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EFFECT OF ACIDITY CORRECTION ON THE SOLUBILITY OF TARTARIC COMPOUNDS FROM WINES

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ABSTRACT *– The paper presents data concerning the effect of acidity correction on the solubility of potassium bitartrate and calcium neutral tartrate, as a result of acid addition (tartaric, malic, citric and succinic) in wines lacking acidity, for improving their organoleptic qualities. The solubility of these compounds was assessed by means of concentration (*P_C *,* P_{CT}*) and solubility (*K_{ST} *,* K_S *) products at −4 ºC, by the excess of KHT and CaT at −4 ºC and saturation theoretical temperatures of KHT and CaT. As a result of acidity correction, we have noticed its increase (at the same proportion for all the acids) and a diminution in pH according to added acid: tartaric, lactic, malic, citric and succinic. By adding tartaric acid, wine instability was created, because of potassium bitartrate, by increasing the values of concentration and solubility products, of KHT excess and theoretical saturation temperatures. In case of calcium tartrate, the same acid favoured wine stability, by diminishing the values of the constants. Adding the other acids in wine was good for the solubility of tartaric compounds, because, in all the cases, the values of constants characterizing solubility were diminished.*

Key Words: acidity, solubility, tartaric compounds, potassium bitartrate, calcium neutral tartrate

REZUMAT *–* ***Efectul corecţiei acidităţii asupra solubilităţii compuşilor tartrici din vinuri.*** *În lucrare se prezintă date referitoare la efectul corecţiei acidităţii asupra solubilităţii tartratului acid de potasiu şi a tartratului neutru de calciu, ca urmare a adaosului de acizi (tartric, malic, lactic, citric şi succinic) în vinuri deficitare în aciditate, în vederea îmbunătăţirii calităţilor organoleptice ale acestora. Solubilitatea acestor compuşi este apreciată prin intermediul produşilor de concentraţii (*P_C *,* P_{CT}*) şi de solubilitate (*K_{ST}*,* K_S*), la −4ºC, prin excesul de KHT şi CaT la −4 ºC şi temperaturile teoretice de saturare a KHT şi CaT. În urma corecţiei acidităţii, se observă o creştere a acesteia (aproape în aceeaşi proporţie la toţi acizii) şi o scăderea a valorii pH în funcţie de acidul adăugat, în ordinea: tartric, lactic, malic, citric şi succinic. Adaosul de acid tartric creează instabilitate vinului, datorită tartratului acid de*

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potasiu, prin creşterea valorilor constantelor produşilor de concentraţii şi de solubilitate, a excesului de KHT şi a temperaturilor teoretice de saturare. În cazul tartratului de calciu, acelaşi acid favorizează stabilitatea vinului, prin diminuarea valorilor aceloraşi constante. Adaosul celorlalţi acizi în vin este benefic solubilităţii compuşilor tartrici, deoarece, în toate cazurile, se micşorează valorile constantelor care caracterizează solubilitatea.

Cuvinte cheie: aciditate, solubilitate, compuşi tartrici, tartrat acid de potasiu, tartrat neutru de calciu

INTRODUCTION

In the dry years for wine-making, when wines lacking acidity are obtained, it is necessary to correct the acidity, according to the present legislation, with one of the acids used for this purpose, respectively tartaric or citric acids. Lactic, malic and succinic acids were used in order to get theoretical information on their role on the solubility of tartaric compounds from wines. The study on the influence of acidity correction (as a result of adding tartaric, malic, lactic, succinic and citric acids) on the solubility of potassium bitatrate and neutral calcium tatrate from wines allowed us to obtain data necessary for explaining physico-chemical phenomena, which influence stability or instability during wine acidification treatments, related to the precipitation of tartaric salts.

MATERIALS AND METHODS

Investigations have been conducted on a white wine obtained from Muscat Ottonel variety, which came from the viticultural centre Iaşi-Copou, within Iaşi vineyard, vintage of year 2004. Experiments were carried out during September-October 2006, at the Research Centre for Oenology of Romanian Academy, Iaşi Branch.

In five wine samples, equivalent quantities of tartaric, malic, lactic, succinic and citric acids, were added at rates of 10, 15, 20, 25, 30 meq/L, respectively, (0.75, 1.13, 1.50, 1.88, and 2.25) g/L tartaric acid; (0.67, 1.01, 1.34, 1.68, and 2.01) g/L malic acid; (0.90, 1.35, 1.80, 2.25, and 2.70) g/L lactic acid; (0.59, 0.89, 1.18, 1.48, and 1.77) g/L succinic acid; (0.64, 0.96, 1.28, 1.60, and 1.92) g/L citric acid. Physico-chemical analyses were carried out on alcoholic concentration, total acidity, pH, total tartaric, malic, lactic, succinic, and citric acids, potassium and calcium, by using the methods shown by present national and international standards or literature (*** 1997, *** 2005). Data obtained after determining the content of potassium, calcium, alcohol, total tartaric acid and pH value were used for the calculation of wine ionic power (μ) and activity coefficients (γ_1, γ_2), for monovalent (K^+, HT^-) and bivalent ions (Ca^{2+}, T^{2-}), and of the dissociation degree of the tartaric acid (% H_2T, % HT^-, % T^{2-}) (Odăgeriu, 2006).

Data on the content of potassium, total tartaric acid, percentage of bitartrate ion (% HT^-) and γ_1 have been used for calculating the concentration product (P_C) and the product of thermodynamic product (P_{CT}) of bitartrate ions and potassium (Cotea, Sauciuc, 1988; Cotea, Sauciuc, 1994; Odăgeriu, 2006). The thermodynamic solubility product (K_{ST}) of potassium bitartrate in hydroalcoholic solutions saturated with KHT (at the ionic power of the studied sample) for the temperature of −4 ºC, and solubility product (K_S) at wine ionic power at −4ºC were calculated according to data from literature (Cotea, Sauciuc, 1988; Cotea, Sauciuc, 1994; Renouil, Féret, 1988; Țârdea et al., 2000; Useglio-Tomasset, 1985).

Data on the content of calcium, total tartaric acid, percentage of tartrate ion (% T^{2-}) and γ_2 have been used for calculating the concentration product (P_C) and the thermodynamic concentration products (P_{CT}) of tartrate ions and calcium. Thermodynamic solubility product (K_{ST}) of neutral calcium tartrate in hydroalcoholic solutions saturated with CaT (at ionic power of studied sample), for the temperature −4 ºC, and solubility product (K_S) at wine ionic power, at the temperature of −4 ºC have been calculated according to ODĂGERIU (Odăgeriu, 2003; Odăgeriu , 2006).

According to solubility product (**K_S**), at the ionic power of analysed wines for the temperature of −4 ºC, we have calculated the quantities of potassium bitartrate and neutral calcium tartrate, found in excess (oversaturation), at the same temperature, according to ODĂGERIU (Odăgeriu, 2006).

Both in case of potassium bitartrate and of neutral calcium tartrate, we have compared thermodynamic concentration products (P_{CT}) to thermodynamic solubility products (K_{ST}). Our objective was to deduce saturation theoretical temperatures (T_{TS}) of analysed wines according to data from specialty literature (Cotea, Sauciuc, 1988; Cotea, Sauciuc, 1994; Renouil, Féret, 1988; Țârdea et al., 2000; Useglio-Tomasset, 1985), according to the methodology proposed by ODĂGERIU in 2006 (Odăgeriu, 2003).

For potassium bitartrate (KHT) and neutral calcium tartrate (CaT), the relative deviations (δ_r) are presented in (%), with which we have changed total acidity, pH, concentration (P_C, P_{CT}) and solubility (K_S, K_{ST}) products, KHT and CaT excess and theoretical saturation temperatures (T_{TS}) of analysed wine samples.

RESULTS AND DISCUSSION

Data concerning the main wine composition characteristics after acidity correction are presented in tables 1−5. According to data shown in tables, the control wine had the following values: 11.50% vol. alcohol; 4.69 g/L $C_4H_6O_6$ total acidity; 0.70 g/L $C_2H_4O_2$; 3.80 pH; 1.28 g/L total tartaric acid; 0.98 g/L malic acid, 0.51 g/L lactic acid; 0.55 g/L succinic acid; 0.16 g/L citric acid; 1030 mg/L potassium and 92 mg/L calcium.

In wine samples, where correction was carried out with tartaric acid (*Table 1*), total acidity has increased from 4.69 to 5.49 ÷ 7.08 g/L $C_4H_6O_6$ (17.06 ÷ 50.96%), pH has decreased from 3.80 to 3.57 ÷ 3.25 (−6.05 ÷ −14.47%) and total tartaric acid has increased from 1.28 to 2.03 ÷ 3.53 g/L.

According to data presented in *Table 2*, in wine samples at which correction was done with malic acid, the total acidity has increased from 4.69 to 5.53 ÷ 7.13 g/L $C_4H_6O_6$ (17.91 ÷ 52.03 %), pH has decreased from 3.80 to 3.63 ÷ 3.40 (−4.47 ÷ −10.53%), and malic acid has increased from 0.98 to 1.65 ÷ 2.99 g/L.

Table 1

Main characteristics of wine composition in case of correction with tartaric acid

No.	Wine sample	Quantity of added acid		Total acidity		pH		Total tartaric acid g/L
		meq/L	g/L	g/L $C_4H_6O_6$	δ r (%)		δ r (%)	
1	**Control**	**–**	**–**	**4.69**	**0.00**	**3.80**	**0.00**	**1.28**
2	**V_{11}**	10	0.75	5.49	17.06	3.57	−6.05	2.03
3	**V_{12}**	15	1.13	5.90	25.80	3.47	−8.68	2.41
4	**V_{13}**	20	1.50	6.29	34.12	3.39	−10.79	2.78
5	**V_{14}**	25	1.88	6.70	42.86	3.31	−12.89	3.16
6	**V_{15}**	30	2.25	7.08	50.96	3.25	−14.47	3.53

Table 2

Main characteristics of wine composition in case of correction with malic acid

No.	Wine sample	Quantity of added acid		Total acidity		pH		Total malic acid g/L
		meq/L	g/L	g/L $C_4H_6O_6$	δ r (%)		δ r (%)	
1	**Control**	**–**	**–**	**4.69**	**0.00**	**3.80**	**0.00**	**0.98**
7	**V_{21}**	10	0.67	5.53	17.91	3.63	−4.47	1.65
8	**V_{22}**	15	1.01	5.95	26.87	3.56	−6.32	1.99
9	**V_{23}**	20	1.34	6.34	35.18	3.50	−7.89	2.32
10	**V_{24}**	25	1.68	6.75	43.92	3.44	−9.47	2.66
11	**V_{25}**	30	2.01	7.13	52.03	3.40	−10.53	2.99

Correction with lactic acid (*Table 3*) has influenced the increase in total acidity from 4.69 to 5.56 ÷ 7.15 g/L $C_4H_6O_6$ (18.55 ÷ 52.45%), pH diminution from 3.80 to 3.61÷ 3.39 (−5.00 ÷ −10.79%), and augmentation of own content from 0.51 to 1.41 ÷ 3.21 g/L.

Table 3

Main characteristics of wine composition in case of correction with lactic acid

No.	Wine sample	Quantity of added acid		Total acidity		pH		Total lactic acid g/L
		meq/L	g/L	g/L $C_4H_6O_6$	δ r (%)		δ r (%)	
1	**Control**	**–**	**–**	**4.69**	**0.00**	**3.80**	**0.00**	**0.51**
12	**V_{31}**	10	0.90	5.56	18.55	3.61	−5.00	1.41
13	**V_{32}**	15	1.35	5.97	27.29	3.54	−6.84	1.86
14	**V_{33}**	20	1.80	6.37	35.82	3.48	−8.42	2.31
15	**V_{34}**	25	2.25	6.76	44.14	3.43	−9.74	2.76
16	**V_{35}**	30	2.70	7.15	52.45	3.39	−10.79	3.21

Correction with succinic acid (*Table 4*) has influenced the increase in total acidity from 4.69 to 5.50 ÷ 7.04 g/L $C_4H_6O_6$ (17.27 ÷ 50.11%), pH diminution from 3.80 to 3.73÷ 3.63 (−1.84 ÷ −4.47%), and augmentation of own content from 0.55 to 1.14 ÷ 2.32 g/L.

Table 4

Main characteristics of wine composition in case of correction with succinic acid

No	Wine sample	Quantity of added acid		Total acidity		pH		Total succinic acid g/L
		meq/L	g/L	g/L $C_4H_6O_6$	δ r (%)		δ r (%)	
1	**Control**	**–**	**–**	**4.69**	**0.00**	**3.80**	**0.00**	**0.55**
17	**V_{41}**	10	0.59	5.50	17.27	3.73	−1.84	1.14
18	**V_{42}**	15	0.89	5.92	26.23	3.70	−2.63	1.44
19	**V_{43}**	20	1.18	6.03	28.57	3.68	−3.16	1.73
20	**V_{44}**	25	1.48	6.66	42.00	3.65	−3.95	2.03
21	**V_{45}**	30	1.77	7.04	50.11	3.63	−4.47	2.32

In wine samples, at which correction was done with citric acid (*Table 5*), the total acidity has increased from 4.69 to 5.49 ÷ 7.07 g/L $C_4H_6O_6$ (17.06 ÷ 50.75%), pH has decreased from 3.80 to 3.65÷3.41 (−3.95 ÷ −10.26%), and citric acid has increased from 0.16 to 0.80 ÷ 2.08 g/L.

Table 5

Main characteristics of wine composition in case of correction with citric acid

No	Wine sample	Quantity of added acid		Total acidity		pH		Total citric acid g/L
		meq/L	g/L	g/L $C_4H_6O_6$	δ r (%)		δ r (%)	
1	**Control**	**–**	**–**	**4.69**	**0.00**	**3.80**	**0.00**	**0.16**
22	**V_{51}**	10	0.64	5.49	17.06	3.65	−3.95	0.80
23	**V_{52}**	15	0.96	5.89	25.59	3.58	−5.79	1.12
24	**V_{53}**	20	1.28	6.29	34.12	3.52	−7.37	1.44
25	**V_{54}**	25	1.60	6.62	41.15	3.47	−8.68	1.71
26	**V_{55}**	30	1.92	7.07	50.75	3.41	−10.26	2.08

Data presented in *tables 1−5* have shown that after correction, total acidity had the same increase (51.00%), and pH has decreased, as follows: −14.47% (sample 6, in case of adding tartaric acid); −10.79% (sample 16, in case of adding lactic acid); −10.53% (sample 11, in case of adding malic acid); −10.26% (sample 26, in case of adding citric acid); −4.47% (sample 21, in case of adding succinic acid).

Concentration products (P_C, P_{CT}) of potassium bitartrate (KHT) and neutral calcium tartrate (CaT) in wine samples, obtained after the correction with acids, are presented in *Table 6*. For the control wine, which molar concentration was of

26.341×10^{-3} mol/L, the concentration product (**P_C**) of potassium ions (K^+) and bitartrate (HT^-) had the value of 146.61×10^{-6} mol^2/L^2. For the same value of molar concentration in potassium, it has increased from 229.81×10^{-6} mol^2/L^2 (56.75 %) to 335.36×10^{-6} mol^2/L^2 (128.74%). In case of samples, at which correction was done with tartaric acid, in the other samples, the value has remained approximately equal to the one of the control wine.

Thermodynamic concentration product (**P_{CT}**) of potassium bitartrate, calculated according to concentration product (**P_C**) and activity coefficient (γ_1 = 0.422) of potassium ions and bitartrate, in analysed wine samples had lower values than the concentration product, comprised between 95.27×10^{-6} mol^2/L^2 in control (sample 1) and 217.91×10^{-6} mol^2/L^2 (sample 6).

Concentration product (**P_C**) of calcium ions (Ca^{2+}) and tartrate (T^{2-}) had the value of 407.24×10^{-8} mol^2/L^2 for the control. For the value of 2.295×10^{-3} mol/L of calcium molar concentration, it has diminished in all analysed samples according to added acid: 145.12×10^{-8} mol^2/L^2 (−64.36%) in the sample 16; 149.36×10^{-8} mol^2/L^2 (−63.32%) in the sample 11; 153.69×10^{-8} mol^2/L^2 (−62.26%) in the sample 26; 262.54×10^{-8} mol^2/L^2 (−35.53%) in the sample 6; 275.50×10^{-8} mol^2/L^2 (−32.35%) in the sample 21.

Thermodynamic concentration product (**P_{CT}**) of neutral calcium tartrate, calculated according to activity coefficient (γ_2 = 0.806) of calcium ions and tartrate, in analysed wine samples had lower values than the concentration product. These values were comprised between 72.60×10^{-8} mol^2/L^2 in control (sample 1) and 25.87×10^{-8} mol^2/L^2 (sample 16).

Table 6

Concentration products (P_C , P_{CT}) of potassium bitartrate (KHT) and neutral calcium tartrate (CaT) in wine samples, obtained after acid correction

No	Wine sample	Potassium bitartrate (KHT)				Neutral calcium tartrate (CaT)			
		$[HT^-]$ × 10^3 mol/L	P_C × 10^6		P_{CT} × 10^6 mol^2/L^2	$[T^{2-}]$ × 10^3 mol/L	P_C × 10^8		P_{CT} × 10^8 mol^2/L^2
			mol^2/L^2	δ_r (%)			mol^2/L^2	δ_r (%)	
1	Control	5.57	146.6	0.00	95.3	1.77	407.2	0.00	72.6
	Tartaric acid correction								
2	V_{11}	8.72	229.8	56.75	149.3	1.64	375.9	−7.70	67.0
3	V_{12}	10.00	263.4	79.69	171.2	1.49	342.3	−15.96	61.0
4	V_{13}	11.07	291.7	98.94	189.5	1.37	315.2	−22.60	56.2
5	V_{14}	11.94	314.6	114.6	204.4	1.23	282.8	−30.57	50.4
6	V_{15}	12.73	335.4	128.7	217.9	1.14	262.5	−35.53	46.8
	Malic acid correction								
7	V_{21}	5.57	146.7	0.06	95.3	1.20	275.5	−32.35	49.1
8	V_{22}	5.49	144.5	−1.43	93.9	1.01	231.0	−43.28	41.2
9	V_{23}	5.38	141.7	−3.38	92.1	0.86	197.2	−51.57	35.2
10	V_{24}	5.24	138.0	−5.89	89.7	0.73	167.3	−58.92	29.8

No	Wine sample	Potassium bitartrate (KHT)				Neutral calcium tartrate (CaT)			
		$[HT^-]$ × 10^3 mol/L	P_C × 10^6 mol^2/L^2	P_C × 10^6 δ r (%)	P_{CT} × 10^6 mol^2/L^2	$[T^{2-}]$ × 10^3 mol/L	P_C × 10^8 mol^2/L^2	P_C × 10^8 δ r (%)	P_{CT} × 10^8 mol^2/L^2
11	**V_{25}**	5.13	135.1	−7.87	87.8	0.65	149.4	−63.32	26.6
Lactic acid correction									
12	**V_{31}**	5.55	146.2	−0.27	95.0	1.14	262.2	−35.61	46.8
13	**V_{32}**	5.45	143.7	−2.01	93.4	0.96	219.3	−46.15	39.1
14	**V_{33}**	5.34	140.5	−4.15	91.3	0.81	186.8	−54.13	33.3
15	**V_{34}**	5.21	137.3	−6.37	89.2	0.71	162.7	−60.06	29.0
16	**V_{35}**	5.10	134.3	−8.40	87.3	0.63	145.1	−64.36	25.9
Succinic acid correction									
17	**V_{41}**	5.60	147.6	0.66	95.9	1.52	348.9	−14.32	62.2
18	**V_{42}**	5.60	147.6	0.68	95.9	1.42	325.7	−20.03	58.1
19	**V_{43}**	5.60	147.5	0.59	95.8	1.35	310.8	−23.69	55.4
20	**V_{44}**	5.58	147.1	0.33	95.6	1.26	289.3	−28.97	51.6
21	**V_{45}**	5.57	146.7	0.06	95.3	1.20	275.5	−32.35	49.1
Citric acid correction									
22	**V_{51}**	5.58	147.1	0.33	95.6	1.26	289.3	−28.97	51.6
23	**V_{52}**	5.52	145.3	−0.91	94.4	1.06	243.1	−40.30	43.4
24	**V_{53}**	5.42	142.7	−2.66	92.7	0.91	208.0	−48.91	37.1
25	**V_{54}**	5.31	139.9	−4.56	90.9	0.79	181.8	−55.36	32.4
26	**V_{55}**	5.16	135.8	−7.36	88.3	0.67	153.7	−62.26	27.4

KHT excess at temperature −4°C and theoretical saturation temperature (T_{TS}) of potassium bitartrate (KHT) in wine samples obtained after acid correction are shown in *Table 7*.

Both at control and the other wine samples, KHT excess at temperature −4°C was calculated according to solubility product at wine ionic power (**K_S**), and according to molar concentrations (in mol/L) of total tartaric acid [TT] and potassium $[K^+]$. The value of 24.49×10^{-6} mol^2/L^2 of the solubility product at wine ionic power (**K_S**) was estimated according to thermodynamic solubility product (**K_{ST}**) of potassium bitartrate, which value was 15.91×10^{-6} mol^2/L^2.

Correlated to solubility product (K_S) of studied wines, at temperature −4ºC, KHT excess had values, which increased, in case of samples where correction was done with tartaric acid. It has increased from 1246.8 mg/L (control) to 2078.3 mg/L (sample 2), respectively, 3398.3 mg/L (sample 6); at the other samples, its value diminished in proportion of 0.02 ÷ −2.07%.

Theoretical saturation temperature (**T_{TS}**) of potassium bitartrate has increased in case of tartaric acid correction (from 17.20ºC at control to 30.43ºC in case of sample 6), and remained almost constant (deviation of ± 1 unit) in case of the other samples.

Table 7

KHT excess at temperature −4 °C and theoretical saturation temperature (T_{TS}) of potassium bitartrate (KHT) in obtained wine samples after acid correction

No.	Wine sample	KHT excess at temperature −4 °C		Theoretical saturation temperature (T_{TS})	
		(mg/L)	δ r (%)	(ºC)	δ r (%)
1	**Control**	1246.8	0.00	17.20	0.00
Tartaric acid correction					
2	V_{11}	2078.3	66.69	23.79	38.31
3	V_{12}	2463.4	97.58	26.06	51.51
4	V_{13}	2810.0	125.38	27.85	61.92
5	V_{14}	3126.8	150.79	29.23	69.94
6	V_{15}	3398.3	172.56	30.43	76.92
Malic acid correction					
7	V_{21}	1247.0	0.02	17.21	0.06
8	V_{22}	1242.0	−0.38	17.01	−1.10
9	V_{23}	1235.4	−0.91	16.75	−2.62
10	V_{24}	1226.4	−1.64	16.40	−4.65
11	V_{25}	1219.0	−2.23	16.13	−6.22
Lactic acid correction					
12	V_{31}	1245.9	–0.07	17.17	–0.17
13	V_{32}	1240.1	–0.54	16.93	–1.57
14	V_{33}	1232.7	–1.13	16.64	–3.26
15	V_{34}	1224.7	–1.77	16.34	–5.00
16	V_{35}	1217.0	–2.39	16.05	–6.69
Succinic acid correction					
17	V_{41}	1248.9	0.17	17.29	0.52
18	V_{42}	1249.0	0.15	17.29	0.52
19	V_{43}	1248.7	0.08	17.28	0.47
20	V_{44}	1247.8	0.02	17.25	0.29
21	V_{45}	1247.0	0.08	17.21	0.06
Citric acid correction					
22	V_{51}	1247.8	0.08	17.25	0.29
23	V_{52}	1243.7	–0.25	17.08	–0.70
24	V_{53}	1237.9	–0.71	16.85	–2.03
25	V_{54}	1231.2	–1.25	16.59	–3.55
26	V_{55}	1221.0	–2.07	16.20	–5.81

CaT excess at temperature −4°C and theoretical saturation temperature (T_{TS}) of neutral calcium tartrate (CaT) in wine samples, obtained after acid correction, are shown in *Table 8*.

Both in control and the other wine samples, CaT excess at temperature of −4°C was calculated according to solubility product at wine ionic power (**K_S**), and molar concentrations (in mol/L) of total tartaric acid [TT] and calcium [Ca^{2+}]. Value of 33.21×10^{-8} mol^2/L^2 of solubility product at wine ionic power (**K_S**), was estimated according to thermodynamic solubility product (**K_{ST}**) of neutral calcium tartrate, which value was 5.92×10^{-8} mol^2/L^2.

Table 8

CaT excess at temperature −4°C and theoretical saturation temperature (T_{TS}) of neutral calcium tartrate (CaT) in wine samples obtained after acid correction

No.	Wine sample	CaT excess at temperature −4 °C		Theoretical saturation temperature (T_{TS})	
		(mg/L)	δ_r (%)	(ºC)	δ_r (%)
1	**Control**	385.6	0.00	44.98	0.00
Tartaric acid correction					
2	**V_{11}**	386.9	0.35	42.71	−5.05
3	**V_{12}**	383.9	−0.43	40.15	−10.74
4	**V_{13}**	380.8	−1.23	37.99	−15.54
5	**V_{14}**	375.9	−2.51	35.26	−21.61
6	**V_{15}**	372.3	−3.45	33.47	−25.59
Malic acid correction					
7	**V_{21}**	364.6	−5.45	34.63	−23.01
8	**V_{22}**	352.4	−8.61	30.51	−32.17
9	**V_{23}**	339.7	−11.91	27.08	−39.80
10	**V_{24}**	324.4	−15.85	23.72	−47.27
11	**V_{25}**	312.6	−18.91	21.54	−52.11
Lactic acid correction					
12	**V_{31}**	361.3	−6.29	33.44	−25.66
13	**V_{32}**	348.4	−9.65	29.36	−34.73
14	**V_{33}**	334.9	−13.14	25.95	−42.31
15	**V_{34}**	321.6	−16.58	23.17	−48.49
16	**V_{35}**	309.5	−19.74	21.00	−53.31
Succinic acid correction					
17	**V_{41}**	378.1	−1.93	40.67	−9.58
18	**V_{42}**	374.5	−2.88	38.84	−13.65
19	**V_{43}**	371.8	−3.56	37.63	−16.34
20	**V_{44}**	367.6	−4.66	35.82	−20.36
21	**V_{45}**	364.6	−5.45	34.63	−23.01
Citric acid correction					
22	**V_{51}**	367.8	−4.66	35.82	−20.36
23	**V_{52}**	358.1	−7.64	31.68	−29.57
24	**V_{53}**	344.1	−10.74	28.21	−37.28
25	**V_{54}**	332.4	−13.79	25.39	−43.55
26	**V_{55}**	315.7	−18.11	22.08	−50.91

In correlation with solubility product (K_S) of analysed wines, at temperature of −4ºC, CaT excess had values which have decreased in all the samples, according to added acid. It diminished from 385.6 mg/L (control) to 309.5 mg/L at sample 16 (−19.74%), 312.6 mg/L at sample 11 (−18.91%), 315.7 mg/L at sample 26 (−18.11%), 364.6 mg/L at sample 21 (−5.45%), and 372.3 mg/L at sample 5 (−3.45%).

Theoretical saturation temperature (**T_{TS}**) of neutral calcium tartrate had lower values compared to the control, in all the studied samples. For the control, **T_{TS}** had the value of 44.98ºC. It has decreased according to added acid, at 21.00ºC, in case of sample 16 (−53.31%); 21.54ºC in case of sample11 (−52.11%); 22.08ºC in case of sample 26 (−50.91%); 33.47ºC in case of sample 6 (−25.59%) and 34.63ºC in case of sample 21 (−23.01%).

CONCLUSIONS

As a result of corrections, total acidity had the same increase value, of almost 51%, and pH has decreased in the following order: 14.47 % (sample 6, in case of adding tartaric acid);10,79 % (sample 16, in case of adding lactic acid); −10.53 % (sample 11, in case of adding malic acid); −10.26 % (sample 26, in case of adding citric acid) and 4.47 % (sample 21, in case of adding succinic acid).

Adding tartaric acid gives instability to wine, because of potassium bitartrate, by increasing the values in constants of concentration and solubility products, KHT excess and saturation temperatures. In case of neutral calcium acid, the same acid favours wine stability, by diminishing the values of the same constants.

Adding the other acids (malic, lactic, citric, and succinic acids) in wine is good for the solubility of tartaric acids, because, in all the cases, the values of constants characterizing solubility diminish.

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