

1 **Table 1**

2 Chemical parameters of musts and wines produced by pure and mixed culture fermentations

Grape variety	Inoculation protocol	Residual sugars (g/L)	Malic acid (g/L)	Acetic acid (g/L)	Succinic acid (g/L)	Glycerol (g/L)	Ethanol (% v/v)	Y(gly/sugar) (g/g)	Y(eth/sugar) (g/g)	pH	TA (g/L)
Chardonnay	Prior inoculation	246.0 ± 2.6	2.55 ± 0.03	< 0.1	0.06 ± 0.01	< 0.1	< 0.1	-	-	3.99 ± 0.01	4.33 ± 0.02
	pure	0.4 ± 0.2	1.55 ± 0.03	0.29 ± 0.10	1.27 ± 0.08	8.4 ± 0.1	14.9 ± 0.1	0.034 ± 0.001	0.061 ± 0.001	3.26 ± 0.27	5.84 ± 0.11
	mixed	0.5 ± 0.1	1.88 ± 0.01	0.28 ± 0.01	1.29 ± 0.02	10.3 ± 0.1	14.7 ± 0.1	0.042 ± 0.001	0.06 ± 0.001	3.35 ± 0.06	6.92 ± 0.06
Sign.		NS	***	NS	NS	***	*	***	*	NS	***
Muscat	Prior inoculation	244.0 ± 1.2	1.28 ± 0.03	< 0.1	0.05 ± 0.01	< 0.1	< 0.1	-	-	3.81 ± 0.03	3.15 ± 0.04
	pure	0.5 ± 0.1	0.83 ± 0.01	0.31 ± 0.01	0.94 ± 0.01	7.8 ± 0.1	14.8 ± 0.1	0.032 ± 0.001	0.061 ± 0.001	3.22 ± 0.14	6.69 ± 0.04
	mixed	0.7 ± 0.1	0.94 ± 0.01	0.27 ± 0.01	1.14 ± 0.01	9.3 ± 0.1	14.6 ± 0.1	0.038 ± 0.002	0.06 ± 0.02	3.24 ± 0.11	7.16 ± 0.04
Sign.		NS	***	***	***	***	*	***	*	NS	***
Riesling	Prior inoculation	245.9 ± 1.1	2.26 ± 0.01	< 0.1	0.04 ± 0.01	< 0.1	< 0.1	-	-	3.82 ± 0.01	4.35 ± 0.06
	pure	0.4 ± 0.1	1.44 ± 0.02	0.36 ± 0.03	1.13 ± 0.03	8.6 ± 0.1	14.7 ± 0.1	0.035 ± 0.001	0.06 ± 0.001	3.35 ± 0.08	5.67 ± 0.06
	mixed	0.9 ± 0.1	1.60 ± 0.01	0.32 ± 0.01	1.21 ± 0.01	10.3 ± 0.1	14.6 ± 0.1	0.042 ± 0.001	0.06 ± 0.001	3.34 ± 0.03	6.27 ± 0.05
Sign.		***	***	NS	**	***	*	***	NS	NS	***
Sauvignon blanc	Prior inoculation	245.7 ± 0.6	1.23 ± 0.01	< 0.1	0.03 ± 0.01	< 0.1	< 0.1	-	-	3.56 ± 0.02	6.51 ± 0.04
	pure	0.7 ± 0.1	0.81 ± 0.01	0.40 ± 0.01	0.92 ± 0.01	8.3 ± 0.1	14.9 ± 0.1	0.034 ± 0.001	0.061 ± 0.001	3.09 ± 0.07	7.08 ± 0.01
	mixed	1.1 ± 0.1	0.86 ± 0.01	0.33 ± 0.01	1.02 ± 0.06	9.8 ± 0.1	14.7 ± 0.1	0.04 ± 0.002	0.06 ± 0.002	3.15 ± 0.03	8.11 ± 0.02
Sign.		***	**	***	*	***	***	***	***	NS	***

3 The values are mean ± standard deviation of three independent experiments. Sign.: *, **, *** and NS indicate significance at $p < 0.05$, $p < 0.01$, $p < 0.001$ and not significant,
 4 respectively. TA: titratable acidity expressed as tartaric acid, Y (gly/sugar consumption): glycerol yield and Y (eth/sugar consumption): ethanol yield.

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16 **Table 2**

17 Volatile composition of the wines produced by pure and mixed culture fermentations

Metabolites	Retention index	Perception threshold	Chardonnay		Muscat		Riesling		Sauvignon blanc		Statistical differences						
			Pure	Mixed	Pure	Mixed	Pure	Mixed	Pure	Mixed	Variety	Yeast	Interaction	Chard.	Mus.	Ries.	S.b.
<i>Alcohols</i>																	
2-Methyl-1-propanol	1113	40000a	372 ± 18	271 ± 30	341 ± 58	269 ± 43	153 ± 22	282 ± 66	160 ± 8	264 ± 13	***	NS	***	***	*	**	***
Isoamylic alcohol	1231	30000a	6905 ± 882	4284 ± 436	5163 ± 872	4064 ± 205	4462 ± 882	4196 ± 827	4514 ± 434	4710 ± 494	***	***	***	***	*	NS	NS
Hexanol	1367	8000a	314 ± 51	386 ± 45	72 ± 4	101 ± 9	204 ± 44	287 ± 46	228 ± 21	352 ± 19	***	***	*	*	***	**	***
(R,R)-2,3-Butanediol	1552	120000c	414 ± 102	284 ± 50	619 ± 64	338 ± 51	324 ± 36	240 ± 56	485 ± 202	356 ± 57	***	***	NS	*	***	*	NS
Octanol	1568	900b	7 ± 2	8 ± 4	13 ± 4	12 ± 4	7 ± 2	8 ± 4	7 ± 3	6 ± 5	***	NS	NS	NS	NS	NS	NS
(R,S-meso)-2,3-Butanediol	1587	120000c	96 ± 30	89 ± 19	168 ± 16	108 ± 20	88 ± 20	60 ± 22	122 ± 53	121 ± 14	***	**	NS	NS	***	*	NS
2-phenylethanol	1885	10000a, 14000d	6685 ± 763	8131 ± 1340	7549 ± 1613	8196 ± 1845	4633 ± 955	7369 ± 1999	5176 ± 531	6036 ± 633	***	***	NS	NS	NS	*	*
∑ <i>Alcohols</i>			14793 ± 1002	13454 ± 1689	13925 ± 1697	13088 ± 2002	9871 ± 1527	12442 ± 2877	10693 ± 708	11825 ± 477	***	NS	*	NS	NS	NS	**
<i>Esters</i>																	
Ethyl acetate	nd	7500a	7434 ± 850	3909 ± 397	8488 ± 1330	3650 ± 250	3721 ± 569	3688 ± 737	4530 ± 335	4649 ± 315	***	***	***	***	***	NS	NS
Ethyl butanoate	1040	20d	206 ± 26	119 ± 18	248 ± 51	87 ± 28	108 ± 22	80 ± 25	94 ± 28	152 ± 18	***	***	***	***	***	NS	**
3-Methyl-1-butanol acetate	1131	30c	19718 ± 3338	1653 ± 340	19119 ± 3367	1499 ± 232	5844 ± 1174	1097 ± 141	5857 ± 1074	2327 ± 368	***	***	***	***	***	***	***
Ethyl hexanoate	1249	5d,14a	5755 ± 910	3209 ± 832	5711 ± 1079	2456 ± 421	3079 ± 930	2373 ± 431	2770 ± 417	4168 ± 393	***	***	***	***	***	NS	***
Hexyl acetate	1286	670-1500c	5450 ± 1015	572 ± 141	1493 ± 309	113 ± 26	1830 ± 541	227 ± 36	1902 ± 277	648 ± 85	***	***	***	***	***	***	***
Ethyl 2-hexenoate	1355	-	13 ± 3	20 ± 5	0 ± 0	2 ± 1	5 ± 2	13 ± 5	3 ± 2	17 ± 3	***	***	***	*	*	**	***
Methyl octanoate	1398	200f	92 ± 35	51 ± 18	79 ± 9	25 ± 11	57 ± 32	40 ± 10	36 ± 5	60 ± 7	*	***	***	*	***	NS	***
Ethyl octanoate	1445	2a,5d	42583 ± 12382	18266 ± 6110	39625 ± 6078	12680 ± 1891	21525 ± 7409	12036 ± 3738	15044 ± 1802	23904 ± 2822	***	***	***	**	***	*	***
Octyl acetate	1478	50000e	81 ± 27	3 ± 2	92 ± 26	3 ± 2	13 ± 9	1 ± 1	16 ± 6	13 ± 4	***	***	***	***	***	*	NS
Ethyl nonanoate	1543	1300b	15 ± 7	35 ± 18	17 ± 3	20 ± 19	6 ± 4	8 ± 3	20 ± 22	19 ± 19	NS	NS	NS	*	NS	NS	NS
Methyl decanoate	1599	1200e	70 ± 35	33 ± 17	55 ± 8	12 ± 5	32 ± 23	20 ± 8	17 ± 5	47 ± 6	**	**	***	NS	***	NS	***
Ethyl decanoate	1648	200a	34198 ± 10455	15223 ± 3991	27364 ± 5403	11097 ± 1946	14863 ± 5067	10398 ± 2922	12358 ± 1658	22455 ± 2577	***	***	***	*	***	NS	***
3-Methyl-butyl octanoate	1663	-	169 ± 64	84 ± 35	194 ± 36	65 ± 16	51 ± 50	40 ± 15	50 ± 16	131 ± 30	***	**	***	*	***	NS	***
Ethyl 9-decenoate	1697	-	340 ± 151	75 ± 22	241 ± 51	32 ± 9	74 ± 58	51 ± 16	117 ± 18	103 ± 21	***	***	***	**	***	NS	NS

2-Phenyl-ethyl acetate	1815	250a	2585 ± 602	1350 ± 253	3140 ± 640	1209 ± 177	1404 ± 376	772 ± 198	1950 ± 216	1124 ± 117	***	***	***	**	***	**	***
Ethyl dodecanoate	1834	1500-2000b	3008 ± 802	2869 ± 744	3732 ± 813	1901 ± 432	1963 ± 580	1808 ± 594	1682 ± 358	3887 ± 1585	*	NS	***	NS	***	NS	**
3-Methyl-butyl decanoate	1846	-	136 ± 28	112 ± 35	146 ± 38	76 ± 17	55 ± 39	61 ± 18	75 ± 15	163 ± 132	*	NS	**	NS	**	NS	NS
Ethyl tetradecanoate	1974	800b	104 ± 47	196 ± 27	142 ± 44	109 ± 31	59 ± 32	86 ± 20	133 ± 19	211 ± 176	**	NS	NS	**	NS	NS	NS
Ethyl hexadecanoate	2122	1500b	74 ± 28	146 ± 26	61 ± 25	75 ± 24	65 ± 36	50 ± 14	122 ± 14	100 ± 24	***	NS	***	**	NS	NS	NS
\sum Esters			122031 ± 19678	47927 ± 10550	109946 ± 13512	35126 ± 4285	45337 ± 20413	32848 ± 8028	46776 ± 5073	64178 ± 5677	***	***	***	***	***	NS	***
<i>Fatty acids</i>																	
Octanoic acid	1986	500a	898 ± 468	329 ± 140	1108 ± 222	319 ± 140	787 ± 174	313 ± 198	900 ± 104	237 ± 186	NS	***	NS	*	***	**	***
Decanoic acid	2138	1000a	389 ± 320	275 ± 62	578 ± 259	70 ± 17	616 ± 144	76 ± 41	587 ± 97	394 ± 36	NS	***	**	NS	***	***	**
\sum Fatty acids			1287 ± 648	604 ± 70	1686 ± 463	389 ± 104	1403 ± 316	389 ± 222	1487 ± 197	631 ± 188	NS	***	NS	*	***	***	***
<i>Terpenes</i>																	
D-Limonene	1205	15g, 200f	0 ± 0	0 ± 0	17 ± 4	9 ± 5	0 ± 0	2 ± 5	0 ± 0	0 ± 0	***	NS	**	NS	*	NS	NS
δ -3-Carene	1330	-	0 ± 0	0 ± 0	40 ± 19	24 ± 11	13 ± 7	6 ± 5	0 ± 0	0 ± 0	***	*	NS	NS	NS	NS	NS
<i>l</i> -Furan linalool oxyde	1457	-	0 ± 0	0 ± 0	0 ± 0	0 ± 0	5 ± 8	1 ± 2	0 ± 0	0 ± 0	NS	NS	NS	*	NS	NS	*
Linalool	1556	25.2d	2 ± 1	3 ± 2	647 ± 61	514 ± 68	101 ± 26	80 ± 18	4 ± 2	7 ± 2	***	***	***	NS	**	NS	*
Hotrienol	1617	100g	0 ± 0	0 ± 0	42 ± 10	41 ± 8	35 ± 13	13 ± 8	3 ± 1	1 ± 1	***	**	***	*	NS	**	*
α -Terpineol	1707	250c	0 ± 0	0 ± 0	31 ± 5	25 ± 5	13 ± 8	6 ± 2	0 ± 0	0 ± 0	***	**	*	NS	NS	NS	**
Citronellol	1770	100c	2 ± 0	9 ± 4	4 ± 2	11 ± 5	2 ± 0	11 ± 3	2 ± 1	9 ± 4	NS	***	NS	**	**	***	***
Geraniol	1836	30a	0 ± 0	3 ± 3	4 ± 5	13 ± 3	1 ± 2	4 ± 3	1 ± 2	3 ± 3	***	***	*	*	**	NS	NS
\sum Terpenes			5 ± 1	15 ± 8	785 ± 85	639 ± 86	169 ± 51	122 ± 30	12 ± 4	21 ± 6	***	**	***	*	*	NS	**
<i>Other metabolites</i>																	
Methionol	1727	1000d	1 ± 2	3 ± 5	2 ± 2	2 ± 4	3 ± 1	9 ± 3	3 ± 1	6 ± 4	**	**	NS	NS	NS	**	NS
β -Damascenone	1820	0.055a	15 ± 3	11 ± 5	26 ± 7	19 ± 5	35 ± 11	18 ± 5	15 ± 7	8 ± 3	***	***	NS	NS	NS	*	NS
\sum other metabolites			17 ± 4	15 ± 5	28 ± 6	22 ± 5	38 ± 12	27 ± 5	19 ± 8	14 ± 5	***	**	NS	NS	NS	NS	NS
<i>Volatile thiols(ng/L)</i>																	
3-mercaptohexanol	-	60h	-	-	-	-	-	-	198 ± 7	269 ± 41	-	-	-	-	-	-	*
3-mercaptohexyl acetate	-	4h	-	-	-	-	-	-	nd	nd	-	-	-	-	-	-	NS

18 Aroma compounds in wines expressed in $\mu\text{g/L}$, as mean \pm standard deviation of three independent experiments (each replicate was analysed two times (total 6)). Sig: *, **, ***
19 and NS indicate significance at $p < 0.05$, $p < 0.01$, $p < 0.001$ and not significant, respectively. Chard., Chardonnay; Mus., Muscat, Ries., Riesling, S.b., Sauvignon blanc.
20 Perception thresholds ($\mu\text{g/L}$) were taken from: (a) Guth (1997), (b) Li (2006), (c) Cullere, Escudero, Cacho & Ferreira (2004), (d) Ferreira, Lopez & Cacho (2000), (e) Li, Tao,
21 Wang & Zhang (2008), (f) Cheng, Liu, Yue & Zhang (2015) and (g) Zhang, Petersen, Liu & Toldam-Andersen (2015), (h) Tominaga, Furrer, Henry & Dubourdieu (1998).
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