Multi-Elemental Analysis of Wine Samples in Relation to Their Type, Origin, and Grape Variety

Magdalena Gajek *, Aleksandra Pawlaczyk and Malgorzata I. Szynkowska-Jozwik

Faculty of Chemistry, Institute of General and Ecological Chemistry, Lodz University of Technology, Zeromskiego 116, 90-924 Lodz, Poland; aleksandra.pawlaczyk@p.lodz.pl (A.P.); malgorzata.szynkowska@p.lodz.pl (M.I.S.-J.)

* Correspondence: magdalena.gajek@edu.p.lodz.pl; Tel.: +48-42-631-30-95

Table S1. A literature review on the content of metals in wines.

Samples	Elements	Technique	Preparation	Conclusions	Ref.
60 white wines from Kosovo	Zn, Fe, Cu, Mn, Hg, As	FAAS HGAAS	Mineralization 100 mL sample + 1 mL HNO_3 (con.)	Max. content of metals: Zn 0.67 mg/L; Fe 2.03 mg/L; Cu 0.84 mg/L; Mn 1.17 mg/L; Hg 6.40 μg/L; As 6.56 μg/L	[2]
13 samples of different wine brands from Croatia: 5 white, 5 red, 1 rosé and 2 fruit wines	Pb, Cd, Cu, Zn	FAAS ZGFAAS FTSCP	Filtering + dilution + 0.1M HCl	Mean content of metals [μg/L]: Pb 9.5; Cd 0.13; Cu 156; Zn 640	[27]
17 homemade fruit wine from Poland	K, Ca, Fe, Zn, Cd, Mg, Pb, Sn, Hg	AES AAS CVAAS GFAAS	Mineralization 10 mL sample + 5 mL HNO_3 + 5 mL H_2O_2	Max. content of metals [μg/L]: Pb 166.3; Zn 316; Cd 18.4; Hg 0.437; Fe 969	[25]
60 wines from Romania and Moldova including 26 red wines (18 different grape varieties)	Ni, Ag, Cr, Sr, Zn, Cu, Rb, Mn, Pb, Co, V	ICP-MS	Mineralization 2,5 mL sample + 2,5 mL HNO_3 (con.)	Max. content of metals [μg/L]: Rb 890; Mn 865; Cu 2594.79; Zn 433,95; Ni 324,73	[6]
4 different brands of wine purchased in Polish market: 1 white and 3 red wine samples (4 different grape varieties)	Al, B, Ba Ca, Cu, Fe, K, Li, Mg, Mn, Na, P, Se, Sr, Zn	ICP-OES	1. Dilution (1:10) 2. Microwave-Assisted Digestion (2 mL of sample + 8 mL HNO3(con.)) 3. Water Bath-Assisted Digestion (2 mL of sample + 8 mL HNO3(con.) + heating)	Range of determined elements (sample prepare in three ways) [mg/L]: Li 0.057 - 0.091 Ba 0.119 – 0.285 Mn 0.57 – 1.62 B 2.44 – 5.26	[23]
44 Polish wines coming from directly 9 Polish vineyards (24	30 elements, e.g.: Ag, Al, Ba, Bi, Hg, Mn, Ni, Ti, Tl, V	ICP-MS ICP-OES	Dilution of the sample (1:10)	Mean content of metals in white wines [μg/L]: Ag 1.4; Al 710; Ba 310; Bi 49; Hg 0.4; Mn 318; Ni 64; Ti 33; Tl 0.87; V 8.2;	[5]

white and 20 red wines)					
10 red wines from Croatia gained directly for vineyards (10 different producers)	Cu, Fe, Zn, Pb	AAS	Mineralization 20 mL sample + Dissolution of the residue in 10 mL 10% HNO_3	Range of determined elements [mg/L]: Cu 0.24 – 1.12 Fe 0.81 – 6.20 Zn 0.27 – 2.43 Pb 0.11 – 0.34	[28]
1 sample of wine from Croatia	V, Cr, Mn, Fe, Ni, Cu, Zn, As, Pb	XRF	10 mL of samples + 30% H_2O_2 + evaporation + 0,5M HNO_3	Max. content of metals [µg/L]: V 1; Cr 3; Mn 5; Fe 61; Ni 6; Cu 6; Zn 59; Pb 30;	[30]
4 sample of different brand of red wines from Madeira (Portugal)	Ti, Cr, Mn, Fe, Ni, Cu, Zn, Rb, Sr, Pb	XRF	Mineralization 2 mL sample + 2 mL HNO_3(con.)	Max. content of metals [mg/L]: Ti 0.13; Cr ≤ 0.02; Mn 2.05; Fe 5.3; Ni 0.06; Cu 1.73; Zn 2.63; Rb 1.24; Sr 1.01; Pb ≤ 0.08;	[31]
60 samples of red (50) and white (10) wines purchased in Korea coming from various countries including France and Australia	Pb, Cd	GFAAS	Mineralization 5 mL sample + 5 mL HNO_3(con.)	Mean content of metals [µg/L]: Pb 29; Cd 0.5	[26]
153 samples of wine (red, white and rosé) wines from the Canary Islands (Spain)	39 trace and ultratrace elements e.g.: La, U, Te, Er	ICP-MS	Dilution of the sample (1:10)	Range of rare earth elements: 0.01 – 5.82 µg/L Range of other elements: 0.011 – 5327 µg/L Te 0.1 – 0.43 µg/L	[24]
10 wines (5 red and 5 white) from Austria	Be	AAS	Wet-ashed method	Range of Be [µg/L]: <LOD - 0.15	[29]
40 wines from three producing regions in South Africa (17 red and 23 white wines)	40 elements e.g.: Li, B, W, Ba, U, Rb, Se	ICP - MS	1. Dilution (1:1) with 0.14 M HNO_3 2. Mineralization 1.5 mL sample + 150 µL HNO_3(con.) + 1.5 mL H_2O_2 (for rare earth elements)	Range of B [mg/L]: 2.55 – 3.5	[22]
20 samples from 4 different brands of Ethiopian wines (2 white and 2 red wines)	13 elements e.g.: K, Na, Ca, Mg, Fe, Zn, Mn	FAAS	Digestion 100 mL sample + HNO_3(con.) + H_2O_2(30%)	Range of some elements [mg/L]: K 694–767 Ca 28.4–37.1 Mg 58.1–79.2	[19]

31 wines from three different regions in Argentina	11 elements e.g.: Ca, Mn, Fe, Zn, Cu	FAAS, FAES	Dilution 1% HNO_3 in the range of 1 - 500 times	Median value for Ca for different regions of Argentina [mg/L]: Córdoba – 50 La Rioja – 31 San Juan - 286	[3]
53 samples of red wine from Argentina (13), Brazil (15), Chile (13) and Uruguay (12)	45 elements e.g.: Ti, Be, Bi, Ca, Tl, Ag, U, Sn, Sr	ICP-MS, ICP-OES	1 ml sample + 3 ml HNO_3 (heating) + dilution to 25 mL	Means values for Ti and U [µg/L]: Argentina Ti – 137; U – 1.2 Brazil Ti – 126; U – 0.2 Chile Ti - 143; U – 0.4 Uruguay Ti - 143; U – 0.7	[21]

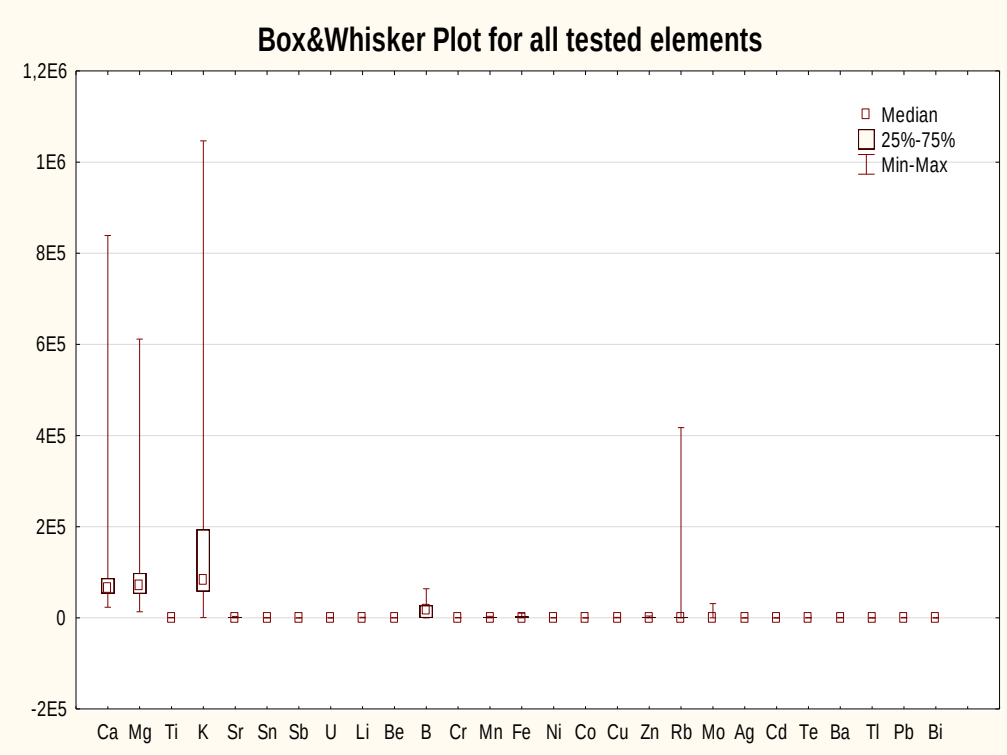

Figure S1. Box&Whisker Plot for content of all determined elements in 180 samples of wine [µg/L].

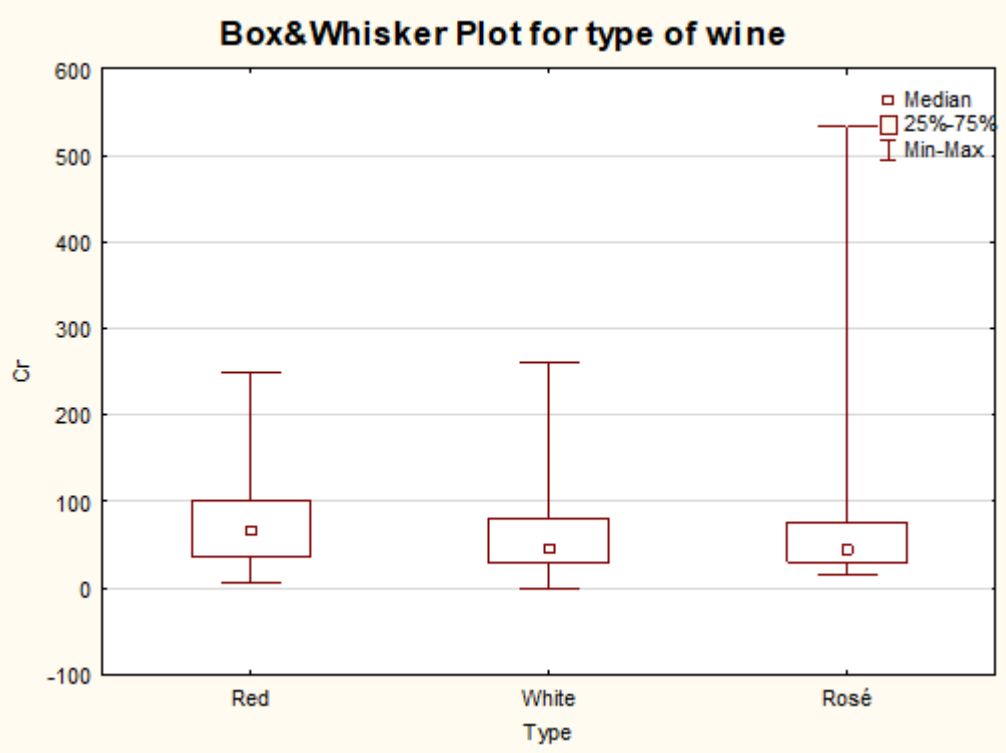

Figure S2. Box&Whisker Plot for content of Cr for obtained results of 180 samples of wine with division according to type [µg/L].

Table S2. Basic statistics of Cr for all wine samples with division according to type (n = 180) [µg/L].

Color	N	Mean	Median	Min	Max	Std. Dev.
Red	79	76.38	66.66	5.130	249.1	49.03
White	75	59.41	45.33	<LOD	262.0	45.15
Rosé	26	75.06	43.61	14.62	534.8	106.2

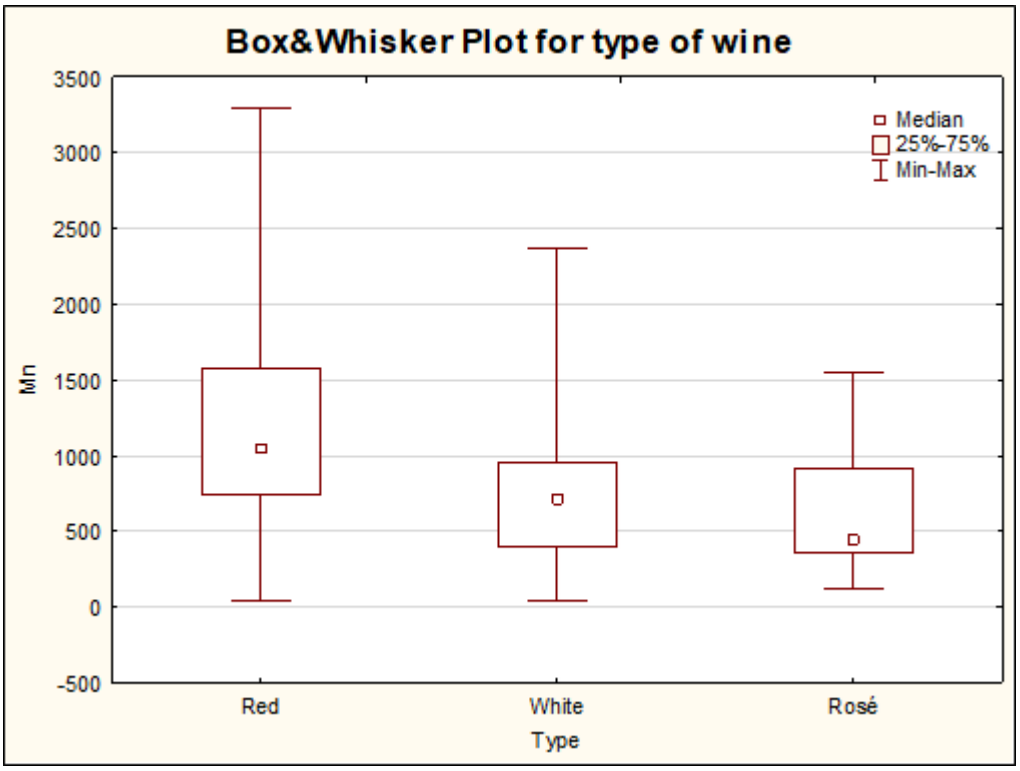

Figure S3. Box&Whisker Plot for content of Mn for obtained results of 180 samples of wine with division according to type [µg/L].

Table S3. Basic statistics of Mn for all wine samples with division according to type (n = 180) [µg/L].

Color	N	Mean	Median	Min	Max	Std. Dev.
Red	79	1172	1050	35.37	3293	690.9
White	75	741.0	715.8	40.01	2376	448.4
Rosé	26	601.9	443.4	124.7	1544	352.7

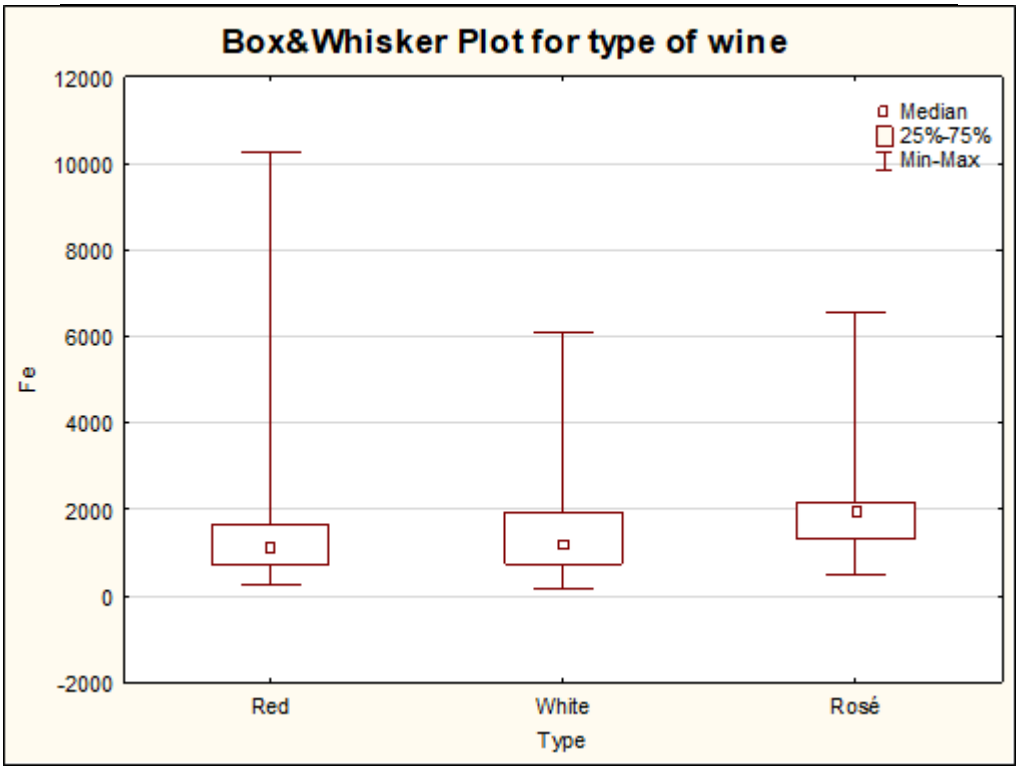

Figure S4. Box&Whisker Plot for content of Fe for obtained results of 180 samples of wine with division according to type [µg/L].

Table S4. Basic statistics of Fe for all wine samples with division according to type (n = 180) [µg/L].

Color	N	Mean	Median	Min	Max	Std. Dev.
Red	79	1454	1111	281.9	10250	1323
White	75	1530	1207	154.9	6093	1126
Rosé	26	2031	1973	483.8	6557	1252

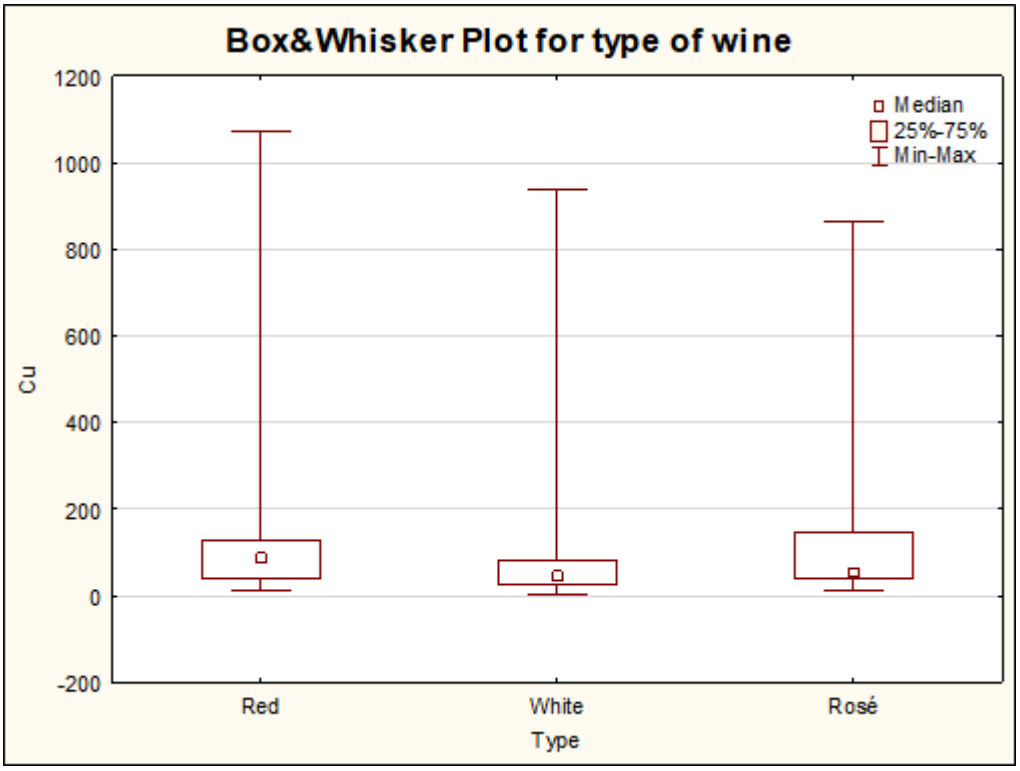

Figure S5. Box&Whisker Plot for content of Cu for obtained results of 180 samples of wine with division according to type [µg/L].

Table S5. Basic statistics of Cu for all wine samples with division according to type (n = 180) [µg/L].

Color	N	Mean	Median	Min	Max	Std. Dev.
Red	79	123.7	87.93	10.49	1072	148.4
White	75	84.91	45.34	4.930	939.1	135.3
Rosé	26	114.3	54.05	14.04	865.0	168.1

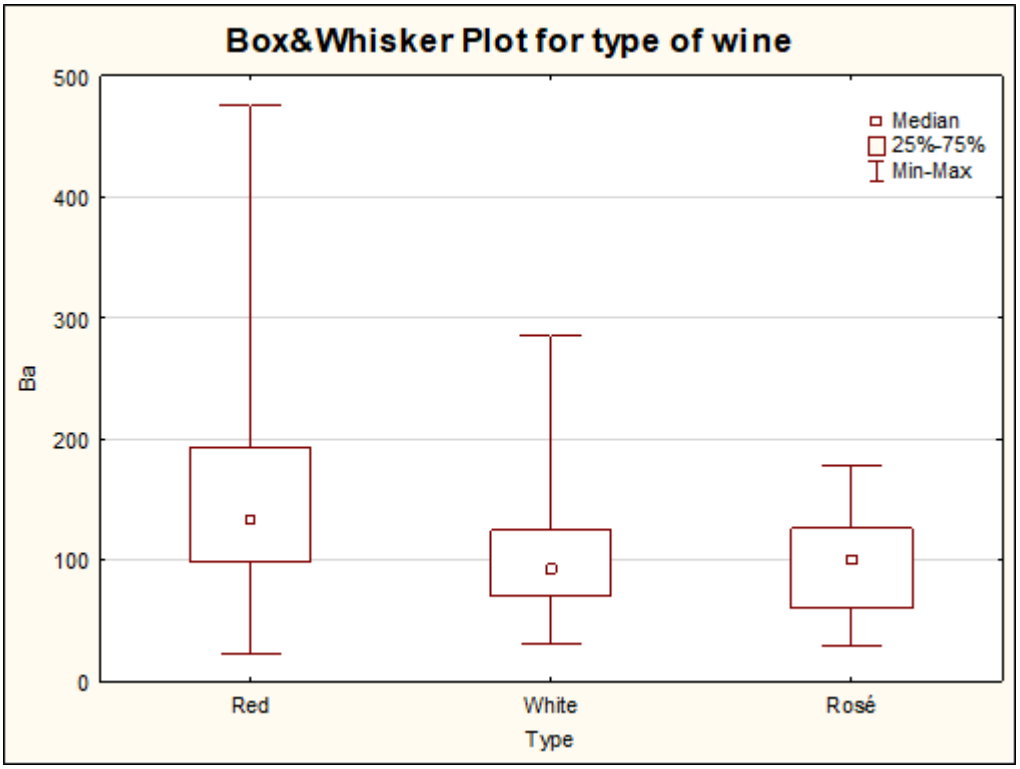

Figure S6. Box&Whisker Plot for content of Ba for obtained results of 180 samples of wine with division according to type [µg/L].

Table S6. Basic statistics of Ba for all wine samples with division according to type (n = 180) [µg/L].

Color	N	Mean	Median	Min	Max	Std. Dev.
Red	79	154.3	134.5	23.45	476.0	80.96
White	75	104.9	93.35	30.66	286.0	49.36
Rosé	26	100.4	100.0	29.37	179.1	44.92

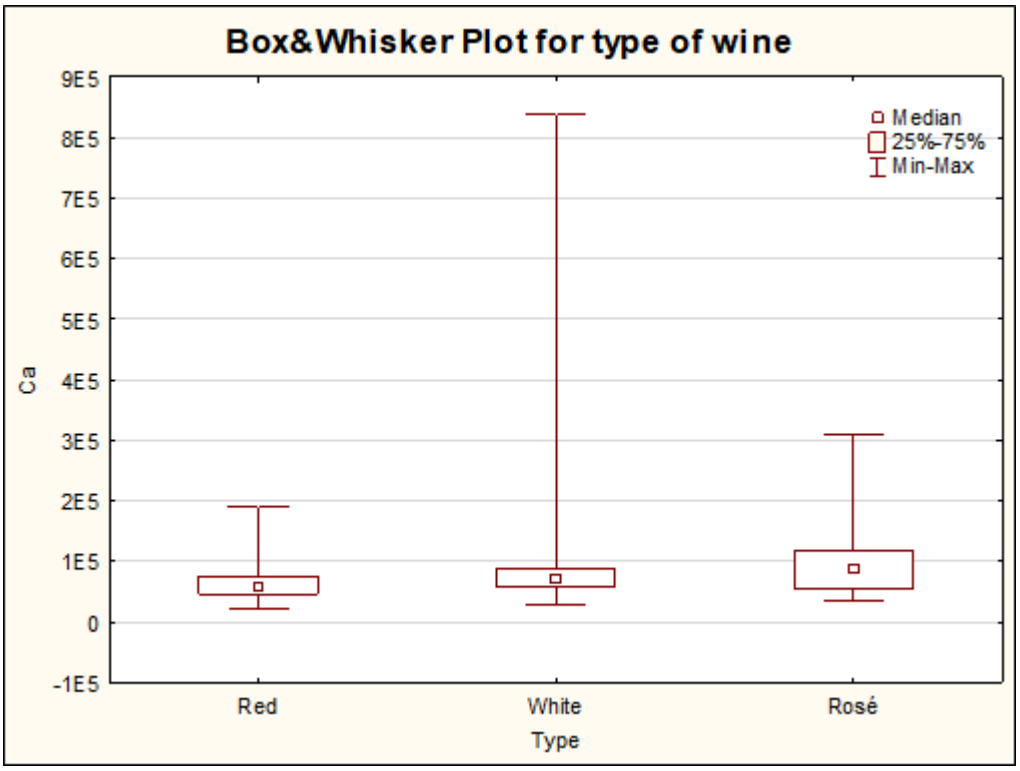

Figure S7. Box&Whisker Plot for content of Ca for obtained results of 180 samples of wine with division according to type [µg/L].

Table S7. Basic statistics of Ca for all wine samples with division according to type (n = 180) [µg/L].

Color	N	Mean	Median	Min	Max	Std. Dev.
Red	79	65669	59537	23113	190352	27654
White	75	101238	70552	30175	839115	109050
Rosé	26	95370	87996	33876	311317	56394

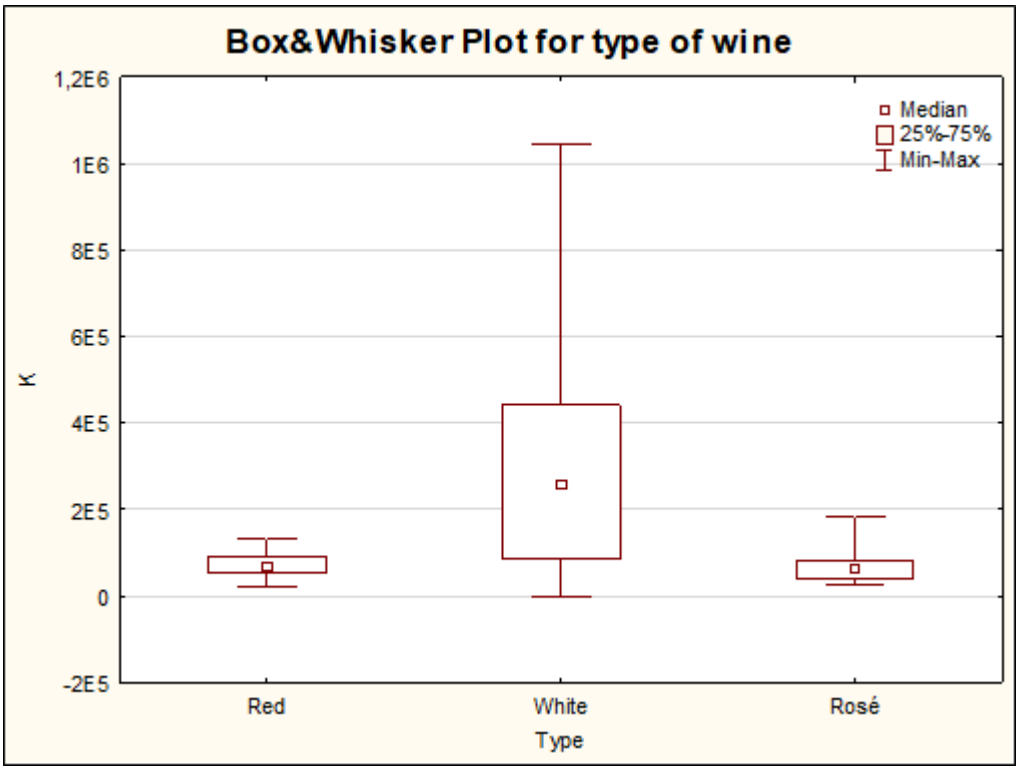

Figure S8. Box&Whisker Plot for content of K for obtained results of 180 samples of wine with division according to type [µg/L].

Table S8. Basic statistics of K for all wine samples with division according to type (n = 180) [µg/L].

Color	N	Mean	Median	Min	Max	Std. Dev.
Red	79	72176	68676	21475	132932	25811
White	75	276782	258826	480.9	1046788	210305
Rosé	26	66799	62545	28422	183589	33994

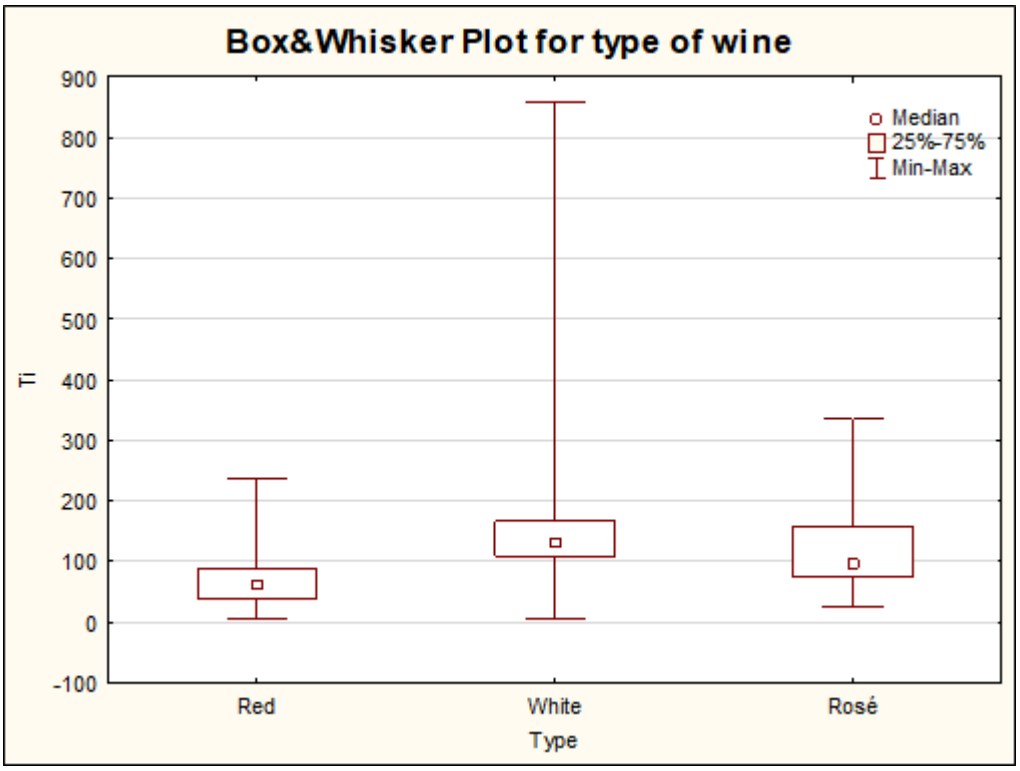

Figure S9. Box&Whisker Plot for content of Ti for obtained results of 180 samples of wine with division according to type [µg/L].

Table S9. Basic statistics of Ti for all wine samples with division according to type (n = 180) [µg/L].

Color	N	Mean	Median	Min	Max	Std. Dev.
Red	79	69.85	62.55	6.360	236.0	43.84
White	75	146.1	131.2	6.222	860.2	102.0
Rosé	26	113.8	96.46	24.72	335.2	63.88

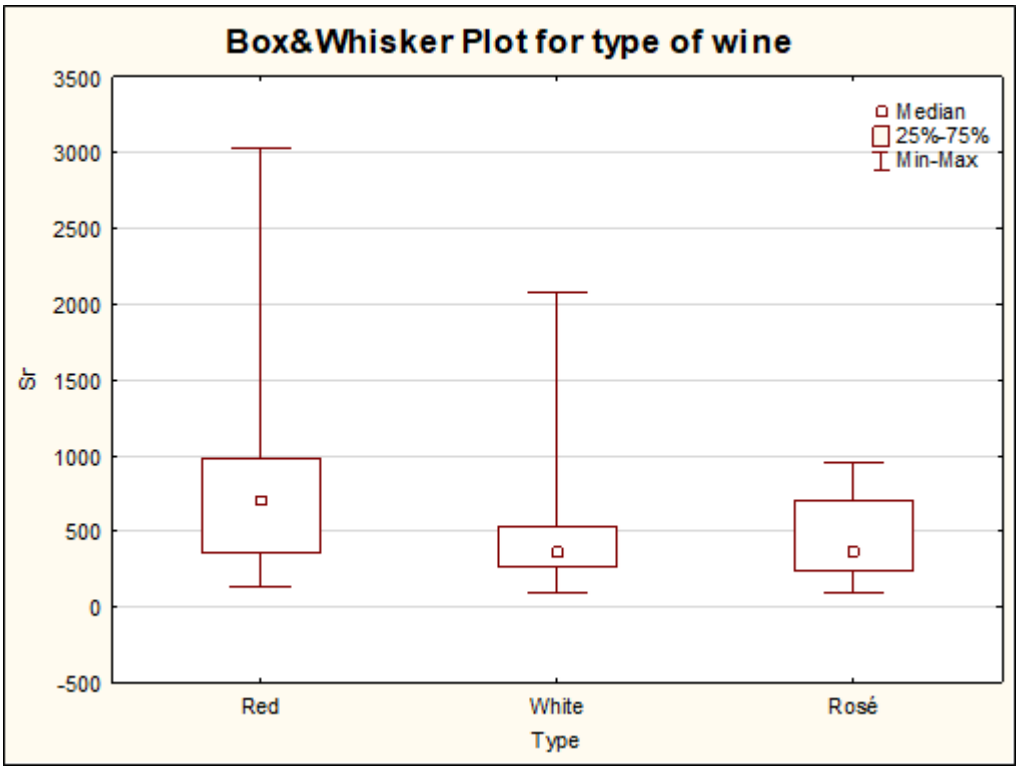

Figure S10. Box&Whisker Plot for content of Sr for obtained results of 180 samples of wine with division according to type [µg/L].

Table S10. Basic statistics of Sr for all wine samples with division according to type (n = 180) [µg/L].

Color	N	Mean	Median	Min	Max	Std. Dev.
Red	79	779.7	697.8	134.4	3034	559.3
White	75	470.9	363.4	98.54	2079	353.0
Rosé	26	462.2	361.1	95.99	951.8	282.2

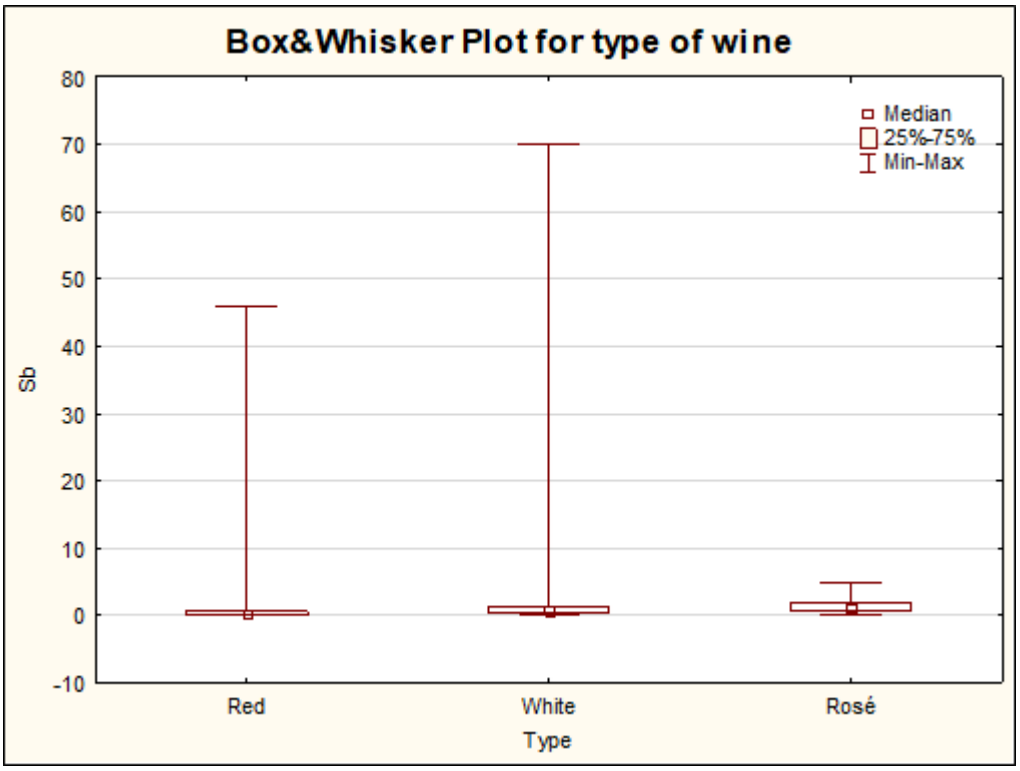

Figure S11. Box&Whisker Plot for content of Sb for obtained results of 180 samples of wine with division according to type [µg/L].

Table S11. Basic statistics of Sb for all wine samples with division according to type (n = 180) [µg/L].

Color	N	Mean	Median	Min	Max	Std. Dev.
Red	79	1.058	0.098	<LOD	45.91	5.279
White	75	1.928	0.481	<LOD	69.95	8.065
Rosé	26	1.398	1.023	<LOD	4.979	1.276

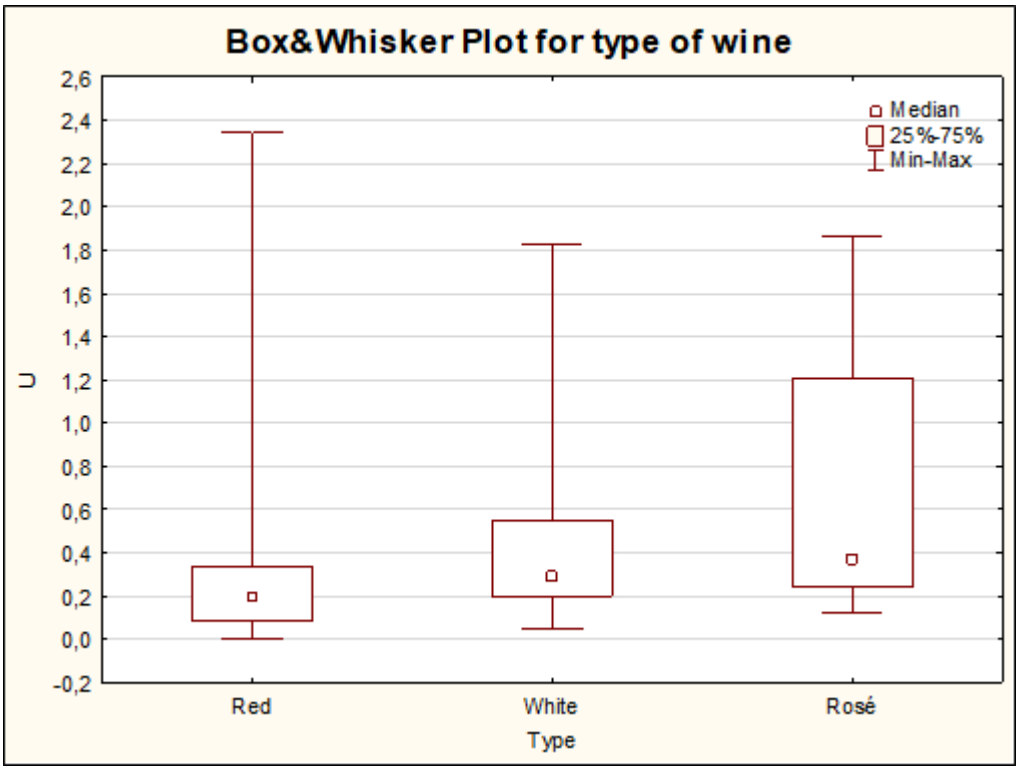

Figure S12. Box&Whisker Plot for content of U for obtained results of 180 samples of wine with division according to type [µg/L].

Table S12. Basic statistics of U for all wine samples with division according to type (n = 180) [µg/L].

Color	N	Mean	Median	Min	Max	Std. Dev.
Red	79	0.291	0.194	<LOD	2.345	0.390
White	75	0.434	0.297	0.048	1.829	0.375
Rosé	26	0.692	0.369	0.123	1.867	0.614

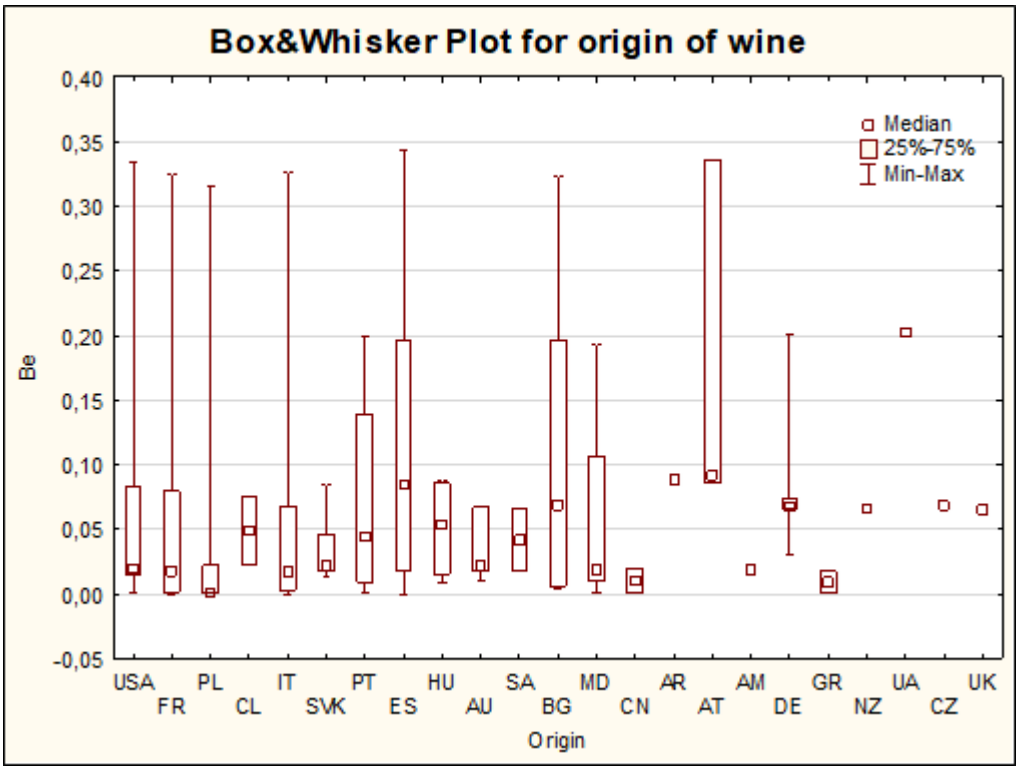

Figure S13. Box&Whisker Plot for content of Be for obtained results of 180 samples of wine with division according to country of origin [µg/L].

Table S13. Basic statistics of Be for all wine samples with division according to country of origin (n = 180) [µg/L].

Origin	N	Mean	Median	Min	Max	Std. Dev.
USA	18	0.076	0.020	0.001	0.334	0.104
FR	16	0.050	0.018	0.000	0.325	0.081
PL	42	0.026	<LOD	0.000	0.316	0.058
CL	2	0.049	0.049	0.022	0.076	0.038
IT	31	0.042	0.018	0.000	0.326	0.067
SVK	8	0.034	0.022	0.014	0.085	0.027
PT	8	0.073	0.045	0.001	0.199	0.082
ES	15	0.095	0.085	0.000	0.343	0.100
HU	4	0.051	0.053	0.009	0.088	0.041
AU	7	0.033	0.022	0.010	0.067	0.024
SA	2	0.042	0.042	0.018	0.066	0.034
BG	5	0.120	0.069	0.005	0.324	0.138
MD	3	0.058	0.019	0.001	0.193	0.091
CN	2	0.010	0.010	0.001	0.020	0.014
AR	1	0.089	0.089	0.089	0.089	-
AT	3	0.172	0.092	0.086	0.336	0.143
AM	1	0.019	0.019	0.019	0.019	-
DE	5	0.088	0.068	0.031	0.201	0.065
GR	2	0.009	0.009	0.000	0.018	0.012
NZ	1	0.067	0.067	0.067	0.067	-
UA	1	0.202	0.202	0.202	0.202	-

CZ	1	0.068	0.068	0.068	0.068	-
UK	1	0.065	0.065	0.065	0.065	-

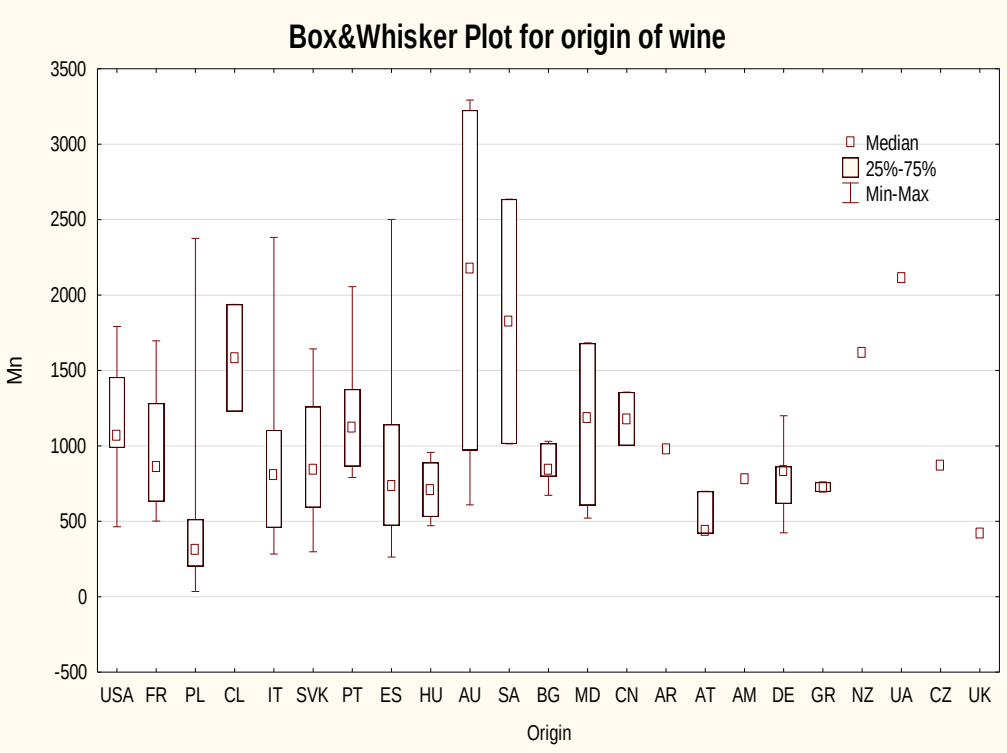

Figure S14. Box&Whisker Plot for content of Mn for obtained results of 180 samples of wine with division according to country of origin [μg/L].

Table S14. Basic statistics of Mn for all wine samples with division according to country of origin (n = 180) [μg/L].

Origin	N	Mean	Median	Min	Max	Std. Dev.
USA	18	1188	1069	464.3	1792	334.0
FR	16	962.2	862.6	501.9	1697	372.9
PL	42	452.5	314.9	35.37	2376	451.1
CL	2	1584	1584	1229	1938	501.3
IT	31	923.1	805.9	282.9	2383	524.5
SVK	8	917.5	847.2	298.1	1644	448.0
PT	8	1196	1118	790.9	2056	418.9
ES	15	876.8	732.6	262.8	2502	588.1
HU	4	709.7	705.4	471.2	956.9	220.0
AU	7	2097	2179	608.8	3293	1087
SA	2	1825	1825	1013	2636	1147
BG	5	872.9	846.8	672.4	1030	151.4
MD	3	1144	1185	521.9	1683	623.5
CN	2	1180	1180	1003	1357	250.4
AR	1	978.3	978.3	978.3	978.3	-
AT	3	520.3	441.3	420.5	698.9	155.1
AM	1	779.2	779.2	779.2	779.2	-
DE	5	787.6	833.0	424.0	1200	291.3

GR	2	727.2	727.2	695.2	759.1	45.20
NZ	1	1618	1618	1618	1618	-
UA	1	2112	2112	2112	2112	-
CZ	1	867.2	867.2	867.2	867.2	-
UK	1	421.4	421.4	421.4	421.4	-

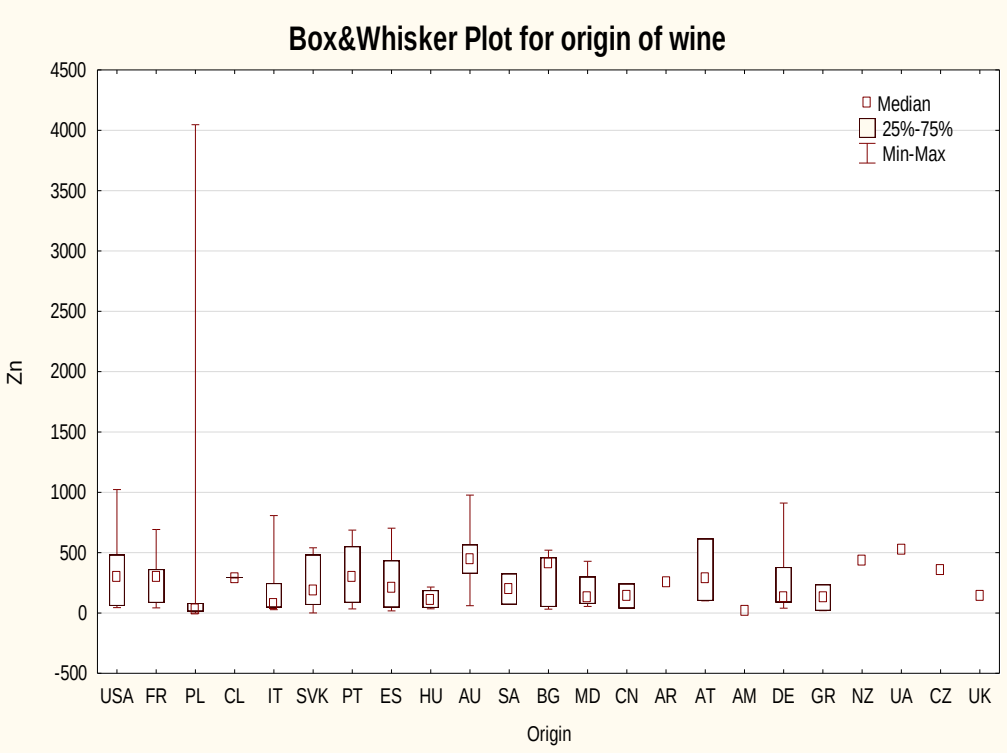

Figure S15. Box&Whisker Plot for content of Zn for obtained results of 180 samples of wine with division according to country of origin [μg/L].

Table S15. Basic statistics of Zn for all wine samples with division according to country of origin (n = 180) [μg/L].

Origin	N	Mean	Median	Min	Max	Std. Dev.
USA	18	331.1	296.2	44.84	1023	279.8
FR	16	251.6	297.7	42.40	692.1	184.2
PL	42	212.4	30.53	<LOD	4046	668.0
CL	2	292.9	292.9	290.0	295.8	4.101
IT	31	185.4	71.03	28.05	807.4	223.8
SVK	8	251.4	185.8	1.100	540.5	220.7
PT	8	324.6	299.6	34.26	687.0	256.5
ES	15	269.5	205.3	17.43	703.1	218.7
HU	4	116.4	108.0	34.95	214.9	87.36
AU	7	468.3	441.2	60.55	977.7	279.5
SA	2	198.7	198.7	71.22	326.2	180.3
BG	5	294.8	410.5	31.95	520.8	234.8
MD	3	187.4	133.6	54.14	428.4	167.7
CN	2	141.7	141.7	41.43	241.9	141.8
AR	1	257.5	257.5	257.5	257.5	-

AT	3	333.4	284.9	100.5	614.7	260.5
AM	1	17.40	17.40	17.40	17.40	-
DE	5	309.9	127.1	39.91	911.2	360.8
GR	2	127.8	127.8	19.58	236.1	153.1
NZ	1	436.0	436.0	436.0	436.0	-
UA	1	525.7	525.7	525.7	525.7	-
CZ	1	357.4	357.4	357.4	357.4	-
UK	1	137.4	137.4	137.4	137.4	-

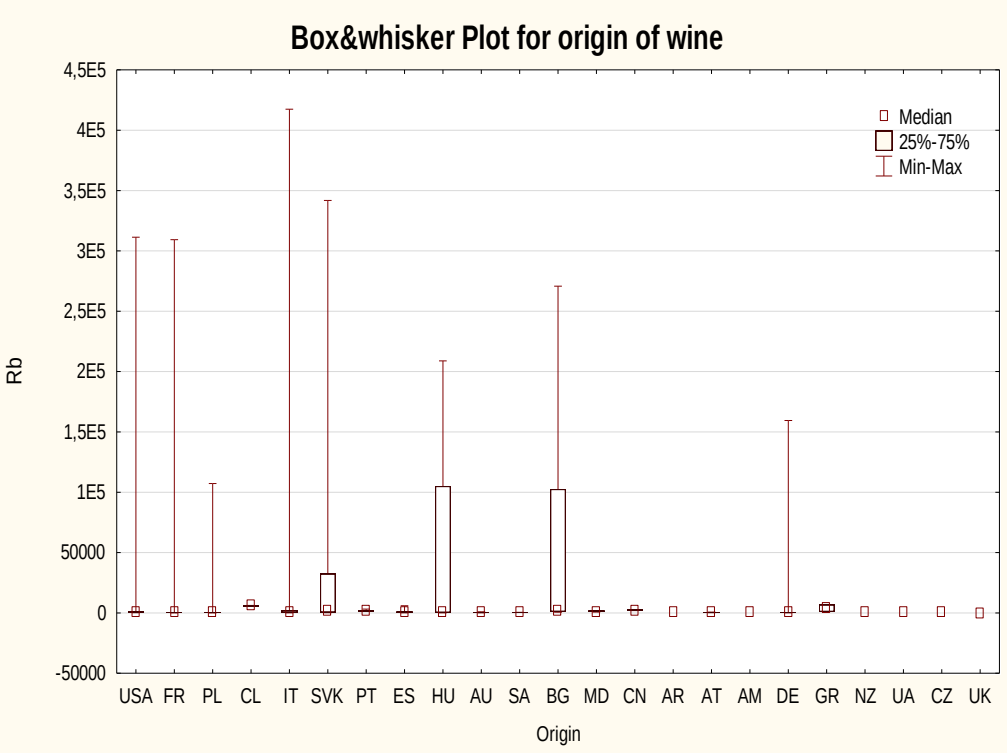

Figure S16. Box&Whisker Plot for content of Rb for obtained results of 180 samples of wine with division according to country of origin [μg/L].

Table S16. Basic statistics of Rb for all wine samples with division according to country of origin (n = 180) [μg/L].

Origin	N	Mean	Median	Min	Max	Std. Dev.
USA	18	18311	1249	140.4	311332	73130
FR	16	42211	537.5	32.18	309332	97923
PL	42	6164	329.5	5.650	107197	23193
CL	2	5956	5956	5661	6251	417.3
IT	31	36495	1132	35.79	417452	100941
SVK	8	51462	1865	131.4	341837	119222
PT	8	1894	1653	1294	3232	685.8
ES	15	940.7	623.1	40.15	6008	1455
HU	4	52675	842.9	79.45	208933	104173
AU	7	537.2	496.6	106.1	947.2	264.1
SA	2	441.1	441.1	362.1	520.1	111.7
BG	5	75313	1431	626.0	270782	117783

MD	3	1231	1162.1	749.8	1849	526.7
CN	2	2409	2409	1991	2827	591.0
AR	1	424.5	424.5	424.5	424.5	-
AT	3	499.7	629.0	202.5	667.7	258.1
AM	1	405.1	405.1	405.1	405.1	-
DE	5	32070	230.2	52.69	159500	71236
GR	2	3892	3892	1103	6681	3944
NZ	1	940.7	940.7	940.7	940.7	-
UA	1	621.4	621.4	621.4	621.4	-
CZ	1	1318	1318	1318	1318	-
UK	1	205.3	205.3	205.3	205.3	-

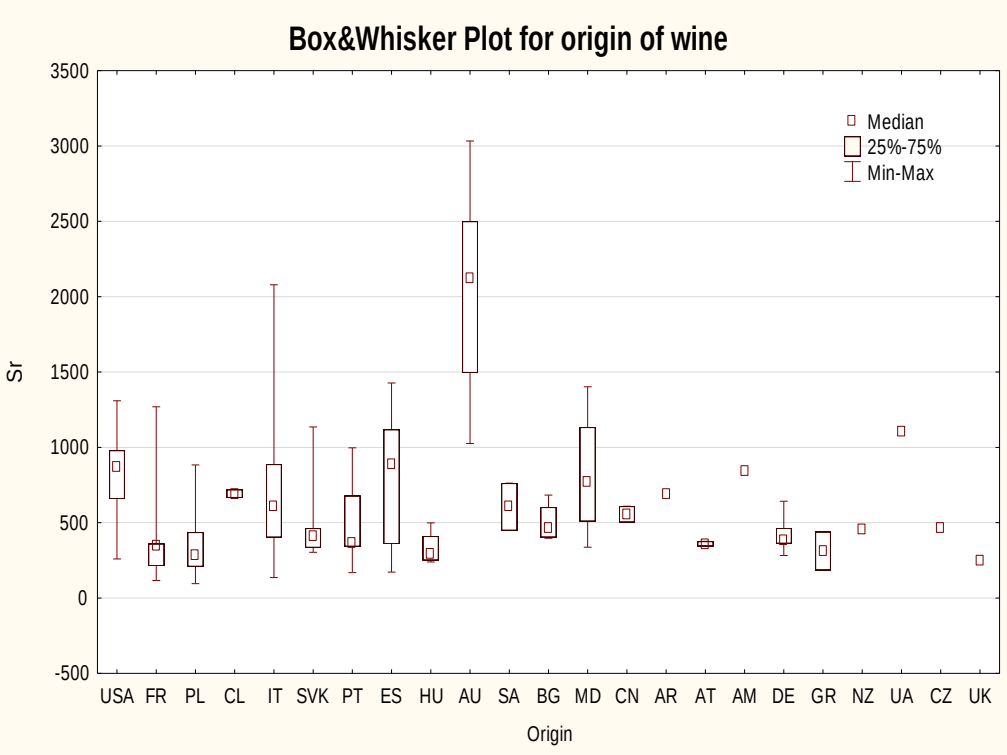

Figure S17. Box&Whisker Plot for content of Sr for obtained results of 180 samples of wine with division according to country of origin [μg/L].

Table S17. Basic statistics of Sr for all wine samples with division according to country of origin (n = 180) [μg/L].

Origin	N	Mean	Median	Min	Max	Std. Dev.
USA	18	798.8	874.3	259.6	1310	311.8
FR	16	384.4	343.6	116.3	1270	280.6
PL	42	336.9	288.5	96.0	883.8	193.0
CL	2	692.5	692.5	664.9	720.0	38.99
IT	31	701.1	613.0	136.0	2079	448.8
SVK	8	481.3	406.7	303.9	1136	271.7
PT	8	491.1	361.9	168.4	997.5	305.7
ES	15	770.2	890.6	171.9	1427	409.1
HU	4	331.4	293.6	239.2	499.0	117.1

AU	7	2094	2123	1025.8	3034	664.9
SA	2	605.3	605.3	447.9	762.8	222.7
BG	5	511.0	467.5	397.0	683.3	127.0
MD	3	822.1	774.2	337.7	1402	444.6
CN	2	557.2	557.2	504.3	610.1	74.82
AR	1	689.4	689.4	689.4	689.4	-
AT	3	361.0	360.4	345.6	376.9	15.66
AM	1	840.9	840.9	840.9	840.9	-
DE	5	427.3	385.3	282.1	642.9	136.9
GR	2	312.1	312.1	185.6	438.7	179.0
NZ	1	453.6	453.6	453.6	453.6	-
UA	1	1107	1107	1107	1107	-
CZ	1	463.4	463.4	463.4	463.4	-
UK	1	248.1	248.1	248.1	248.1	-

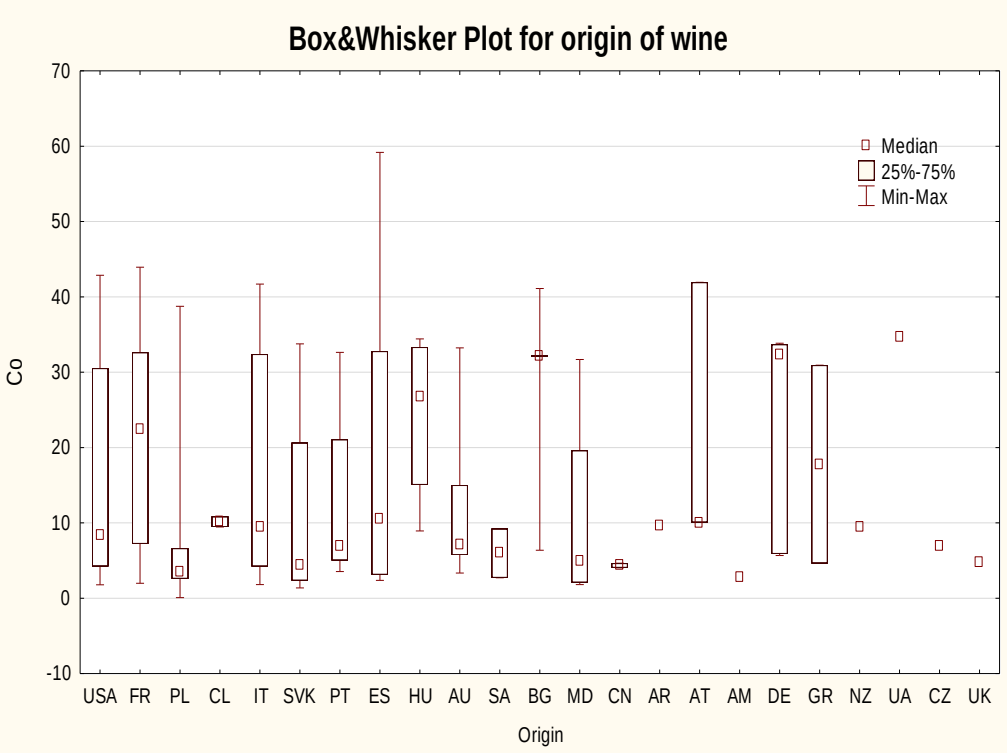

Figure S18. Box&Whisker Plot for content of Co for obtained results of 180 samples of wine with division according to country of origin [μg/L].

Table S18. Basic statistics of Co for all wine samples with division according to country of origin (n = 180) [μg/L].

Origin	N	Mean	Median	Min	Max	Std. Dev.
USA	18	14.64	8.352	1.780	42.87	14.34
FR	16	20.42	22.53	1.990	43.95	14.51
PL	42	8.377	3.621	0.080	38.75	10.90
CL	2	10.15	10.15	9.460	10.83	0.969
IT	31	16.13	9.420	1.810	41.70	13.74
SVK	8	11.25	4.455	1.370	33.77	13.50

PT	8	12.81	7.018	3.550	32.64	12.10
ES	15	18.55	10.55	2.370	59.18	17.05
HU	4	24.20	26.73	8.940	34.42	11.71
AU	7	11.25	7.080	3.350	33.24	10.34
SA	2	5.965	5.965	2.720	9.210	4.589
BG	5	28.80	32.19	6.370	41.12	13.13
MD	3	10.86	4.955	1.820	31.70	14.13
CN	2	4.355	4.355	4.050	4.660	0.432
AR	1	9.700	9.700	9.700	9.700	-
AT	3	20.71	10.10	10.09	41.94	18.39
AM	1	2.750	2.750	2.750	2.750	-
DE	5	22.30	32.37	5.680	33.85	15.09
GR	2	17.81	17.81	4.670	30.94	18.58
NZ	1	9.470	9.470	9.470	9.470	-
UA	1	34.77	34.77	34.77	34.77	-
CZ	1	6.920	6.920	6.920	6.920	-
UK	1	4.710	4.710	4.710	4.710	14.34

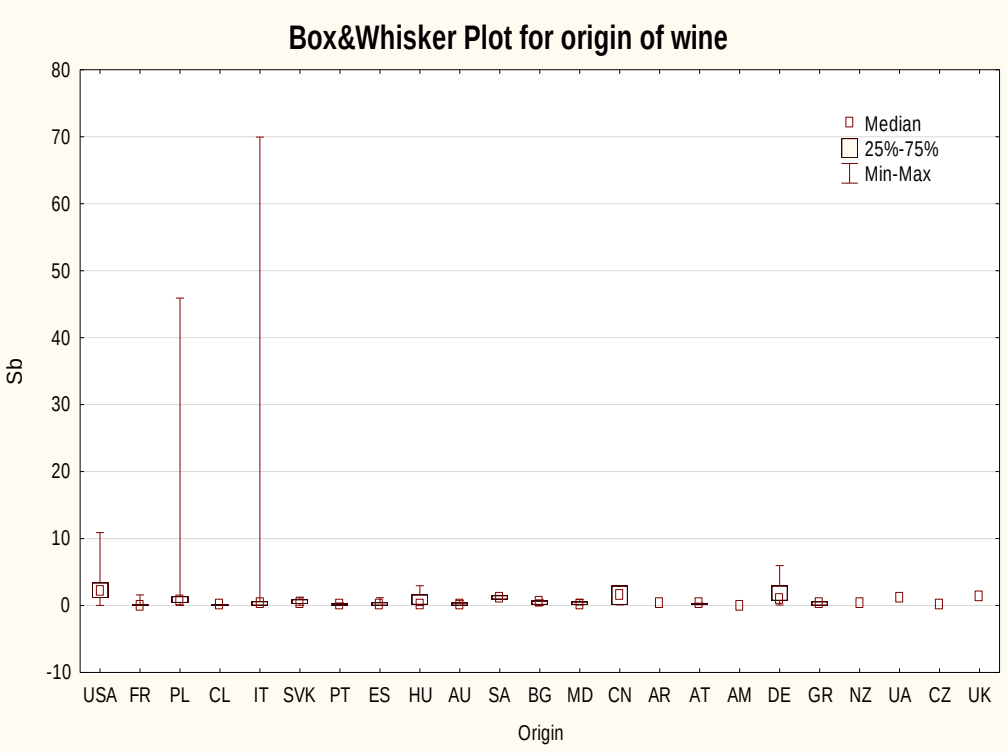

Figure S19. Box&Whisker Plot for content of Sb for obtained results of 180 samples of wine with division according to country of origin [μg/L].

Table S19. Basic statistics of Sb for all wine samples with division according to country of origin (n = 180) [μg/L].

Origin	N	Mean	Median	Min	Max	Std. Dev.
USA	18	2.752	2.147	<LOD	10.88	2.426
FR	16	0.187	<LOD	<LOD	1.584	0.411
PL	42	2.181	0.815	<LOD	45.91	7.025

CL	2	0.059	0.059	<LOD	0.109	0.070
IT	31	2.603	0.275	<LOD	69.95	12.51
SVK	8	0.561	0.451	0.051	1.246	0.423
PT	8	0.146	0.113	<LOD	0.389	0.150
ES	15	0.311	0.202	<LOD	1.166	0.365
HU	4	0.862	0.238	<LOD	2.962	1.404
AU	7	0.223	0.065	<LOD	0.767	0.287
SA	2	1.221	1.221	0.935	1.507	0.405
BG	5	0.432	0.512	<LOD	0.848	0.365
MD	3	0.326	0.153	0.075	0.925	0.403
CN	2	1.510	1.510	0.099	2.921	1.996
AR	1	0.266	0.266	0.266	0.266	-
AT	3	0.262	0.308	0.124	0.354	0.122
AM	1	0.019	0.019	0.019	0.019	-
DE	5	2.124	0.925	0.075	5.966	2.399
GR	2	0.297	0.297	<LOD	0.584	0.406
NZ	1	0.302	0.302	0.302	0.302	-
UA	1	1.217	1.217	1.217	1.217	-
CZ	1	0.084	0.084	0.084	0.084	-
UK	1	1.377	1.377	1.377	1.377	-

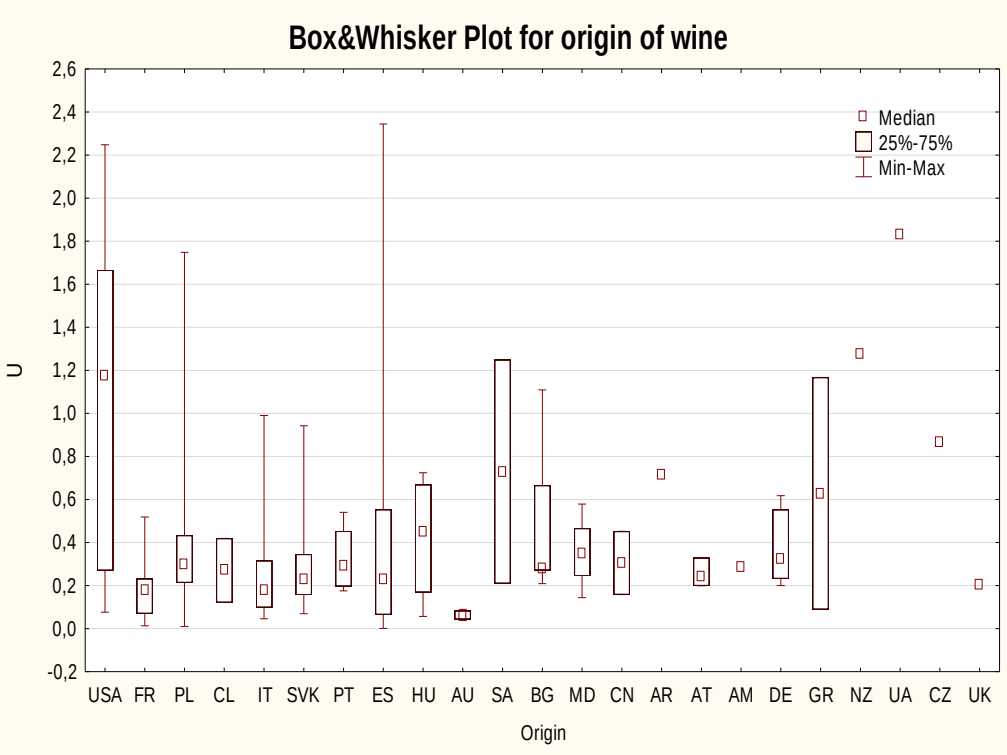

Figure S20. Box&Whisker Plot for content of U for obtained results of 180 samples of wine with division according to country of origin [μg/L].

Table S20. Basic statistics of U for all wine samples with division according to country of origin (n = 180) [μg/L].

Origin	N	Mean	Median	Min	Max	Std. Dev.

USA	18	1.028	1.175	0.077	2.248	0.721
FR	16	0.181	0.181	0.013	0.519	0.131
PL	42	0.367	0.298	<LOD	1.748	0.300
CL	2	0.270	0.270	0.122	0.419	0.210
IT	31	0.239	0.178	0.046	0.990	0.190
SVK	8	0.309	0.229	0.070	0.943	0.276
PT	8	0.325	0.290	0.176	0.540	0.149
ES	15	0.427	0.226	<LOD	2.345	0.582
HU	4	0.419	0.447	0.057	0.725	0.306
AU	7	0.061	0.057	0.038	0.090	0.019
SA	2	0.729	0.729	0.210	1.248	0.734
BG	5	0.507	0.280	0.209	1.109	0.382
MD	3	0.355	0.349	0.144	0.579	0.178
CN	2	0.305	0.305	0.158	0.452	0.208
AR	1	0.715	0.715	0.715	0.715	-
AT	3	0.256	0.241	0.199	0.328	0.066
AM	1	0.283	0.283	0.283	0.283	-
DE	5	0.386	0.327	0.200	0.618	0.189
GR	2	0.629	0.629	0.090	1.167	0.762
NZ	1	1.275	1.275	1.275	1.275	-
UA	1	1.829	1.829	1.829	1.829	-
CZ	1	0.869	0.869	0.869	0.869	-
UK	1	0.204	0.205	0.205	0.205	-

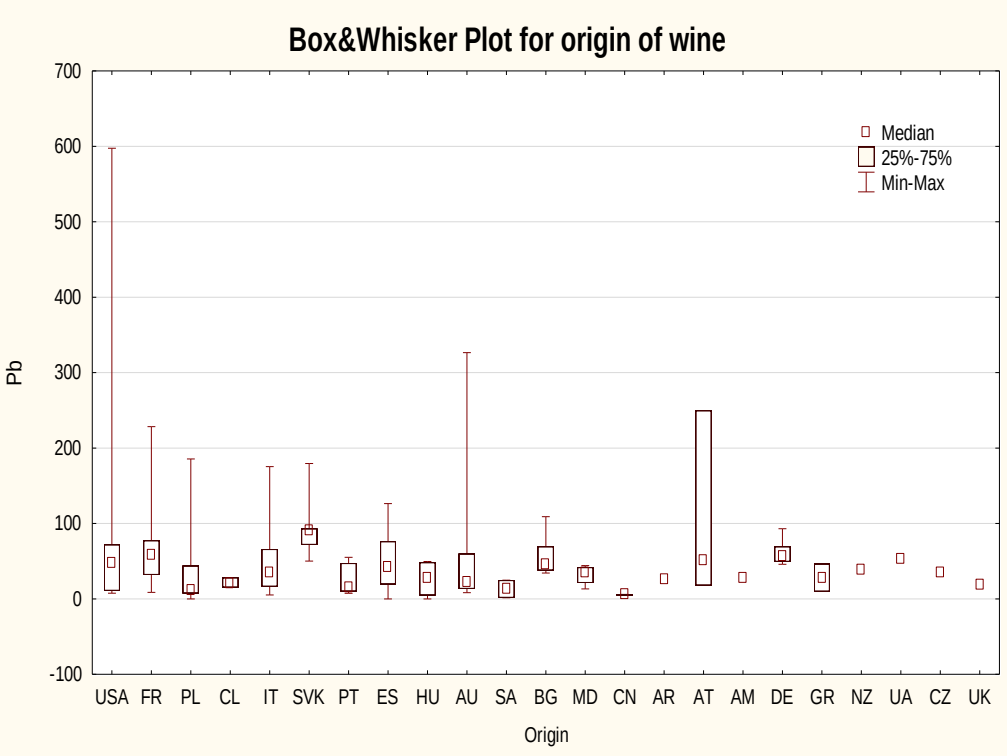

Figure S21. Box&Whisker Plot for content of Pb for obtained results of 180 samples of wine with division according to country of origin [μg/L].

Table S21. Basic statistics of Pb for all wine samples with division according to country of origin (n = 180) [μg/L].

Origin	N	Mean	Median	Min	Max	Std. Dev.
USA	18	88.53	48.02	7.512	597.6	141.0
FR	16	64.74	59.23	8.730	228.5	51.77
PL	42	31.77	12.22	<LOD	185.6	42.41
CL	2	21.80	21.80	15.40	28.19	9.044
IT	31	45.26	35.09	5.310	175.3	37.37
SVK	8	92.83	91.59	50.11	179.6	38.43
PT	8	26.09	15.39	7.400	55.16	20.13
ES	15	49.76	42.59	<LOD	126.4	38.85
HU	4	26.81	28.79	<LOD	49.66	25.40
AU	7	69.41	22.66	8.300	326.5	114.6
SA	2	13.23	13.23	1.520	24.94	16.56
BG	5	59.32	45.81	34.38	109.1	30.95
MD	3	31.50	34.49	13.25	44.14	13.81
CN	2	5.513	5.513	4.980	6.047	0.754
AR	1	25.78	25.78	25.78	25.78	-
AT	3	106.3	50.93	18.13	249.7	125.3
AM	1	28.06	28.06	28.06	28.06	-
DE	5	62.96	57.17	45.87	93.01	19.07
GR	2	28.21	28.21	10.06	46.37	25.68
NZ	1	39.26	39.26	39.26	39.26	-
UA	1	53.09	53.09	53.09	53.09	-
CZ	1	34.64	34.64	34.64	34.64	-
UK	1	18.65	18.65	18.65	18.65	-

Abbreviations:

USA – United States of America

FR – France

PL – Poland

CL – Chile

IT – Italy

SVK – Slovakia

PT – Portugal

ES – Spain

HU – Hungary

AU – Australia

SA – South Africa

BG – Bulgaria

MD – Moldova

CN – China

AR – Argentina

AT – Austria

AM – Armrnia

DE – Germany

GR – Grecce

NZ – New Zealand

UA – Ukraine

CZ – Czech Republic

UK – United Kingdom

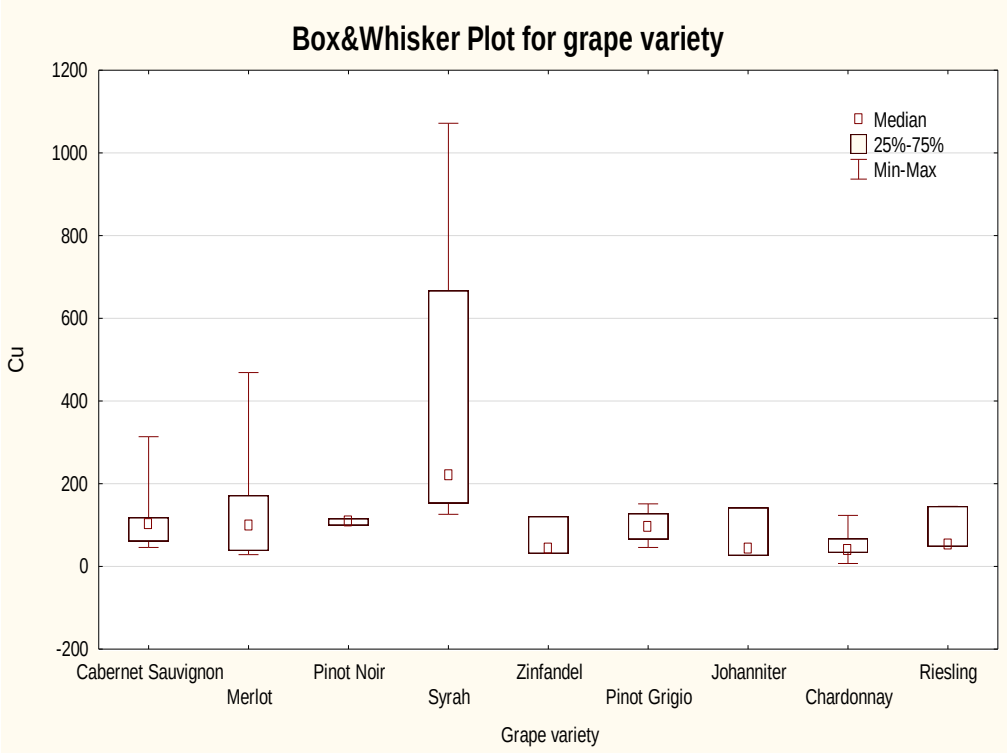

Figure S22. Box&Whisker Plot for content of Cu for obtained results of 38 samples of wine with division according to grape variety [µg/L].

Table S22. The basic statistic information of Cu content in five grape variety (n=38) [µg/L].

Grape variety	N	Mean	Median	Min	Max	Grape variety	N	Mean	Median	Min	Max
Cabernet Sauvignon	5	128.8	104.1	46.05	313.9	Pinot Grigio	4	96.92	95.19	45.92	151.4

Merlot	5	161.7	100.8	28.49	469.0	Johanniter	3	70.77	44.09	26.55	141.7
Pinot Noir	2	107.7	107.7	99.77	115.5	Chardonnay	9	54.68	39.95	7.180	123.3
Syrah	4	410.2	221.3	125.9	1072	Riesling	3	82.21	52.69	48.60	145.3
Zinfandel	3	64.75	41.95	31.32	120.9						

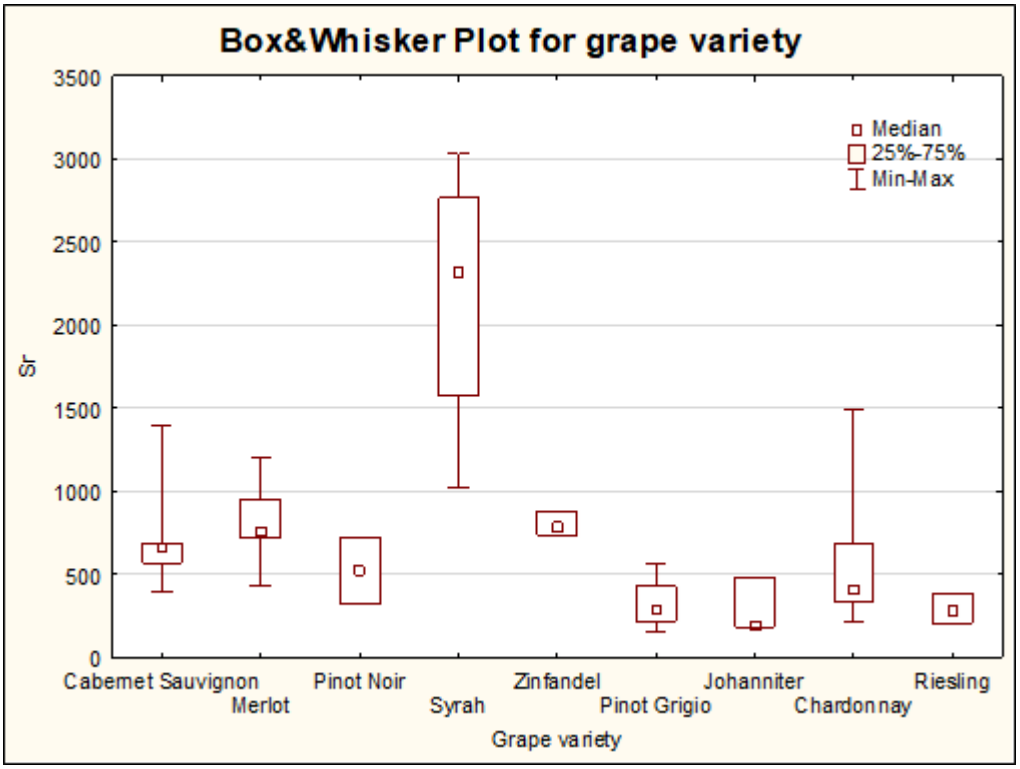

Figure S23. Box&Whisker Plot for content of Sr for obtained results of 38 samples of wine with division according to grape variety [μg/L].

Table S23. The basic statistic information of Sr content in five grape variety (n=38) [μg/L].

Grape variety	N	Mean	Median	Min	Max	Grape variety	N	Mean	Median	Min	Max
Cabernet Sauvignon	5	743.7	664.9	397.0	1402	Pinot Grigio	4	324.6	289.7	159.1	559.9
Merlot	5	814.6	762.8	433.8	1200	Johanniter	3	288.8	194.9	185.7	485.7
Pinot Noir	2	524.9	524.9	322.8	726.9	Chardonnay	9	613.8	404.0	214.8	1494
Syrah	4	2170	2311	1025	3033	Riesling	3	292.1	282.1	209.0	385.3
Zinfandel	3	803.1	786.8	739.6	882.8						

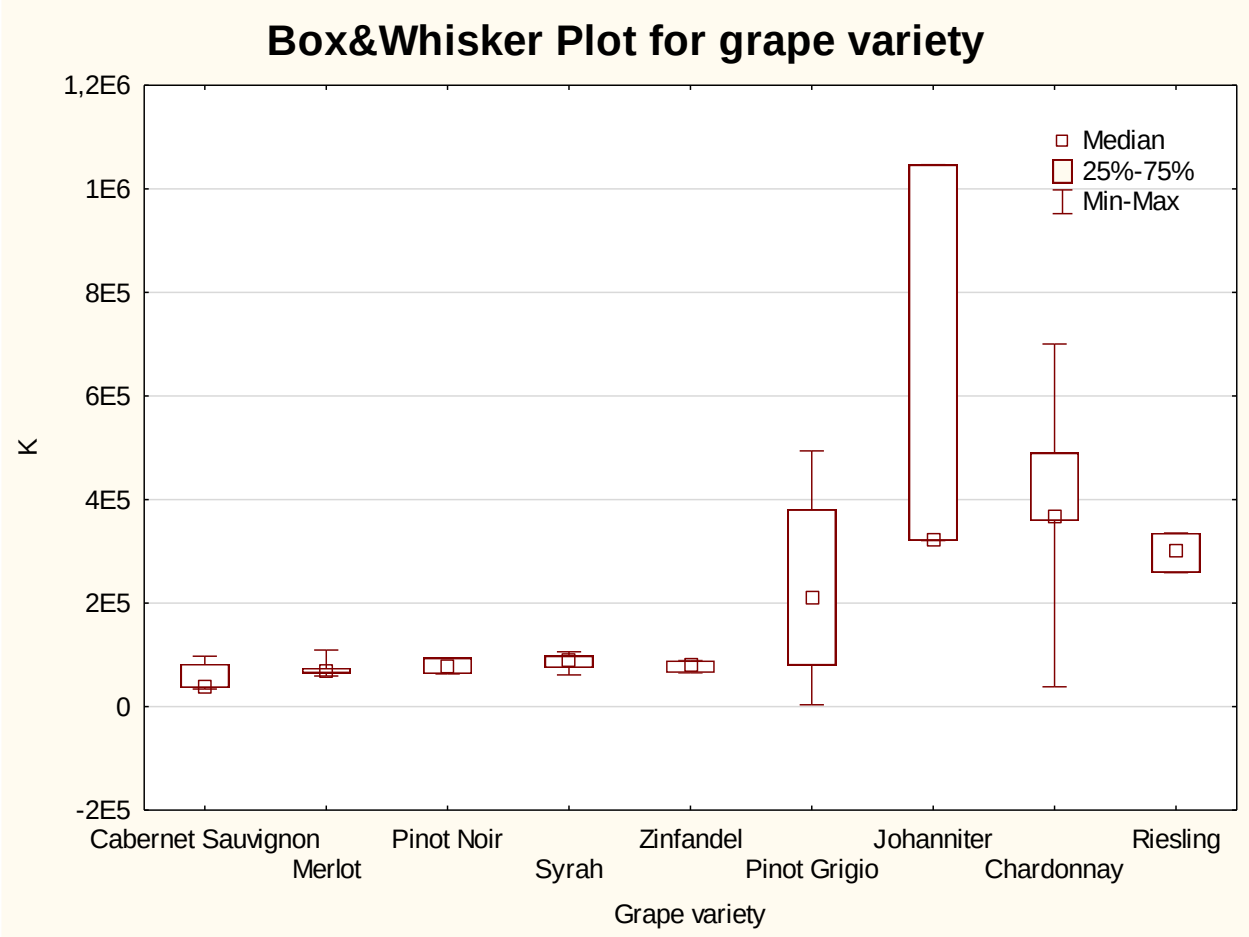

Figure S24. Box&Whisker Plot for content of K for obtained results of 38 samples of wine with division according to grape variety [μg/L].

Table S24. The basic statistic information of K content in five grape variety (n=38) [μg/L].

Grape variety	N	Mean	Median	Min	Max	Grape variety	N	Mean	Median	Min	Max
Cabernet Sauvignon	5	57488	37448	34082	97261	Pinot Grigio	4	230314	211920	3562	493856
Merlot	5	75306	68676	59101	109371	Johanniter	3	562940	321233	320800	1046788
Pinot Noir	2	78646	78646	63249	94042	Chardonnay	9	393750	366750	38250	700228
Syrah	4	86492	89514	61154	105787	Riesling	3	298287	300724	258826	335310
Zinfandel	3	78259	80496	65331	88950						

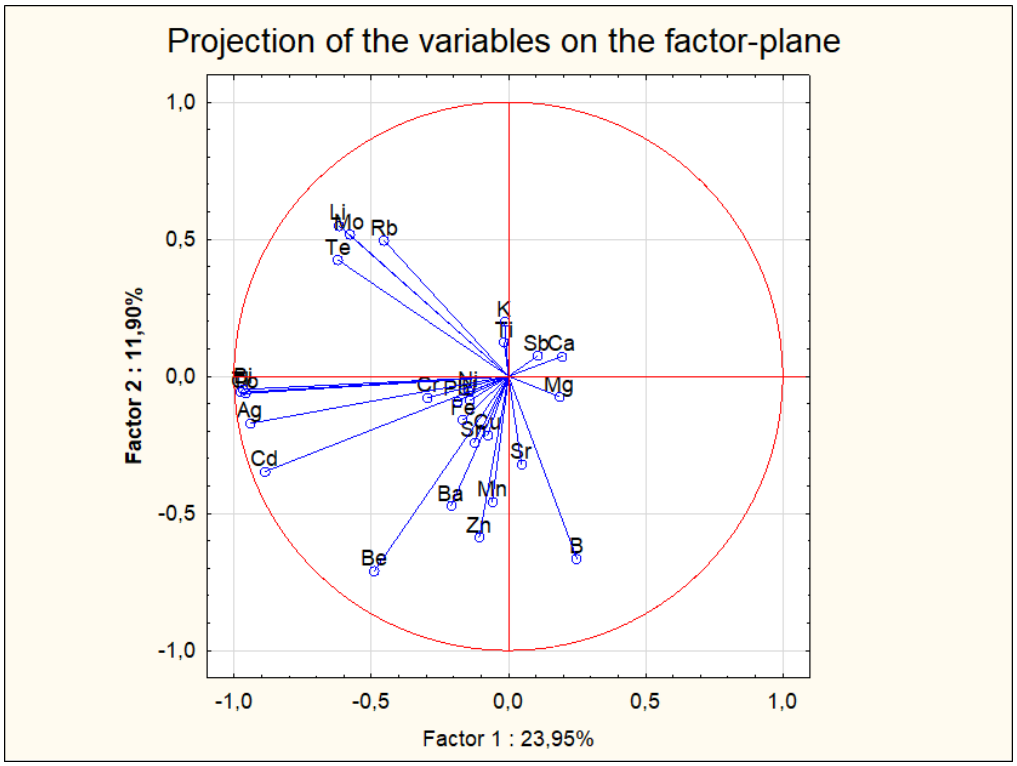

Figure S25. Projection of the variables on the factor-plane in 180 samples investigated in this study for the whole data set [µg/L].

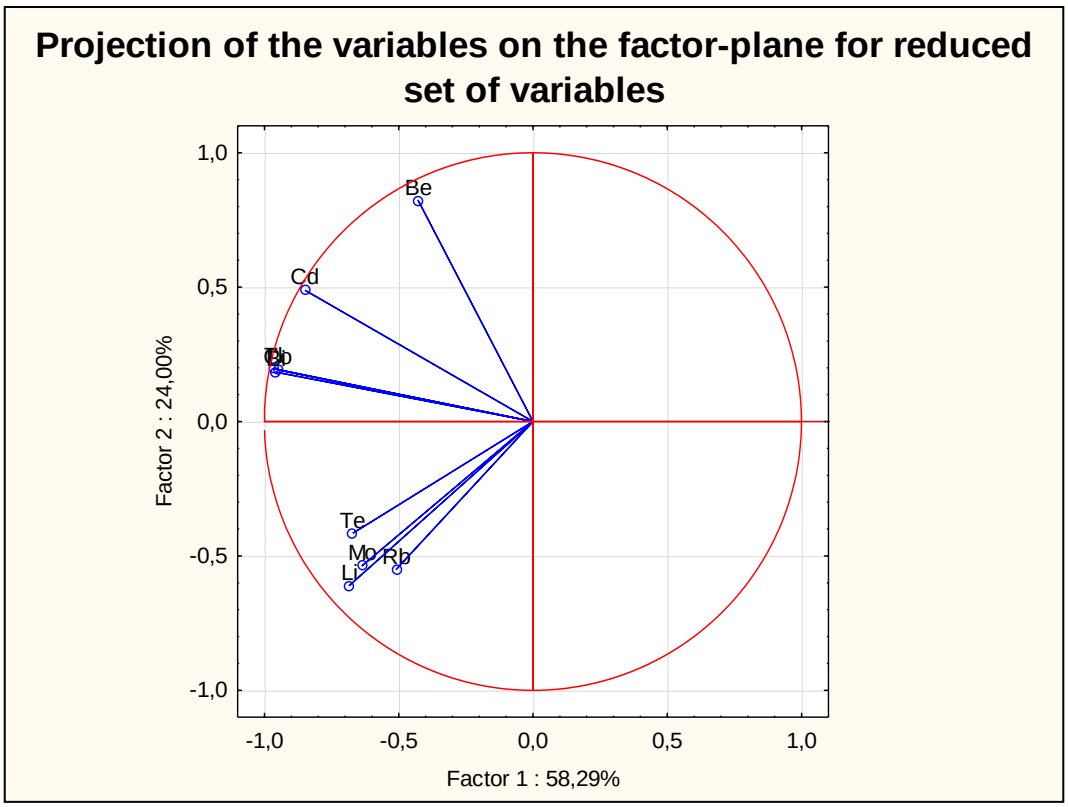

Figure S26. Projection of the variables on the factor-plane in 180 samples investigated in this study for the reduced data set [µg/L].

Table S25. The characterization of the wine samples

Sample Code	Type	Price [€/0.75L]	Alcohol content [%]	Grape variety	Origin
1R	Red – Semi Sweet	5.5	11	Concord	USA - Pennsylvania
2R	Red - Dry	8.5	0	Cabernet Sauvignon	France - Languedoc
3R	Red - Sweet	4	14	Multifruit	Poland - Dobron
4R	Red - Dry	6	13	Merlot	Chile
5R	Red – Semi Dry	6	12.5	Ruby Cabernet	USA - California
6R	Red - Dry	17	13.5	Pinot Noir	France - Languedoc
7R	Red - Dry	16	14	Sangiovese, Sagrantino, Merlot	Italy - Umbria
8R	Red – Semi Sweet	6.5	11	Multifruit	Slovakia
9R	Red - Dry	6.5	12	Alibernet	Slovakia - Moravia
10R	Red - Dry	6.5	13.5	Castelao, Tinta Roriz	Portugal - Lisbon
11R	Red - Dry	6.5	12.5	Cabernet Sauvignon	Slovakia - Dolné Ohňavy
12R	Red - Dry	6	12.5	Tempranillo	Spain - Castilla
13R	Red - Dry	14	13	Pinot Noir	Hungary - Matra
14R	Red - Dry	6	12	Primitivo	Italy - Puglia
15R	Red - Dry	10.5	14	Cabernet Franc	France - Languedoc
16R	Red - Dry	6	13.5	Tempranillo	Spain - Carinera
17R	Red - Sweet	6	9	Multifruit	USA - California

18R	Red - Dry	14	15	Zinfandel, Petite Sirah, Merlot, Malbec	USA - California
19R	Red - Dry	8	13.5	Syrah	Australia - South - East
20R	Red - Dry	19.5	14	Cabernet Syrah	France - Languedoc
21R	Red - Dry	17.5	13	Cabernet Sauvignon	Chile – Maipo Valley
22R	Red - Dry	13	14	Syrah	Australia - South - East
23R	Red - Dry	7	13.5	Multifruit	Slovakia - Dolné Ohňavy
24R	Red - Dry	25.5	15	Multifruit	Spain - Priorat
25R	Red - Dry	17.5	13	Susumaniello	Italy - Puglia
26R	Red - Dry	9	13.5	Merlot, Cabernet Franc	Italy - Tuscany
27R	Red - Dry	20	14	Syrah	Australia – Barossa Valley
28R	Red - Dry	17.5	13	Nerello Mascalese, Nerello Cappuccio	Italy - Sicilia
29R	Red - Dry	6	13	Merlot, Cabernet Sauvignon, Cabernet Franc	France - Bordeaux
30R	Red - Dry	6	13	Multifruit	USA - California
31R	Red - Sweet	5	11	Multifruit	Poland -Dobron
32R	Red – Semi Sweet	7	10.5	Alicante Bouschet, Tinta Roriz, Touriga Nacional	Portugal - Lisbon
33R	Red - Sweet	5	11	Multifruit	Poland -Dobron
34R	Red - Sweet	5	10	Multifruit	USA - Pennsylvania
35R	Red - Dry	16	12	Merlot	Italy - Veneto
36R	Red - Sweet	5	11	Multifruit	Poland -Dobron

37R	Red - Sweet	2.5	14	Multifruit	Poland - Torun
38R	Red - Sweet	7	20	Multifruit	Portugal - Porto
39R	Red – Semi Sweet	5	13	Primitivo	Italy - Salento
40R	Red - Dry	7	-	-	France
41R	Red – Semi Sweet	7	11	Le Carillon	France -Loire Valley
42R	Red - Sweet	45	17	Pedro Ximenez	Spain - Andalusia
43R	Red - Dry	8.5	13	Dolcetto	Italy - Monferrato
44R	Red - Dry	12	13.5	Montepulciano	Italy - Abruzzo
45R	Red - Dry	24.5	14	Merlot	Italy - Tuscany
46R	Red - Dry	14.5	13	Listán Negro	Spain - Tenerife
47R	Red – Semi Dry	8.5	14	Cabernet Sauvignon, Merlot	Australia - South - East
48R	Red - Dry	7.5	13.5	Grenache, Syrah	France - Languedoc
49R	Red - Dry	12.5	13.5	Barbera	Italy - Tuscany
50R	Red - Dry	14	15.9	Zinfandel	USA – Dry Creek Valley
51R	Red - Sweet	14.5	9	Terrano	Italy - Romagna
52R	Red – Semi Sweet	3.5	13	Merlot	South Africa – Western Cape
53R	Red – Semi Dry	6	13	Mataro, Syrah	Australia - South - East
54R	Red – Semi Dry	4.5	14	Syrah	Australia - South - East
55R	Red – Semi Dry	7	13	Cabernet Sauvignon, Syrah	France - Languedoc
56R	Red – Semi Dry	3.5	13.5	Merlot	USA - California

57R	Red - Dry	4.5	12	Multifruit	Bulgaria - Eger
58R	Red - Sweet	-	-	Multifruit	Poland - Lodz
59R	Red - Sweet	-	-	Multifruit	Poland - Skierniewice
60R	Red – Semi Dry	4.5	12	Cabernet Sauvignon	Bulgaria - Valley of Roses
61R	Red - Dry	4.5	13	Cabernet Sauvignon, Merlot	Moldova - Ethulia
62R	Red – Semi Sweet	7	12.5	Alicante Bouschet, Tinta Roriz, Touriga Nacional	Portugal - Lisbon
63R	Red – Semi Dry	11.5	13.5	Negroamaro	Italy - Apulia
64R	Red - Sweet	3.5	11.5	Tempranillo, Shiraz	Spain
65R	Red – Semi Sweet	4.5	11.5	Cabernet Sauvignon	Moldova - Ethulia
66R	Red - Sweet	4.5	14.5	Multifruit	Poland
67R	Red - Dry	17.5	13.5	Garnacha, Tempranillo	Spain - La Rioja
68R	Red - Dry	13	13.5	Barbera	Italy - Piedmont
69R	Red - Sweet	12	19.5	Multifruit	Portugal - Lisbon
70R	Red - Sweet	3.5	12	Multifruit	Poland
71R	Red - Sweet	2.5	13	Multifruit	Poland
72R	Red - Sweet	-	-	Multifruit	Poland - Legionowo
73R	Red - Dry	3.5	12	Carmenere	Chile
74R	Red - Dry	3.5	12.5	Sangiovese, Canaiolo	Italy - Tuscany
75R	Red - Sweet	4.5	13.5	Multifruit	Poland

76R	Red - Sweet	6	9	Multifruit	USA - California
77R	Red – Semi Dry	4.5	12	Bobal	Spain - Requena
78R	Red – Semi Sweet	3.5	5.5	Multifruit	Poland
79R	Red - Sweet	4.5	13.5	Multifruit	Poland
1W	White - Dry	14	12.5	Pinot Grigio	Italy - Veneto
2W	White – Sweet	46.5	7.5	Johanniter	Poland - Baniewice
3W	White - Dry	23.5	11.5	Garnacha Blanco	Spain - Priorat
4W	White - Dry	9.5	11.5	Chardonnay	France - Gascogne
5W	White – Sweet	18	16	Malvasia	Italy - Sicilia
6W	White - Dry	14	11.5	Tempranillo, Garnacha	Spain - Rioja
7W	White - Dry	6.5	12	Muller Thurgau	Italy - Adyga
8W	White – Semi Dry	6.5	13	Trebbiano	Slovakia - Dolné Ohňavy
9W	White - Dry	6.5	12	Morawski Muscat	Slovakia - Moravia
10W	White - Dry	6	11.5	Sauvignon Blanc, Chardonnay, Verdejo	Spain - Castilla
11W	White - Dry	10	12.5	Sauvignon Blanc	Chile - Valparaiso
12W	White - Dry	11.5	12.5	Chardonnay	Argentina - Mendoza
13W	White - Dry	16	11.5	Gruner Veltliner	Austria - Wachau
14W	White - Dry	12	14	Pecorino	Italy - Offida
15W	White - Dry	8	11.5	Sauvignon Blanc, Ugni Blanc, Colombard	France - Gascogne
16W	White – Semi Dry	7	12	Chardonnay	Bulgaria - Stara Zagora

17W	White – Sweet	6	10	Multifruit	USA - Pennsylvania
18W	White - Dry	17.5	12	Kangun	Armenia - Aragatsotn
19W	White - Dry	14	12.5	Chardonnay	Portugal - Tejo
20W	White - Dry	7	12	Muller Thurgau	Slovakia - Dolné Ohňavy
21W	White – Semi Dry	7	0	Multifruit	Germany - Moguncja
22W	White – Semi Dry	9.5	12.5	Irsai Oliver	Slovakia
23W	White – Semi Dry	7	11	Multifruit	Italy - Veneto
24W	White – Semi Dry	11.5	12.5	Merseguera, Moscatel	Spain - Alicante
25W	White - Dry	14	13	Malvasia	Italy - Emilia
26W	White – Semi Sweet	11.5	10	Riesling	Germany - Mosel
27W	White - Dry	10	12.5	Johanniter	Poland - Zbyczyna
28W	White - Dry	6	12	Pinot Grigio	Italy – Delle Venezie
29W	White – Semi Sweet	4.5	10	Multifruit	USA - Pennsylvania
30W	White – Semi Sweet	3.5	11.5	Muscat Ottonel	Hungary - Kunsag
31W	White - Dry	47	12	Pinot Grigio	Italy - Veneto
32W	White – Sweet	2.5	-	Chardonnay	Moldova - Onesti
33W	White – Sweet	4.5	10	Multifruit	Poland - Dobron
34W	White – Semi Dry	6	11.5	Chardonnay	Bulgaria
35W	White – Sweet	9.5	7.5	Multifruit	Italy - Asti
36W	White – Sweet	2.5	14	Multifruit	Poland - Torun

37W	White - Dry	7.5	13	Rolle	France - Provence
38W	White - Dry	21	12	Furmint, Chardonnay	Hungary – Nagy Somló
39W	White - Dry	14	11	Xarel-lo, Parellada, Macabeu	Spain - Cava
40W	White - Dry	24.5	13	Roditis	Greece - Pella
41W	White - Dry	10	13.5	Garganega	Italy - Soave
42W	White - Dry	11.5	0	Riesling	Germany - Rhringau
43W	White - Dry	11.5	12.5	Furmint, Hárslevelű, Sárgamuskotály	Hungary - Tokaj
44W	White – Semi Dry	12.5	12.5	Gewurztraminer	New Zealand - Nelson
45W	White - Dry	17.5	11.5	Johanniter	Poland - Sandomierz
46W	White - Dry	16	12	Riesling	Poland - Lower Silesia
47W	White - Dry	8.5	13	Chardonnay	France - Languedoc
48W	White – Semi Sweet	8	15	Multifruit	Italy - Turin
49W	White - Dry	6	12.5	Chardonnay	Australia - South - East
50W	White – Sweet	7	13	-	Poland – Nowy Sacz
51W	White – Semi Sweet	6	9.5	-	Germany - Nahe
52W	White – Semi Sweet	4.5	12	Cabernet Sauvignon	Bulgaria - Valley of Roses
53W	White – Semi Dry	4.5	13	Sauvignon Blanc	Moldavia
54W	White - Dry	6	13	Chenin Blanc	South Africa – Western Cape
55W	White - Dry	8	10.5	Colombard, Gros Manseng, Sauvignon Blanc, Ugni Blanc	France - Gascogne

56W	White - Dry	8	12.5	Insolia, Cataratto, Grillo	Italy - Sicilia
57W	White - Dry	8	12.5	Gewurztraminer	Spain - Aragonia
58W	White – Dry	8	12	Loureiro, Arinto	Portugal - Minho
59W	White – Semi Dry	6	10.5	Chardonnay	Ukraine
60W	White - Sweet	4.5	14	Multifruit	Poland
61W	White - Sweet	3.5	14.5	Multifruit	Poland
62W	White - Sweet	4.5	14	Multifruit	Poland
63W	White – Semi Sweet	4.5	11	Multifruit	Greece - Crete
64W	White – Semi Sweet	3.5	10	Multifruit	Poland
65W	White – Semi Dry	3.5	10	Multifruit	Poland
66W	White - Sweet	3.5	5.5	Multifruit	Poland
67W	White – Semi Dry	2.5	7.5	Multifruit	Italy - Arduini
68W	White - Dry	4.5	12	Pinot Grigio	Italy - Veneto
69W	White – Semi Sweet	2.5	9	Multifruit	Poland
70W	White - Sweet	2.5	10	Multifruit	Poland
71W	White - Sweet	3.5	10.5	Multifruit	Poland
72W	White - Dry	7	14	Chardonnay, Arinto	Portugal - Tejo
73W	White - Sweet	6	15	Multifruit	Poland
74W	White - Sweet	2.5	15	Multifruit	Poland
75W	White - Sweet	2.5	10	Multifruit	Poland

1Ro	Rosé - Dry	10	12.5	Grenache, Syrah	France - Languedoc
2Ro	Rosé - Sweet	6	10	Multifruit	USA - California
3Ro	Rosé - Dry	11.5	11	Grauburgunder, Neuburger, Pinot Blanc	Austria – Burgenland
4Ro	Rosé – Semi Sweet	7	10	Multifruit	USA - California
5Ro	Rosé - Sweet	4.5	10	Multifruit	Poland - Dobron
6Ro	Rosé - Sweet	4.5	10	Multifruit	Poland - Dobron
7Ro	Rosé – Semi Sweet	4.5	10	Zinfandel	USA - Pennsylvania
8Ro	Rosé – Semi Dry	7	-	-	France
9Ro	Rosé - Dry	7	11.5	Svatovavrinecke	Czech Republic - Moravia
10Ro	Rosé – Semi Dry	7	10	Multifruit	USA - California
11Ro	Rosé – Semi Dry	3.5	10.5	Zinfandel	USA - California
12Ro	Rosé - Sweet	3.5	9	Multifruit	UK
13Ro	Rosé - Sweet	12	7.5	Muscato	Italy - Veneto
14Ro	Rosé - Dry	12	11	Grauburgunder, Neuburger, Pinot Blanc	Austria – Burgenland
15Ro	Rosé - Sweet	4.5	10	Multifruit	Poland - Dobron
16Ro	Rosé - Dry	10	11.5	-	Germany - Kirrweiler
17Ro	Rosé - Dry	18	11.5	Pinot Noir, Grenache, Cava Rimarts	Spain - Catalonia
18Ro	Rosé – Semi Sweet	3.5	10	Multifruit	Poland
19Ro	Rosé - Sweet	2	12	Multifruit	Poland
20Ro	Rosé - Sweet	4.5	10	Multifruit	Poland - Dobron

21Ro	Rosé - Sweet	6	10	Multifruit	USA - California
22Ro	Rosé - Sweet	6	10	Multifruit	USA - California
23Ro	Rosé - Sweet	4.5	9.5	Multifruit	Poland
24Ro	Rosé - Sweet	7	10	Multifruit	Poland - Dobron
25Ro	Rosé – Semi Sweet	7	11	Multifruit	Italy
26Ro	Rosé – Sweet	3.5	5.5	Multifruit	Poland