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Supplementary Material

SUPPLEMENTARY TABLE S1. ^{1}H NMR chemical shifts used for amino acid identification and quantification.

Metabolite	δ^{1}_{H} (multiplicity, *J* in Hz, Assignment)
Alanine	1.47 (*d*, 7.1, CH_3), 3.77 (*q*, 7.7, CH)
Arginine*	1.68 (*m*, CH_2), 1.89 (*m*, CH_2), 3.23 (*t*, 7.0, CH_2), 3.75 (*t*, 4.9, CH)
Choline	3.19 (*s*, 3CH_3), 3.51 (*dd*, CH_2), 4.05 (*m*, CH_2)
Glutamine*	2.14 (*m*, CH_2), 2.44 (*m*, CH_2), 3.77 (*t*, 7.0, CH)
Glycine	3.56 (*s*, CH_2)
Histidine*	3.14 (*dd*, 15.4 and 7.7, CH), 3.22 (*dd*, 15.4 and 4.9, CH), 3.99 (*dd*, 7.7 and 4.9), 7.15 (*s*, CH), 8.21 (*s*, CH)
Isoleucine*	0.93 (*t*, 7.7, CH_3), 1.00 (*d*, 7.7, CH_3), 1.25 (*m*, CH_2), 1.44 (*m*, CH_2), 1.97 (*m*, CH_3), 3.67 (*d*, 4.2, CH)
Proline	2.01 (*m*, CH_2), 2.34 (*m*, CH), 3.32 (*dt*, 11.9 and 7.7, CH), 3.41 (*dt*, 11.9 and 7.0, CH), 4.11 (*dd*, 9.1 and 7.0, CH)
Leucine	0.95 (*t*, 8.4, 2CH_3), 1.70 (*m*, $CHCH_2$), 3.70 (*m*, CH)
Phenylalanine	3.11 (*dd*, 14.7 and 8.4, CH), 3.27 (*dd*, 14.7 and 5.6, CH), 3.98 (*dd*, 8.4 and 5.6, CH), 7.35 (*m*, 5CH)
Threonine*	1.32 (*d*, 7.0, CH_3), 3.59 (*d*, 4.9, CH), 4.24 (*m*, CH)
Tyrosine	3.02 (*dd*, 15.4 and 7.7, CH_2), 3.17 (*dd*, CH2), 3.92 (*dd*, 14.7 and 4.9, CH), 6.88 (*m*, 2CH), 7.18 (*m*, 2CH)
Uracil*	5.79 (*d*, 14, CH), 7.52 (*d*, 14, CH)
Valine*	0.99 (*d*, 7.3, CH_3), 1.04 (*d*, 7.3, CH_3), 2.28 (*m*, CH), 3.66 (*d*, 4.3, CH)

*Compound below detection limit.

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SUPPLEMENTARY TABLE S2. Treatment*Time Interval ANOVA with Tukey post-hoc test for sugar composition of wines treated with variable dosage composition at 0-, 9-, and 18-months of bottle aging.

Category	Time Interval (months)	Fructose	Glucose	Residual sugar (fru + glu)	Sucrose
CTRL		0.53 ab	0.45 a	0.78 a	
GLU		3.60 d	3.64 e	6.36 d	
FRU		2.84 c	2.72 d	6.19 cd	
CAN	0	0.35 a	0.32 a	7.24 fg	1.31 d
BET		0.12 a	0.15 a	7.52 g	1.12 bc
MAL		3.84 d	3.76 e	0.70 a	
MCR		4.52 f	5.67 f	6.59 de	
CTRL		1.00 b	1.77 c	1.87 b	
GLU		3.84 d	3.72 e	5.79 c	
FRU		3.03 c	3.60 e	6.35 cd	
CAN	9	0.50 ab	0.41 a	7.44 fg	1.18 c
BET		0.20 a	0.28 a	7.24 fg	1.05 ab
MAL		4.42 ef	3.91 e	0.67 a	
MCR		7.21 h	6.23 g	6.61 de	
CTRL		0.57 ab	0.88 b	0.91 a	
GLU		3.66 d	3.68 e	6.20 cd	
FRU		2.85 c	3.56 e	7.36 fg	
CAN	18	0.36 a	0.34 a	7.72 g	0.98 a
BET		0.14 a	0.17 a	7.22 fg	1.02 ab
MAL		4.00 de	3.76 e	0.80 a	
MCR		5.94 g	6.00 fg	6.94 ef	

Data represents the mean value of triplicate bottles analyzed in duplicate (n=3). *Dosage* treatments include: zero sugar control (CTR); D-glucose (GLU); D-fructose (FRU); sucrose derived from sugar beets (BET) and sugar cane (CAN); maltose (MAL); and the commercial product MCR Sucraisin® rectified grape must concentrate (MCR). Different letters within each column represent the difference between means as determined by Tukey's tests.

SUPPLEMENTARY TABLE S3. Treatment*Time Interval ANOVA with Tukey post-hoc test for amino acid and nutrient composition of wines treated with variable *dosage* composition at 0- and 18-months of bottle aging.

Category	Time Interval (months)	Alanine	Glycine	Tyrosine
CTRL	0	225.40 de	180.65 abcd	7.74 a
GLU		214.27 cde	166.83 abc	7.93 ab
FRU		189.32 bcd	256.06 e	7.93 ab
CAN		263.04 e	263.04 e	8.22 ab
BET		214.52 cde	225.40 de	8.01 ab
MAL		256.06 e	189.32 bcd	7.77 a
MCR		218.56 cde	211.92 cde	7.94 ab
CTRL	18	175.12 abcd	136.22 a	8.36 ab
GLU		211.48 cde	175.12 abcd	8.56 b
FRU		166.83 abc	218.56 cde	7.90 ab
CAN		211.92 cde	211.48 cde	8.42 ab
BET		136.22 a	214.52 cde	8.32 ab
MAL		180.65 abcd	155.58370105 ab	8.09 ab
MCR		155.58 ab	214.27 cde	8.10 ab

Data represents the mean value of triplicate bottles analyzed in duplicate (n=3). *Dosage* treatments include: zero sugar control (CTR); D-glucose (GLU); D-fructose (FRU); sucrose derived from sugar beets (BET) and sugar cane (CAN); maltose (MAL); and the commercial product MCR Sucraisin® rectified grape must concentrate (MCR). Different letters within each column represent the difference between means as determined by Tukey's tests.

SUPPLEMENTARY TABLE S4. Treatment*Time Interval ANOVA with Tukey post-hoc test for Maillard reaction-associated product composition of wines treated with variable dosage composition at 0- and 18-months of bottle aging.

Category	Time Interval (months)	Ethyl-3-mercaptopropionate	2-Acetylfuran	Furfuryl ethyl ether
CTRL	0	5.83 bcd	6.274 cd	6.888 e
GLU		6.37 b	5.128 a	6.625 de
FRU		6.27 bc	5.208 a	6.518 de
CAN		5.43 cd	5.893 bc	6.519 de
BET		5.13 bc	5.432 ab	6.371 cde
MAL		6.52 cd	5.55 ab	6.43 cde
MCR		6.63 d	5.829 bc	5.893 bc
CTRL	18	5.89 a	6.888 e	6.274 cd
GLU		6.43 a	6.625 de	6.362 cde
FRU		6.36 a	6.43 cde	5.55 ab
CAN		5.55 a	6.519 de	5.208 a
BET		5.21 a	6.362 cde	5.432 ab
MAL		6.52 a	6.518 de	5.829 bc
MCR		6.89 a	6.371 cde	5.128 a

Data represents the mean value of triplicate bottles analyzed in duplicate (n=3). *Dosage* treatments include: zero sugar control (CTR); D-glucose (GLU); D-fructose (FRU); sucrose derived from sugar beets (BET) and sugar cane (CAN); maltose (MAL); and the commercial product MCR Sucraisin® rectified grape must concentrate (MCR). Different letters within each column represent the difference between means as determined by Tukey's tests.

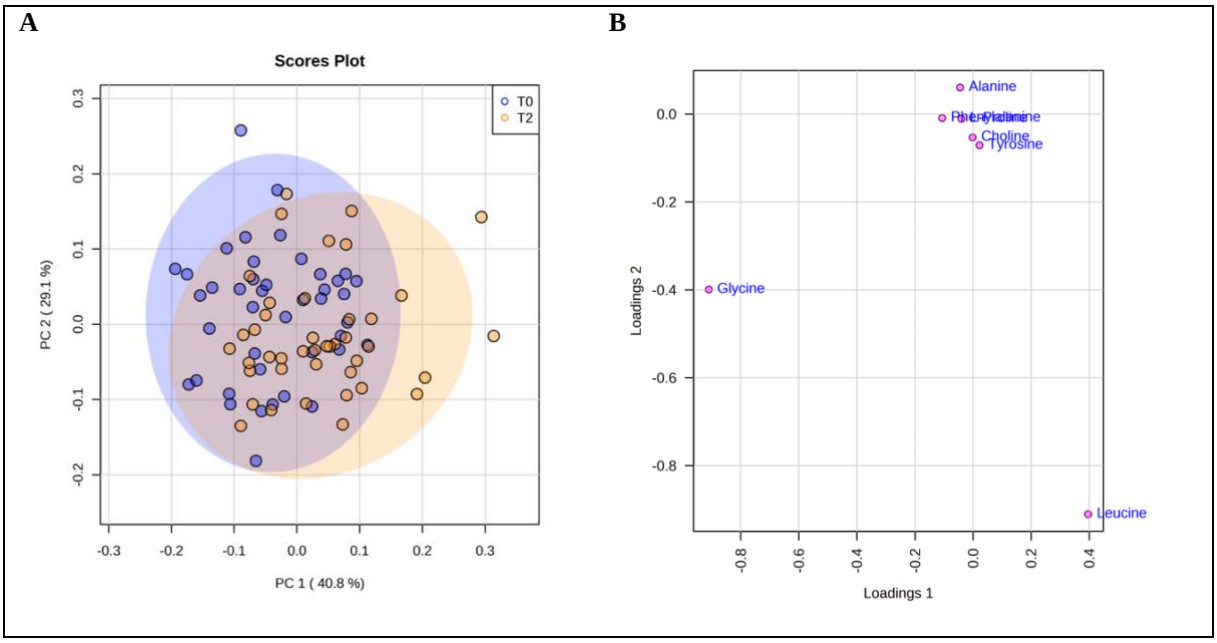
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SUPPLEMENTARY TABLE S5. Mean concentrations of major and trace elements in sparkling wines with different *dosage* sugar treatments prior to aging.

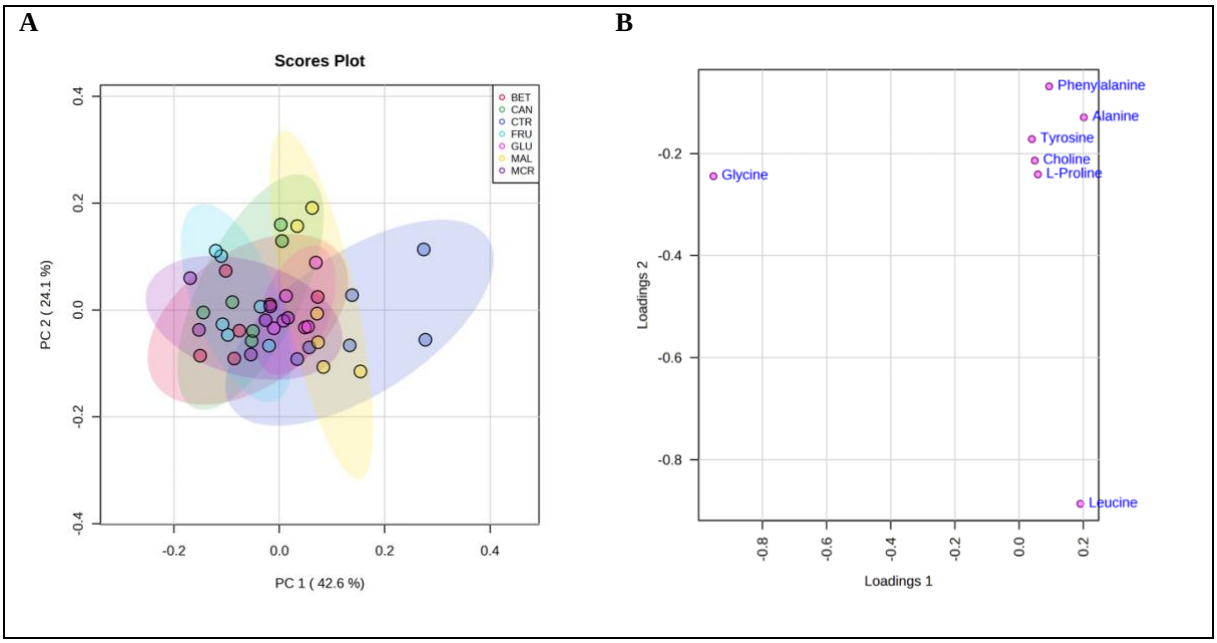
Element	Concentration of element in sparkling wines by *dosage* sugar treatment							
	CTR	GLU	FRU	CAN	BET	MAL	MCR	Significance
	mg L^{-1}							
Boron	3.1 ± 0.0 bc	3.1 ± 0.1 c	3.1 ± 0.0 bc	2.9 ± 0.1 ab	2.8 ± 0.2 a	3.0 ± 0.1 abc	3.1 ± 0.1 c	**
Calcium	71 ± 1	70 ± 3	72 ± 1	73 ± 1	71 ± 4	68 ± 4	71 ± 2	n.s.
Magnesium	78 ± 1	79 ± 2	79 ± 1	80 ± 2	77 ± 5	74 ± 4	79 ± 2	n.s.
Manganese	0.53 ± 0.01	0.54 ± 0.02	0.54 ± 0.01	0.55 ± 0.01	0.53 ± 0.04	0.51 ± 0.03	0.54 ± 0.01	n.s.
Potassium	377 ± 15	360 ± 20	343 ± 6	360 ± 0	363 ± 15	357 ± 21	350 ± 0	n.s.
Sodium	6.8 ± 0.1	6.9 ± 0.2	7.0 ± 0.1	7.0 ± 0.2	6.7 ± 0.5	6.5 ± 0.3	6.9 ± 0.1	n.s.
Strontium	0.24 ± 0.01	0.24 ± 0.01	0.24 ± 0.00	0.24 ± 0.00	0.24 ± 0.01	0.23 ± 0.01	0.24 ± 0.01	n.s.
Zinc	0.89 ± 0.01	0.90 ± 0.02	0.90 ± 0.01	0.92 ± 0.03	0.90 ± 0.04	0.86 ± 0.05	0.91 ± 0.08	n.s.
	µg L^{-1}							
Aluminium	105 ± 8	95 ± 4	99 ± 2	113 ± 15	97 ± 5	94 ± 7	95 ± 5	n.s.
Antimony	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	n.s.
Arsenic	<10	<10	<10	13 ± 3	<10	<10	<10	–
Barium	20 ± 1 b	18 ± 1 ab	18 ± 0 a	18 ± 1 ab	19 ± 1 ab	18 ± 1 a	18 ± 0 a	*
Beryllium	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	n.s.
Cadmium	0.16 ± 0.03	0.13 ± 0.01	0.15 ± 0.02	0.16 ± 0.01	0.16 ± 0.03	0.14 ± 0.01	0.14 ± 0.01	n.s.
Chromium	13 ± 0	12 ± 1	13 ± 1	13 ± 0	13 ± 1	12 ± 1	13 ± 1	n.s.
Cobalt	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	n.s.
Copper	28 ± 11	39 ± 2	40 ± 2	29 ± 4	44 ± 9	25 ± 10	30 ± 10	n.s.
Iron	<500	<500	<500	<500	<500	<500	<500	n.s.
Lead	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	n.s.
Molybdenum	<10	<10	<10	<10	<10	<10	<10	n.s.
Nickel	12 ± 0	12 ± 0	12 ± 0	12 ± 1	12 ± 1	12 ± 1	14 ± 4	n.s.
Selenium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	n.s.
Silver	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	n.s.
Thallium	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	n.s.
Tin	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	n.s.
Titanium	<100	<100	<100	<100	<100	<100	<100	n.s.
Uranium	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	n.s.
Vanadium	<10	<10	<10	<10	<10	<10	<10	n.s.

Data represents the mean value ± standard deviation of triplicate bottles analyzed in duplicate (n=3). *Dosage* treatments include: zero sugar control (CTR); D-glucose (GLU); D-fructose (FRU); sucrose derived from sugar beets (BET) and sugar cane (CAN); maltose (MAL); and the commercial product MCR Sucraisin® rectified grape must concentrate (MCR). Comparisons of treatment means was carried out via one-way ANOVA followed by Tukey's post-hoc means separation tests. Different letters across each row represent the difference between means as determined by Tukey's tests. Significance: n.s. = $p > .05$; * = $p < .05$; ** = $p < .01$. Values below the limit of detection for each metal are indicated as <LOD. Statistical analysis was not carried out for arsenic due to the high proportion of censored data.

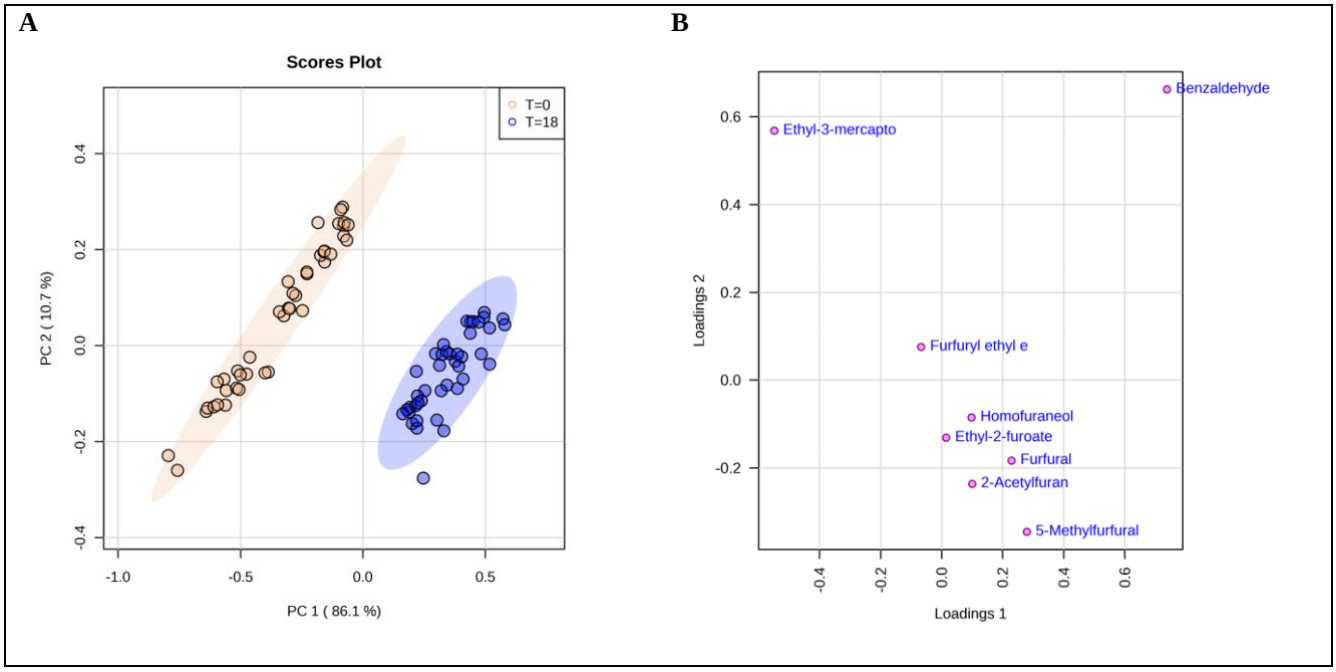
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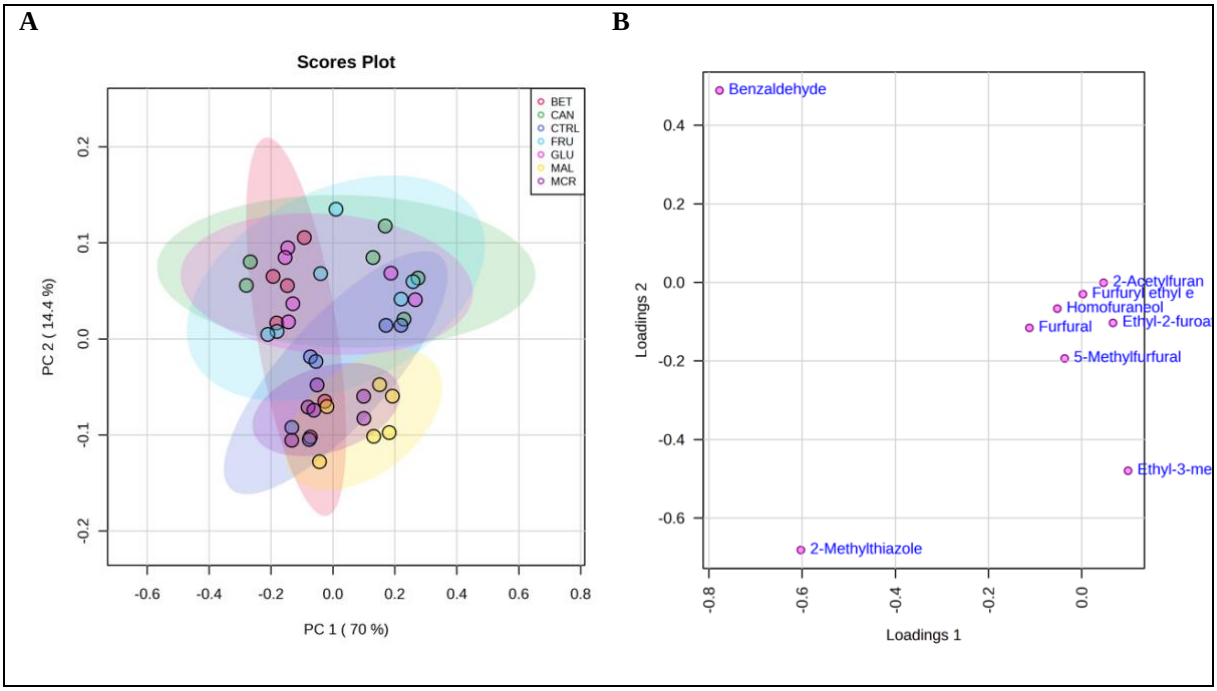
SUPPLEMENTARY FIGURE S1. PCA score (A) and loading plot (B) for amino acids in sparkling wines aged with different *dosage* sugar-types for 0-months (T0) and 18-months (T2).



SUPPLEMENTARY FIGURE S2. PCA score (A) and loading plot (B) for amino acids in sparkling wines aged with different *dosage* sugar-types at the 18-month interval.



SUPPLEMENTARY FIGURE S3. PCA score (A) and loading plot (B) for Maillard reaction-associated product data at 0-months (T0) and 18-months (T18) aging.



SUPPLEMENTARY FIGURE S4. PCA score (A) and loading plot (B) for Maillard reaction-associated product data in sparkling wines aged with different *dosage* sugar-types at the 18-month interval aging.