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Aroma characteristics of wines from the cultivar 'Manzoni bianco' ('White Riesling' x 'Pinot blanc')

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Aroma specifics of wines from the 'Manzoni bianco' cultivar, a 'White Riesling' x 'Pinot blanc' crossing for full-bodied quality wines, are presented. The wine is characterised by a rather high level of 3,7-dimethyl-1,7-octadiene-3,7-diol [diendiol (I)] and, especially in cooler area, by a rather low content of linalool, even if a 'White Riesling'-type floral-resinous aroma is present. The hypothesis is suggested, that the 'Riesling' scent, which is observed in 'Manzoni bianco' is caused by the formation of diendiol (I) derivatives, although only some ethoxy ethylethers of diendiol (I) at trace level have been identified.
Key words: wine, free and glycosidic monoterpenols, terpenylethylethers, norisoprenoids, diendiol (I)

Aromaeigenschaften von Weinen der Sorte 'Manzoni bianco' ('Weißer Riesling' x 'Pinot blanc'). *Die Eigenheiten des Aromas von Weinen der Sorte 'Manzoni bianco', einer Kreuzung von 'Weißer Riesling' und 'Pinot blanc' für qualitativ hochwertige, körperreiche Weine, werden dargestellt. Die Weine weisen ziemlich hohe Gehalte an 3,7-Dimethyl-1,7-Octadien-3,7-Diol [Diendiol (I)] und, vor allem in kühleren Anbaugebieten, eher geringe Linaloolgehalte auf, selbst bei typischer Riesling-Aromatik. Es wird angenommen, dass der 'Riesling'-Duft der 'Manzoni bianco'-Weine durch Diendiol (I)-Derivate verursacht wird, obwohl nur einige Ethoxyethylether in Spuren identifiziert wurden.*
Schlagwörter: Wein, freie und glykosidisch gebundene Monoterpene, Terpenylethylether, Norisoprenoide, Diendiol (I)

Caractéristiques de l'arôme des vins du cépage *"Manzoni bianco" ("Riesling blanc" x "Pinot blanc").* *Certaines particularités de l'arôme du vin "Manzoni bianco", un croisement du "Riesling blanc" et du "Pinot blanc", pour des vins de qualité étoffés sont présentés. Le "Manzoni bianco" se caractérise principalement par une teneur relativement élevée en 3,7-diméthyl-1,7-octadien-3,7-diol [diendiol (I)] et par une teneur plutôt faible en linalool, surtout dans des régions plus froides, même en présence d'un arôme floral-résineux de type "Riesling". Il est formulé l'hypothèse que cet arôme de Riesling observé dans le "Manzoni bianco" est dû à la formation de dérivés du diendiol (I), bien qu'il n'ait été trouvé que quelques traces d'éther d'éthyle de diendiol (I).*
Mots clés: vin, substances aromatiques, monoterpenols libres et glycosidiques, éthers d'éthyle terpéniques, norisoprénoïdes, diendiol (I)

The cultivar 'Manzoni bianco', alias 'Incrocio Manzoni 6.0.13', is a white grape cultivar achieved by Prof. LUIGI MANZONI - the famous breeder and director of the Technical Institute for Agriculture in Conegliano - in the early thirties of the past century. His declared aim was „to obtain a white-fruited grape to substitute advantageously the cultivars grown till today" (CANCELLIER and RONCADOR, 1997). Among several other new crosses produced by MANZONI, the crossing with the number 6.0.13 is the most interesting and extensively cultivated. Since the beginning, it was declared as 'White Riesling' (female) x 'Pinot blanc' (male) crossing, and this origin was confirmed recently by DNA markers, micro-satellites and RAPD (GRANDO et al., 1997). Agronomically, at ripeness 'Manzoni bianco' grapes have high levels of sugar and total acidity. Besides, they are less susceptible to *Botrytis cinerea* and less fruitful than the cultivar 'Chardonnay' (VERSINI et al., 2001). Since 1978 'Manzoni bianco' is in the Italian Catalogue of Wine Grape Cultivars (Ministero dell'

Agricoltura e delle Foreste, 1988). In 1992 the first clones (SMA-ISV 222 and SMA-ISV 237) were approved and included into the Catalogue as a result of a collaborative research of the Agricultural Institute of S. Michele all'Adige (SMA) and the Experimental Institute for Viticulture at Conegliano (ISV). Since 1991 'Manzoni bianco' is tested with other white cultivars within a national research project named „Updating and qualification of the national ampelographic platform" (COSTACURTA, 2000; UBIGLI et al., 2000).

First investigations about free and bound terpenes of a 'Manzoni bianco' wine produced in Central Italy were reported by DI STEFANO (1987). In particular, he noticed interesting levels of free linalool, hotrienol, alpha-terpineol, 3,7-dimethyl-1,5-octadiene-3,7-diol [hodiendiol (I)], 3,7-dimethyl-1-octene-3,7-diol (endiol) and cis 2,6-dimethyl-2,7-octadiene-1,6-diol (cis 8-hydroxylinalool) similar to 'White Riesling', as well as the nearly absence of geraniol. Among the aglycons trans furan linalooloxide, ho-diendiol (I) and trans hydroxygeraniol were dominating.

VERSINI et al. (1997a) analyzed the profile of the monoterpene aglycons from glycosides after isolation with Amberlite XAD-2 resin and enzymatic hydrolysis with Cytolase PCL5 and observed strong similarities between 'Manzoni bianco' and 'White Riesling'. In particular, they observed similar ratios of trans to cis furan linalooloxide and pyran linalooloxide, and of trans to cis 8-hydroxylinalool, with dominance of the cis form.

The present paper focuses on the composition specifics of the free and glycosidic aroma compounds of 'Manzoni bianco' authentic wines, mostly from grapes of the SMA-ISV 222 and SMA-ISV 237 clones which were grown in Trentino.

Materials and methods

'Manzoni bianco' monoclonal grapes (ISV-SMA 222; ISV-SMA 237) were harvested from vineyards located under following pedoclimatic conditions in Trentino (north-eastern Italy):

– Telve (south exposed hilly plot; 430 m a.s.l.; Guyot; 5000 vines/hectare; 1994-1998, 2000),
– San Michele-Giaroni (plain; 210 m a.s.l.; double pergola; 3300 vines/hectare; 1991-1992)
– Gardolo (plain; 200 m a.s.l.; double pergola; 3700 vines/hectare; 1993).

Other samples were also harvested at S. Colombano al Lambro (southern Lombardy; vintage 2000). The relevant wines were produced in experimental scale with the standardized winemaking procedures of the experimental winery of the Agrarian Institute at S. Michele all'Adige. 'Manzoni bianco' experimental wine samples were also collected from Sicilia, vintage 1995. Analyses were performed in spring 2001.

Methanol and higher alcohols were analysed according to GABRI and SALVAGIOTTO (1980). Free and bound aroma compounds were analysed after solid phase extraction (SPE) and fractionated elution on a cartridge (Isolute ENV+, International Sorbent Technology Ltd., Mid Glamorgan, UK) filled with 1 g of a polyhydroxylated polystirenic resin with high crosslinking (SDVB; 40-140 µm, surface 1100 m^2/g, cod. n° 915-0100-C). The cartridge was activated with methanol (5 ml) and rinsed with distilled water. 100 ml diluted wine (1:1) with added internal standard (2-octanol) were percolated through the cartridge. Free aroma compounds were eluted with 30 ml of dichloromethane, while bound forms were eluted with methanol (30 ml). The fraction with the free terpenes was concentrated after addition of 60 ml distilled pentane (azeotrope at 31 °C). The fraction with the bound aroma compounds was brought to dryness, redissolved in a pH 5.0 buffered citrate solution and reacted with the enzyme Cytolase PCL5 (Genecor Co.), afterwards again extracted and concentrated as previously reported (VERSINI et al., 1997a). Aroma compounds were quantified by HRGC-FID, HRGC-MS and MS-SIM.

Some very volatile compounds with possible sensory relevance and often present in traces - like monoterpene ethers (e.g. neroloxide), ethylethers and norisoprenoids, e.g. 1,1,6-trimethyl-1,2-dihydronaphthalene (TDN, a kerosene-like, often detrimental aroma), isomeric vitispiranes (VTP, eucalyptus-like scent), beta-damascenone (DAM; floral-hay scent) and actinidol ethyl-ethers (eucalyptus-like scent) -, were analysed by Solid Phase Micro-Extraction (SPME) in headspace according to VERSINI et al. (1999), using fused silica fiber covered with 100 mm polydimethylsiloxane (PDMS) (Supelco Inc., Bellefonte, PA, USA, cod. n° 5-7300) and quantified as relative ratios to 2-octanol.

Results and discussion

Table 1 focuses on important varietal and pre-fermentative compounds, as well as some fermentation compounds selected as possibly non-depending on ageing.

In particular, for the pre-fermentative compounds (e.g. methanol, 1-hexanol, trans 3-hexenol and cis 3-hexenol,

Table 1:
Volatile compounds (µg/l) of 'Manzoni bianco' wines

	S. Michele (Trentino)				Gardolo (Trentino)				Telve (Trentino)								S. Colombano (Lombardy)			
	1991		1992		1993		1995		1996		1997		1998		2000		2000			
	clone		clone		clone		clone		clone		clone		clone		clone		sample			
	237	222	237	222	237	222	237	222	237	222	237	222	237	222	237	222	1	2	3	4
wine pH	3,03	3,00	2,94	2,98	3,11	3,24	2,62	2,70	3,01	3,00	2,93	2,92	3,12	3,10	3,00	2,99	2,98	2,97	3,02	3,02
methanol (mg/l)	34,0	35,5	39,0	39,0	45,0	47,5	25,5	28,5	37,0	32,5	34,0	32,5	37,0	28,5	24,5	27,5	27,0	28,0	28,5	27,0
higher alcohols (mg/l)	279	252	345	391	308	224	275	319	302	317	257	336	331	259	268	249	283	319	312	280
ethyl hexanoate	426	502	510	421	373	541	527	379	589	409	658	505	580	709	647	670	562	581	543	614
ethyl octanoate	272	279	557	302	526	871	438	329	939	487	1110	500	500	1052	910	970	902	865	931	940
ethyl lactate (mg/l)	4,0	4,5	4,0	4,0	6,0	5,0	5,5	5,0	7,0	5,5	3,5	6,0	6,0	1,5	1,5	1,5	4,0	4,5	2,0	3,5
1-hexanol	396	521	651	666	1914	1716	2323	1810	2197	2326	1510	1367	2237	1912	1273	1186	675	674	693	614
benzyl alcohol	85	68	33	34	76	73	16	12	50	30	16	4	50	21	69	102	119	318	308	264
2-phenylethanol (mg/l)	11	13	37	69	33	29	16	13	24	26	26	47	38	14	22	15	12	11	13	20
trans 3-hexenol	31	20	27	24	217	165	41	20	40	24	77	45	45	51	76	47	19	33	8	15
cis 3-hexenol	29	20	50	49	61	106	131	85	58	100	64	54	65	74	51	69	44	22	43	32
cis furan linalooloxide	68	41	40	14	42	89	66	99	20	14	7	5	10	7	1	1	1	8	5	2
trans pyran linalooloxide	<1	1	1	1	15	15	14	28	5	8	2	4	6	8	4	1	1	6	1	2
neroloxide	13	8	25	15	20	19	32	25	10	9	6	5	11	10	1	<0.5	1	6	5	1
linalool	<1	2	<1	2	<1	1	1	4	<1	3	4	<1	3	4	7	9	13	28	27	22
alpha-terpineol	15	<1	3	3	8	10	5	3	3	2	6	4	10	7	4	1	7	6	13	30
ho-trienol	1	1	<1	<1	15	15	14	28	5	8	2	4	6	8	4	1	1	6	1	2
ho-diendiol (I)	70	90	122	105	153	271	193	184	30	134	62	36	186	185	452	314	127	170	151	129
citronellol	9	8	3	3	2	25	14	19	9	9	5	4	6	7	2	<1	1	4	5	4
geraniol	1	1	5	1	33	96	2	14	<1	3	1	1	2	1	1	12	5	3	3	8
endiol	25	29	20	7	20	61	15	14	5	24	7	5	8	17	2	5	7	22	5	8
7-ethoxyhodiendiol (I)	<1	<1	<1	<1	<1	<1	4	3	<1	5	<1	<1	<1	6	15	11	8	7	2	5

Table 2 (continued):
Aroma compounds (µg/L) in bound form in 'Manzoni bianco' wines

	S. Michele (Trentino)				Gardolo (Trentino)						Telve (Trentino)						S. Colombano (Lombardy)			
	1991		1992		1993		1995		1996		1997		1998		2000		2000			
	clone		clone		clone		clone		clone		clone		clone		clone		sample			
	237	222	237	222	237	222	237	222	237	222	237	222	237	222	237	222	1	2	3	4
Monoterpenes																				
trans furan linalooloxide	50	64	81	92	75	73	129	149	93	110	45	48	57	87	46	45	13	14	12	10
cis furan linalooloxide	83	98	134	141	75	59	73	82	41	48	51	53	29	39	44	38	22	23	24	18
trans pyran linalooloxide	17	19	28	35	25	26	30	41	22	28	18	21	14	23	13	14	4	3	5	3
cis pyran linalooloxide	19	26	42	43	24	17	22	25	14	16	15	17	5	10	3	5	1	2	2	1
linalool	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	14	12	1	1	2	1
alpha-terpineol	<1	1	1	<1	<1	1	<1	2	<1	<1	1	1	3	2	6	5	2	2	3	2
citronellol	3	3	<1	<1	<1	1	<1	1	1	<1	<1	<1	3	<1	3	2	1	1	1	<1
nerol	6	5	3	6	4	1	2	1	2	2	2	2	6	6	11	8	3	4	5	3
geraniol	9	9	17	15	10	4	10	8	5	5	<1	2	16	5	13	14	6	6	7	6
trans geranic acid	10	<1	3	2	2	<1	2	4	3	<1	4	3	2	2	20	16	4	8	5	4
ho-trienol	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	3	2	4	3
ho-diendiol (I)	6	9	5	9	7	8	3	7	4	5	2	5	7	11	23	23	9	7	6	5
trans 8-hydroxylinalool	8	5	8	9	8	14	3	14	8	13	16	10	35	22	42	37	16	31	11	14
cis 8-hydroxylinalool	14	8	17	22	10	18	3	17	8	9	22	20	18	37	65	56	40	49	53	31
7-hydroxy geraniol	4	4	3	6	2	9	2	14	5	7	9	5	20	15	4	2	2	3	2	1
Others																				
3-oxo-alpha-ionol	206	270	199	150	110	203	90	143	170	85	87	85	90	150	140	100	99	92	139	53
benzyl alcohol	632	553	296	261	251	292	264	296	235	221	242	271	200	269	195	195	121	107	104	99
2-phenylethanol	135	124	145	184	112	127	91	107	103	108	144	141	178	162	123	115	65	58	74	58
1-hexanol	30	23	34	38	26	41	34	37	35	31	24	28	56	64	38	39	38	35	22	27
trans 3-hexenol	<1	<1	<1	<1	<1	<1	<1	<1	1	<1	1	2	1	3	<1	<1	<1	<1	<1	<1
cis 3-hexenol	4	5	7	6	4	2	5	7	4	3	5	5	4	4	5	5	4	3	3	3
trans 2-hexenol	6	5	6	8	3	3	3	3	3	2	1	2	10	10	2	2	<1	<1	<1	<1

Table 3:
Aroma compounds (relative ratios to 2-octanol) in the headspace (GC-MS SPME technique) of 'Manzoni bianco' wines. Absolute values (µg/l) of vitispiranes and TDN are also reported

	S. Michele (Trentino)				Gardolo (Trentino)				Telve (Trentino)								S. Colombano (Lombardy)				Sicily	
	1991		1992		1993		1995		1996		1997		1998		2000		2000				1995	
	clone		clone		clone		clone		clone		clone		clone		clone		sample				sample	
	237	222	237	222	237	222	237	222	237	222	237	222	237	222	237	222	1	2	3	4	GU	MA
a-terpenyl ethyl ether m/z 59	0,023	0,024	0,034	0,040	0,011	0,015	0,030	0,003	0,054	0,011	0,005	<0,003	0,022	0,015	0,005	0,005	0,008	0,010	0,014	0,012	0,024	0,012
geranyl ethyl ether m/z 69	<0,002	<0,002	<0,002	<0,002	0,004	0,006	<0,002	<0,002	<0,002	0,003	0,004	0,002	0,013	0,008	0,003	0,003	<0,002	0,008	0,010	0,009	0,007	<0,002
vitispiranes 1° isomer	0,56	0,49	0,87	0,80	1,13	0,73	0,53	0,58	0,18	0,41	0,11	0,07	0,16	0,10	<0,05	0,12	<0,05	<0,05	<0,05	<0,05	0,53	0,81
vitispiranes 2° isomer	0,61	0,50	0,83	0,74	0,99	0,74	0,52	0,64	0,30	0,39	0,12	<0,05	0,18	0,16	0,07	0,14	<0,05	<0,05	<0,05	<0,05	0,69	0,84
Sum of vitispiranes	*1,17*	*0,99*	*1,70*	*1,54*	*2,11*	*1,47*	*1,05*	*1,22*	*0,47*	*0,80*	*0,23*	*0,11*	*0,34*	*0,26*	*0,12*	*0,26*	*<0,05*	*<0,05*	*<0,05*	*<0,05*	*1,22*	*1,65*
Sum of vitispiranes (µg/l)	*9,80*	*8,28*	*14,3*	*13,0*	*17,8*	*12,4*	*8,84*	*10,3*	*3,98*	*6,70*	*1,95*	*0,62*	*2,89*	*2,20*	*0,62*	*2,17*	*<0,4*	*<0,4*	*<0,4*	*<0,4*	*10,3*	*13,8*
actinidol 1° isomer m/z 163	0,017	0,016	0,013	0,002	0,007	0,006	0,008	0,002	0,004	0,005	0,004	0,007	0,003	0,004	0,001	0,001	<0,001	<0,001	<0,001	<0,001	0,004	0,004
actinidol 2° isomer m/z 163	0,011	0,010	0,009	0,011	0,005	0,004	0,005	0,001	0,003	0,003	0,003	0,005	0,002	0,003	0,001	0,001	<0,001	<0,001	<0,001	<0,001	0,004	0,006
Sum of actinidols ethyl ethers	*0,028*	*0,026*	*0,022*	*0,013*	*0,012*	*0,010*	*0,013*	*0,003*	*0,007*	*0,008*	*0,007*	*0,012*	*0,005*	*0,007*	*0,002*	*0,002*	*<0,001*	*<0,001*	*<0,001*	*<0,001*	*0,007*	*0,009*
TDN	0,11	0,06	0,18	0,18	0,25	0,46	0,11	0,09	0,21	0,29	0,09	0,06	0,18	0,08	0,05	0,08	<0,05	<0,05	<0,05	<0,05	0,37	0,64
TDN (µg/l)	0,55	0,29	0,90	0,92	1,24	2,35	0,57	0,44	1,08	1,48	0,44	0,32	0,91	0,41	0,23	0,41	<0,2	<0,2	<0,2	<0,2	1,85	3,22
beta-damascenone m/z 69	0,018	0,014	0,007	0,007	0,013	0,014	0,003	0,011	0,023	0,004	0,003	0,002	0,003	0,003	0,003	0,007	0,009	0,013	0,014	0,012	0,003	0,006

benzyl alcohol) we observed prevailing and remarkable effects related to the "site and vintage", i.e. S. Michele *vs.* Gardolo and Telve, and also a "regional" effect, i.e. samples from Trentino and Lombardy of the 2000 vintage.

Among the fermentation compounds, 2-phenylethanol ranged usually below 50 mg/l, which is the level of possible sensory significance. The low pH-levels, which are a typical cultivar characteristic, and the reduced contents of ethyl lactate denote the absence of malolactic fermentation.

Among the free monoterpenols (Table 1), in particular we observed:

- furan linalooloxide was higher in the more aged wines, as a consequence of the hydrolysis of the relative bound form and cyclisation of free triol (Williams et al., 1980), as well as nerol oxide from diendiol (I), all reactions promoted by low pH-levels.
- Linalool was rather low in comparison with previous findings (Di Stefano, 1987) and compared to 'White Riesling' wines, even if the young wines had a remarkable 'Riesling'-like floral scent. Linalool contents did not exceed 10 µg/l in the products from Trentino. Higher levels were found in wines from warmer areas, like Lombardy. This fact makes the usual correlation of linalool with the 'Riesling'-like wine aroma questionable, and accounts for the rather low amounts of alpha-terpineol and endiol

in older wines. The finding of DI STEFANO (1987) that the contents of linalool and its possible reaction products were remarkably lower in wines from cooler areas than in wines from warmer, more southern areas was confirmed by our analyses with 'Manzoni bianco' wines from Sicily (data not given).
- In some wines, ho-diendiol (I) reached rather high content levels, comparable to typical 'White Riesling' wines, but hotrienol, with its possible honey-floral aroma contribution, remained at low levels.
- Geraniol and citronellol were detected in amounts of no interest by a sensory point of view, except in the wines of the vintage 1993.

Among free monoterpene forms examined with GC-SIM no other terpene was found in significant amounts. Trans furan linalooloxide was found at levels similar to the cis isomeric form. Also traces of ho-diendiol (II), roughly less than 1/20 of ho-diendiol (I), were detected in the wines. Furthermore very low amounts of cis and trans 8-hydroxylinalool were analyzed.

Table 2 shows the aglycons from the same wines reported in Table 1. It was possible to confirm previous results (VERSINI et al., 1997a), but with no clear tendency for the ratio of trans to cis furan linalooloxide. In wines from cooler areas (Telve) the concentration of the trans form seems to be higher than that of the cis isomer and vice versa in wines from warmer areas (Trentino - samples of the vintages 1991 and 1992 - , and S. Colombano). The possible inversion of another ratio (trans to cis pyranic oxide) happened in the same wines from the quoted plain area in Trentino, with a remarkably reduced content of these oxides in the wines from Lombardy. A reduced content of geraniol, trans geranic acid and nerol was found among the bound forms, as already observed for the free forms. Analogous to 'White Riesling' wines, the concentration of cis 8-hydroxylinalool was always higher than that of the trans form. In some cases, like in the wines from Lombardy, trans hexenol as aglycon was present in traces.

The results of the SPME analysis (Table 3) emphasise the general increases of VTPs and TDN with ageing. The amounts of these compounds are at levels typical for 'White Riesling' wines from northern Italian regions (MARAIS et al., 1992), but do not seem to reach the remarkable levels typical for 'White Riesling' wines from a warm area like Sicily (VERSINI et al., 1997b). Also the actinidols ethylethers increased during wine ageing, while beta-damascenone was at normal levels and similar in all wines, independent on ageing, which confirms the results of a previous work (VERSINI et al., 2002). Among the ethylether derivatives of monoterpenes, it is interesting to notice mostly the derivatives of alpha-terpineol. Besides, those of geraniol, linalool and diendiol (I) are at trace levels. It is assumed that the ho-diendiol (I) derivatives, 3,7-dimethyl-7-ethoxy-1,5-octadien-3-ol and 3,7-dimethyl-5-ethoxy-1,6-octadien-3-ol, (both ranging from 0.024 to 0.030 as relative amounts in headspace analyses of 2000 vintage wines) are produced by ethanolysis of free ho-diendiol (I) (STRAUSS et al., 1985) or during hydrolysis of glycosidic bound ho-diendiol (I) derivated at the position 7 (STRAUSS and WILLIAMS, 1983). Furthermore it is suggested that the ethoxy forms of alpha-terpineol, geraniol and linalool could be produced during ethanolysis of linalool or during early hydrolysis of linalool glycosides (STRAUSS and WILLIAMS, 1983), as no formation of geranilethylether was observed from both free and bound forms of geraniol (SKOUROUMOUNIS and SEFTON, 2000). Therefore, it is questioning whether the diendiol (I) derivatives could account for the 'Riesling'-scent observed in 'Manzoni bianco' wines. This, also in the light of their degradation during ageing (e.g. 7-ethoxy hodiendiol (I) in Table 1), as previously observed on wines from 'Garganega' grapes (data not given).

After an eight-years long investigation, no particular and stable difference was observed for the aroma composition of wines produced from the two clones (SMA-ISV 222 and SMA-ISV 237) officially available up to this day.

Conclusions

'Manzoni bianco' wines are characterised by low monoterpenol contents, as typical for so-called neutral cultivars, except when coming from vineyards in warmer regions of Italy. An exception is the rather high level of ho-diendiol (I) among the free monoterpenediols, which is typical for 'White Riesling' wines and some relevant crossings. Ho-diendiol (I) contents seem to correlate to the 'Riesling'-like floral-resinous flavour, even if this compound is assumed as flavourless. Probably, derivatives of ho-diendiol (I) which are formed during fermentation cause the peculiar aroma of 'Manzoni bianco' wines, even if, up to now, only some ethoxy ethylethers of diendiol (I) at trace level have been identified. Some peculiarities in the ratios between cis and trans furan linalooloxide and pyran linalooloxide aglycons have also been observed, likely connected to the regional effect. Unlike 'White Riesling', 'Manzoni

bianco' grown in warmer areas does not seem to favour the formation of high levels of norisoprenoid precursors like VTP and TDN.

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