^{a}	100.00^{a}
5	77.23^{a}	81.69^{a}	82.11^{a}	5	88.53^{a}	89.44^{a}	89.50^{a}
8	63.90^{a}	63.46^{a}	65.78^{a}	8	83.51^{a}	83.24^{a}	83.42^{a}
11	56.40^{a}	58.34$^{a.b}$	59.99^{b}	11	79.14^{a}	79.50^{a}	80.46^{a}
19	30.61^{a}	31.58$^{a.b}$	32.98^{a}	19	64.35^{a}	62.98^{a}	63.64^{a}
26	18.08^{a}	19.26^{b}	20.61^{c}	26	55.86^{a}	55.89^{a}	56.58^{a}
33	10.34^{a}	11.46^{a}	12.87^{b}	33	48.92^{a}	49.34^{a}	50.85^{a}
41	4.45^{a}	5.52^{b}	6.63^{c}	41	40.82^{a}	41.48$^{a.b}$	43.66^{b}
49	2.28^{a}	2.81^{b}	3.32^{c}	49	35.34^{a}	35.98^{a}	37.07^{b}
56	1.10^{a}	1.36^{b}	1.62^{c}	56	30.57^{a}	30.67^{a}	32.44^{b}
63	0.48^{a}	0.64^{b}	0.76^{b}	63	24.35^{a}	24.39^{a}	26.17^{b}
70	0.23^{a}	0.27$^{a.b}$	0.32^{b}	70	18.63^{a}	18.34^{a}	20.18^{b}
78	0.19^{a}	0.22^{a}	0.24^{a}	78	18.25^{a}	18.25^{a}	20.94^{b}
90	n.d.	n.d.	n.d.	90	12.63^{a}	12.62^{a}	13.94^{b}
98	n.d.	n.d.	n.d.	98	11.31^{a}	10.92^{b}	12.40^{c}
Day	**Pt 3-glc****			**Day**	**Pn 3-glc****		
0	100.00^{a}	100.00^{a}	100.00^{a}	0	100.00^{a}	100.00^{a}	100.00^{a}
5	84.73^{a}	86.38^{a}	87.79^{a}	5	88.40^{a}	89.70^{a}	90.84^{a}
8	77.72^{a}	77.24^{a}	78.56^{a}	8	84.40^{a}	83.53^{a}	84.26^{a}
11	72.10^{a}	72.74^{a}	74.83^{a}	11	80.71^{a}	80.83^{a}	82.59^{a}
19	52.47^{a}	52.84^{a}	54.65^{a}	19	70.02^{a}	69.81^{a}	70.69^{a}
26	41.65^{a}	42.52^{a}	44.40^{b}	26	62.33^{a}	62.40^{a}	63.65^{b}
33	32.29^{a}	33.84$^{a.b}$	35.97^{b}	33	56.70^{a}	56.07^{a}	58.31^{b}
41	23.16^{a}	24.53^{a}	26.68^{b}	41	49.53^{a}	48.56^{a}	51.68^{b}
49	12.92^{a}	13.95^{b}	15.28^{c}	49	44.53^{a}	43.61^{a}	46.41^{b}
56	8.88^{a}	9.60^{a}	11.14^{b}	56	39.69^{a}	38.61^{a}	41.58^{b}
63	4.87^{a}	5.82^{b}	6.56^{c}	63	33.86^{a}	33.88^{a}	36.56^{b}
70	2.87^{a}	3.42^{b}	4.11^{c}	70	30.74^{a}	30.05^{a}	32.78^{b}
78	2.06^{a}	2.45$^{a.b}$	3.12^{b}	78	28.07^{a}	26.85^{a}	30.10^{b}
90	n.d.	n.d.	n.d.	90	23.19^{a}	22.13^{b}	24.70^{c}
98	n.d.	n.d.	n.d.	98	22.19^{a}	21.08^{b}	24.25^{c}
Day	**Mv 3- glc****			**Day**	**Total anthocyanin 3-glc****		
0	100.00^{a}	100.00^{a}	100.00^{a}	0	100.00^{a}	100.00^{a}	100.00^{a}
5	87.13^{a}	87.72^{a}	89.10^{a}	5	85.28^{a}	86.88^{a}	87.98^{a}
8	85.43^{a}	84.62^{a}	85.77^{a}	8	80.02^{a}	79.37^{a}	80.62^{a}
11	80.33^{a}	80.40^{a}	82.38^{a}	11	74.71^{a}	75.25^{a}	77.08^{a}
19	66.69^{a}	66.59^{a}	68.42^{a}	19	58.39^{a}	58.51^{a}	60.00^{b}
26	61.94^{a}	61.76^{a}	64.32^{b}	26	50.49^{a}	50.84^{a}	52.70^{b}
33	56.23^{a}	56.52^{a}	59.10^{b}	33	43.75^{a}	44.29^{a}	46.44^{b}
41	49.60^{a}	49.47^{a}	52.53^{b}	41	36.65^{a}	36.93^{a}	39.42^{b}
49	44.41^{a}	44.24^{a}	47.32^{b}	49	31.15^{a}	31.26^{a}	33.41^{b}
56	39.71^{a}	39.19^{a}	42.39^{b}	56	27.16^{a}	26.96^{a}	29.22^{b}
63	31.62^{a}	31.28^{a}	34.18^{b}	63	21.60^{a}	21.69^{a}	23.61^{b}
70	27.76^{a}	27.27^{a}	30.26^{b}	70	18.73^{a}	18.53^{a}	20.48^{b}
78	27.66^{a}	26.62^{a}	30.05^{b}	78	18.03^{a}	17.48^{a}	19.75^{b}
90	18.97^{a}	18.63^{a}	21.20^{b}	90	12.84^{a}	12.52^{a}	14.12^{b}
98	17.68^{a}	17.00^{b}	19.65^{c}	98	12.05^{a}	11.56^{b}	13.32^{c}

* **Dp**: delphinidin. **Cy**: Cyanidin. **Pt**: Petunidin: **Pn**: Peonidin. **Mv**: Malvidin. *AC*: Model system added with tannin *C*. *AS*: Model system added with tannin *S*. *A*: Reference model system.

** Different lower case letters within each file and for each anthocyanin indicate significant differences (n=6. $p<0.05$). n.d.: non-detected.

Table S2. Evolution of the percentage in relation to the initial content of the different anthocyanin 3-*O*-glucoside in the model systems prepared in the fermentative medium.

Percentage in relation to initial content*

Dp 3-glc**				Cy 3-glc**			
Day	*ATCF*	*ATSF*	*AF*	**Day**	*ATCF*	*ATSF*	*AF*
0	100.00[a]	100.00[a]	100.00a	0	100.00[a]	100.00[a]	100.00[a]
5	67.70[a]	65.27[a]	63.09[a]	5	79.51[a]	79.16[a]	80.98[a]
8	40.57[a]	39.56[a]	34.83[b]	8	66.33[a]	66.53[a]	66.60[a]
11	32.40[a]	30.89[a]	26.55[b]	11	60.98[a]	60.44[a]	60.36[a]
19	8.66[a]	8.03[a]	5.37[b]	19	39.67[a]	39.24[a]	38.51[b]
26	2.43[a]	2.32[a]	1.25[b]	26	28.87[a]	28.36[a]	26.61[b]
33	0.86[a]	0.81[a]	0.47[b]	33	21.69[a]	21.20[a]	19.59[b]
41	0.31[a]	0.29[a]	0.19[b]	41	15.21[a]	14.33[a]	13.01[b]
49	0.16[a]	0.16[a]	n.d.	49	10.26[a]	10.07[a]	9.46[b]
56	n.d.	n.d.	n.d.	56	7.35[a]	7.32[a]	6.22[b]
63	n.d.	n.d.	n.d.	63	5.26[a]	5.07[a]	4.05[b]
70	n.d.	n.d.	n.d.	70	3.86[a]	3.71[a]	2.83[b]
78	n.d.	n.d.	n.d.	78	2.60[a]	2.61[a]	1.84[b]
90	n.d.	n.d.	n.d.	90	1.53[a]	1.45[a]	1.02[b]
98	n.d.	n.d.	n.d.	98	1.20[a]	1.11[a]	0.80[b]
Day	**Pt 3-glc****			**Day**	**Pn 3-glc****		
0	100.00[a]	100.00[a]	100.00a	0	100.00[a]	100.00[a]	100.00[a]
5	76.11[a]	74.19[a]	74.98[a]	5	83.28[a]	82.79[a]	86.11[a]
8	55.52[a]	55.47[a]	53.50[a]	8	72.73[a]	72.56[a]	74.90[a]
11	49.54[a]	48.03[a]	45.97[b]	11	67.99[a]	67.39[a]	69.66[a]
19	23.56[a]	22.71[a]	19.79[b]	19	49.64[a]	49.03[a]	50.83[a]
26	10.07[a]	9.53[a]	6.54[b]	26	39.54[a]	38.52[a]	39.29[a]
33	4.72[a]	4.37[a]	2.55[b]	33	31.59[a]	30.71[a]	31.25[a]
41	1.67[a]	1.59[a]	0.74[b]	41	24.37[a]	23.25[a]	23.73[a]
49	0.66[a]	0.69[a]	0.35[b]	49	19.56[a]	18.53[b]	19.40[a]
56	0.27[a]	0.30[a]	0.16[b]	56	15.29[a]	14.30[b]	14.40[b]
63	n.d.	n.d.	n.d.	63	11.26[a]	10.36[b]	10.44[b]
70	n.d.	n.d.	n.d.	70	8.86[a]	8.04[b]	8.18[b]
78	n.d.	n.d.	n.d.	78	6.97[a]	6.14[b]	6.23[b]
90	n.d.	n.d.	n.d.	90	4.67[a]	4.09[b]	4.07[b]
98	n.d.	n.d.	n.d.	98	3.71[a]	3.21[b]	3.17[b]
Day	**Mv 3-glc***			**Day**	**Total anthocyanin 3-glc****		
0	100.00[a]	100.00[a]	100.00[a]	0	100.00[a]	100.00[a]	100.00[a]
5	80.81[a]	79.82[a]	83.21[a]	5	78.06[a]	76.77[a]	78.63[a]
8	70.04[a]	69.70[a]	72.24[a]	8	62.63[a]	62.27[a]	62.58[a]
11	64.61[a]	63.99[a]	66.48[a]	11	56.74[a]	55.82[a]	56.14[a]
19	44.63[a]	43.97[a]	46.36[a]	19	35.31[a]	34.63[a]	34.95[a]
26	35.65[a]	34.65[a]	35.60[a]	26	25.77[a]	25.31[a]	24.76[b]
33	28.08[a]	27.89[a]	27.92[a]	33	19.60[a]	19.36[a]	18.90[b]
41	21.15[a]	21.00[a]	20.76[a]	41	14.43[a]	14.26[a]	13.84[b]
49	16.70[a]	15.84[a]	16.91[a]	49	11.24[a]	11.17[a]	11.16[a]
56	12.77[a]	12.44[a]	11.81[b]	56	8.57[a]	8.43[a]	8.04[b]
63	9.16[a]	9.20[a]	8.35[b]	63	6.17[a]	6.01[a]	5.61[b]
70	6.97[a]	6.78[a]	6.35[b]	70	4.74[a]	4.63[a]	4.29[b]
78	5.47[a]	5.30[a]	4.72[b]	78	3.70[a]	3.56[a]	3.20[b]
90	3.28[a]	3.00[a]	2.76[b]	90	2.31[a]	2.23[a]	1.95[b]
98	2.56[a]	2.37[a]	2.14[b]	98	1.81[a]	1.79[a]	1.01[b]

* **Dp**: delphinidin. **Cy**: Cyanidin. **Pt**: Petunidin: **Pn**: Peonidin. **Mv**: Malvidin. *ACF*: Model system added with tannin *C*. *ASF*: Model system added with tannin *S*. *AF*: Reference model system.

** Different lower case letters within each file and for each anthocyanin indicate significant differences (n=6. $p<0.05$). n.d.: non-detected.