Scientific Papers. Series B, Horticulture. Vol. LXI, 2017
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

EFFECTS OF ADDING GLUTATHIONE AND ASCORBIC ACID BEFORE THE ALCOHOLIC FERMENTATION OF THE MUSTS ON THE SENSORY PROFILE OF THE WHITE WINES

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Abstract

Considering the fact that in the last decade consumers' preference turned to fresh white wines with a strong aromatic profile, wine producers have set as a priority the preservation of varietal aromas from the early stages of primary winemaking during all the process of wine production to the final product, and then, after bottling, until final consumption. In this direction, new antioxidants have been proposed by experts, and the natural antioxidant glutathione (GSH), on which winemakers have great expectations, was recently approved for use in must and wine by OIV.
The present work evaluates the influence of using different doses of reduced glutathione (GSH), as such or in combination with ascorbic acid (AA), on the sensory profile of produced wines, treatments applied before the inoculation with selected yeasts of the musts produced in reductive manner in the presence of sulphur dioxide (SO_2), from Sauvignon Blanc and Muscat Ottonel grapes.The results of the study show that the type and dosage of antioxidants have a significant influence on the sensory profiles of obtained wines and that a higher dosage than 20 mg/L approved by the OIV could be necessary to obtain wines with sensory profiles more appreciated by the consumers.

Key words*: white wine aromas, sensory profile, glutathione, ascorbic acid, Sauvignon Blanc, Muscat Ottonel.*

INTRODUCTION

Oxidation is the main cause for the loss of musts' and wines' varietal aromatic characteristics (Kilmartin, 2010). Therefore, choosing the way of antioxidant protection during winemaking, from the initial crushing of the grapes and till the alcoholic fermentation beginning, is extremely important for defining the style and maintaining the quality of the wine we wish to produce.
Without an adequate management of the must contact with oxygen oxidation reactions of phenolic compounds that give wine and typical varietal character can occur. Oxidative changes start since the time of the grape harvest and during the transport to the cellar due to the contact with the oxygen of the must originating from broken berries (Badea and Antoce, 2015). Under the action of absorbed oxygen, phenolic compounds oxidation in musts takes place simultaneously both by chemical (non-enzymatic) and enzymatic mechanisms (Antoce, 2007; Badea and Antoce, 2015). Simultaneously with destemming and crushing the grapes, in contact with the oxygen and in the presence of polyphenoloxidases (PPOs) derived from healthy grapes such as tyrosinase, cresolase, and catechol oxidase and of laccase enzymes associated with *Botrytis cinerea* fungus contaminated grapes, the oxidation process of the phenolic compounds responsible for the wine aromas and of the flavour precursors starts (du Toit and Oberholster, 2014; Badea and Antoce, 2015). The enzymatic oxidation affects mostly the cinnamic acid and its esters with tartaric acid (caftaric acid and cutaric acid) causing the formation of quinones, easy oxidable compounds further participating to reactions of oxidation and oxidative polymerization (du Toit and Oberholster, 2014; Badea and Antoce, 2015). The quinones formed from the caffeic acid oxidation have a high affinity to react with catechins resulting catechin quinones, which further participate to condensation reaction (Cheynier et al., 1989). The enzymatic oxidation of the phenolic compounds occurs mostly during the berries' crushing operation, but other non-enzymatic oxidation reactions can occur later (Sonni et al., 2011 a; Ugliano et al., 2011). Non-enzymatic oxidation can also occur in musts leading to

similar chemical processes and the formation of same undesirable compounds through the action of hydrogen peroxide formed from the oxidation of ortho-catechins to ortho-diquinones (Singleton, 1987; Antoce, 2007). The processes continue throughout all the applied technological operations until the start of alcoholic fermentation of the must (du Toit et al., 2006).

This is why antioxidant agents such as sulphur dioxide (SO_2) and ascorbic acid (AA), whose action is to reduce or eliminate quinones, are used in the winemaking for the control of the oxidative processes which take place in musts and wines and to assure a better protection of varietal aromas and stability of wines (Brajkovich et al., 2005; Lavigne Cruège et al., 2003; Ugliano et al., 2011). The sulphur dioxide is used in winemaking as it has both capacities to protect musts from enzymatic oxidation and antimicrobial properties (Garde-Cerdán and Ancín-Azpilicueta, 2007). The ascorbic acid is used in different combinations and doses together with sulphur dioxide because of their abilities to inhibit the musts' and wines' polyphenol oxidation (Oliveira et al., 2002). However, because it is well known the allergenic potential of sulphur dioxide and the belief that its use represents a risk to human (Walker, 1985; Garde-Cerdán and Ancín-Azpilicueta, 2007) and researchers have shown that ascorbic acid addition can lead to sotolon formation and can damage the wine aromas (Pons et al., 2010) other solutions must be found for the antioxidant protection of musts and wines. In the last years, the reduced glutathione (GSH), an antioxidant naturally found in grapes was the subject of research for its capacity to protect varietal aromas of musts or wines. Quantities of GSH from small traces to 100 mg/L or more, depending on the variety, oxygen absorption, enzymatic activity and the applied technology (crushing, maceration and pressing conditions) have been measured in grape musts (Cheynier et al., 1989; Park et al., 2000; du Toit et al., 2007; Maggu et al., 2007; Patel et al., 2010), but at least 50-100 mg/L of free GSH in the crushed grapes are necessary for musts antioxidant protection (Singleton et al., 1985). It was already shown that GSH has the capacity to react with caftaric acid quinones leading to 2-S-glutathionyl caftaric acid, also named Grape Reaction Product (GRP) and protect the musts against the browning phenomenon (Singleton et al., 1985; Cheynier et al., 1986; Du Toit et al., 2006; Antoce, 2007; Sonni et al., 2011 a, b). Vaimakis and Roussis (1996) reported that the addition of GSH to oxygenated musts determined the achievement of wines free of oxidation typical aromas and with a level of quality obviously improved. Du Toit and his collaborators (2006) have shown that the treatment with GSH confer to wines a better aromatic profile. Webber and his team (2014) have shown that the addition of 10-20 mg/L GSH to the base must and not in the base wine, led to better quality sparkling wines.

Therefore in July 2015 the addition of up to 20 mg/L GSH to must and wine became an approved oenological practice by OIV (Resolutions OENO-TECHNO 10-445 and 10-446 / July 2015).

In the present work the sensory profiles of two wines, Sauvignon Blanc and Muscat Ottonel have been studied, aiming to evaluate the effect of different doses of glutathione addition as such or in combination with ascorbic acid in sulphited musts, added in clarified musts prior to the alcoholic fermentation initialisation.

MATERIALS AND METHODS

The wine samples have been prepared from Sauvignon Blanc and Muscat Ottonel respectively clarified musts with a certain free SO_2 content. The musts have been produced in a reductive manner by treating the grapes in the receiving tank with 1 g/kg potassium metabisulphite and very small quantities of catechin tannin (0.045 - 0.05 g/kg).

A very small quantity of AA of 0.13 g/kg has been administered on Sauvignon Blanc grapes in the receiving tank. Various dosages of GSH as such or in combination with ascorbic acid have been applied in both types of musts.

The base must of Sauvignon Blanc, with a sugar content of 212 g/L, was produced between the 10^{th} and 12^{th} of September 2015 in the Domeniile Dealu Mare Urlati winery, Prahova County, Romania, from grapes originating from an eight year old plantation (2007).

The base must of Muscat Ottonel, with a sugar content of 210 g/L, was produced between the 25^{th} and the 26^{th} of September 2015 in the same

winery, from grapes originating from a more than 40 years old vineyard.
The technology used for producing both types of musts was the same. After destemming and crushing the grapes, followed by maceration on the skins performed directly in the press for 12 hours, the must drained by gravity without pressing the grapes was subjected to clarification by refrigeration at 10°C in the presence of pectolytic enzymes in tanks with cooling jacket. Musts acidity corrections with tartaric acid (1.4 - 1.65 g/L) and SO_2 correction up to min. 50 mg/L were performed.
The musts produced in this manner were treated in 25 L demijohns with different doses of reduced glutathione (GSH), as such or in combination with a dose of 50 mg/L ascorbic acid (AA).
The experimental variants and the type of treatments are presented in Table 1.

Table 1. Experimental research variants

Experimental variant	Type of Treatment
Musts from Sauvignon Blanc and Muscat Ottonel grape varieties produced in September 2015 treated prior to inoculation with selected yeasts (free SO_2 content: min. 50 mg/L)	GSH doses of 20 mg/L or 40 mg/L
	GSH doses of 20 mg/L or 40 mg/L and AA fixed dose of 50 mg/L

The treatments were applied to musts prior to the inoculation with selected yeast and activators used to initiate the controlled alcoholic fermentation.
The wine samples were prepared in 5 variants and 3 repetitions of each version for both types of musts (Table 2).

Table 2. Variants of musts and administered treatments

Grape variety	Must Sample Code	Dosage
Sauvignon Blanc	SBControl	Control, without treatment
	SBGSH20AA00	20 mg/L Glutathione and 0 mg/L Ascorbic Acid
	SBGSH20AA50	20 mg/L Glutathione and 50 mg/L Ascorbic Acid
	SBGSH40AA00	40 mg/L Glutathione and 0 mg/L Ascorbic Acid
	SBGSH40AA50	40 mg/L Glutathione and 50 mg/L Ascorbic Acid
Muscat Ottonel	MOControl	Control, without treatment
	MOGSH20AA00	20 mg/L Glutathione and 0 mg/L Ascorbic Acid
	MOGSH20AA50	20 mg/L Glutathione and 50 mg/L Ascorbic Acid
	MOGSH40AA00	40 mg/L Glutathione and 0 mg/L Ascorbic Acid
	MOGSH40AA50	40 mg/L Glutathione and 50 mg/L Ascorbic Acid

The same winemaking protocols were applied to both types of musts, as it can be seen in Figure 1.

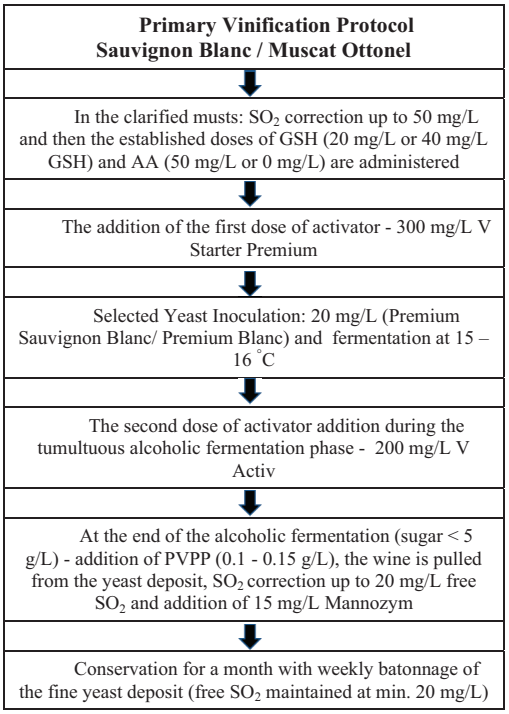

Figure 1. Primary vinification protocols applied to the studied musts

All the oenological materials were supplied by Enologica Vason Italy.

The obtained wine samples were analysed freshly, immediately after the end of the winemaking and before bottling.
The sensory evaluation of the obtained wines was performed directly into the cellar by a group of three authorised wine tasters based on two evaluation sheets: the unified card OIV UIOE used for international competitions - for still wines, and an evaluation tasting form specially designed (Stoian, 2011; Antoce and Namolosanu, 2007).
On the unified card OIV UIOE (Figure 2), the wines were evaluated by providing scores for the visual aspect (limpidity, aspect), in terms of odour (genuineness, intensity, quality), taste (genuineness, intensity, persistence, quality) and overall harmony.

Fiche unifiée OIV UIOE á l'usage des concours internationaux: VINS TRANQUILLES
Unified card OIV UIOE used for international wine contests: STILL WINES
Fişă comună OIV UIOE pentru utilizare la concursuri internţionale: VINURI LINIŞTITE

Commission n° / Commission no./ Comisia nr.	Nom du dégustateur/ Judge name/ Numele degustătorului	Sample/ Échantillon/ Proba

		Excellent Excellent Excelent	Très bon Very Good Foarte bun	Bon Good Bun	Satisfaisant Satisfactory Satisfăcător	Insuffisant Insufficient Insuficient	Remarques Observations Observaţii
VUE/ VISUAL/ VIZUAL	Limpidité/ Limpidity/ Limpiditate	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1	
	Aspect/ Aspect/ Aspect	☐ 10	☐ 8	☐ 6	☐ 4	☐ 2	
ODORAT/ SMELL/ MIROS	Franchise/ Genuineness/ Tipicitate	☐ 6	☐ 5	☐ 4	☐ 3	☐ 2	
	Intensité/ Intensity/ Intensitate	☐ 8	☐ 7	☐ 6	☐ 4	☐ 2	
	Qualité/ Quality/ Calitate	☐ 16	☐ 14	☐ 12	☐ 10	☐ 8	
GOÛT/ TASTE/ GUST	Franchise/ Genuineness/ Tipicitate	☐ 6	☐ 5	☐ 4	☐ 3	☐ 2	
	Intensité/ Intensity/ Intensitate	☐ 8	☐ 7	☐ 6	☐ 4	☐ 2	
	Persistance/ Persistence/ Persistenţă	☐ 8	☐ 7	☐ 6	☐ 5	☐ 4	
	Qualité/ Quality/ Calitate	☐ 22	☐ 19	☐ 16	☐ 13	☐ 10	
HARMONIE / GLOBAL JUGEMENT HARMONY / OVERALL JUDGEMENT ARMONIE / EVALUARE GLOBALĂ		☐ 11	☐ 10	☐ 9	☐ 8	☐ 7	
						TOTAL	

Signature du dégustateur/ Judge signature/ Semnătura degustătorului	
Signature du président/ President signature/ Semnătura preşedintelui	

Figure 2. Model of unified card OIV UIOE for evaluation of still wines used in international competitions (reproduced after Stoian, 2011)

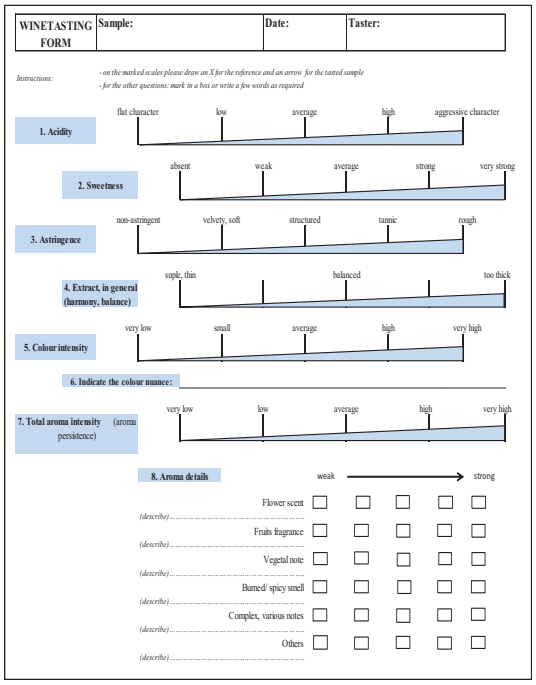

Figure 3. Model of wine tasting form for evaluation of still wines (reproduced after Antoce and Namolosanu, 2007)

On the second tasting form, the wines were first evaluated according to some basics characteristics of the wines, like the acidity, the sweet taste, the extract (Figure 3).

The evaluation methodology is based on scales of 10 cm length, which can be very easy converted in values from 0 to 10 by direct measurement with a normal ruler on the data sheet, scale on which the tasters indicate the level evaluated for each of the analysed characteristics.

These scales have a specific triangle shape, with the sharpest angle pointing towards the left and the base pointing to the right, suggesting that values are increasing in this direction (Antoce, 2007).

Furthermore, some anchors are marked corresponding to each evaluation criteria on the largest triangle leg, as follows:

- acidity: flat character, low, average, high, aggressive character;
- •sweetness: absent, weak, average, strong, very strong;
- •astringency: non-astringent, velvety / soft, structured, tannic, rough;
- •extract, in general (harmony, balance): supple / thin, balanced, too thick;
- •colour intensity: very low, small, average, high, very high.

As regarding the specific parameters of the evaluated wines, the hue and the flavour intensity, the wine tasters had to directly describe on the evaluation form the colour nuance of the wines they have observed.

They also had to evaluate the overall flavour intensity of the wines by indicating the level they have observed on the scale from 1 to 10 with some anchors (very low, low, average, high, very high), available on the tasting sheet for the aroma persistence (Antoce, 2007).

The last evaluation the wine tasters had to achieve is the description of flavour specifying the aroma details by ticking one of the five squares strung from left to right on the evaluation form, rating six flavour nuances from weak to strong: flower scent, fruits fragrance, vegetal note, burned / spicy smell, complex, various notes and other nuances they identified. Other comments can be mentioned on the evaluation form if there are special observations regarding the aroma details.

Because the evaluators did not noticed big sensory differences between the repetitions of the same treatment variant, average samples were made by combining the 3 repetitions for each experimental variant and for both wines Sauvignon Blanc and Muscat Ottonel.
These average wine samples have been then evaluated according the wine sensory evaluation forms previously described and scores have been awarded for each type of wine sample.
The numerical results determined by measuring the assessment of each taster have been grouped into tables and the average scores for each parameter and each wine sample have been calculated.
The main observations made by wine tasters on aroma details have been also centralized in tables for each wine variety and samples variants. Based on the obtained results, the sensory profile of each evaluated wine sample was built for both varieties of wine. The sensory profiles have been reported as a spider web chart and a description of the main characteristics of the analysed samples.
Also, based on the obtained scores on the unified card OIV UIOE, the ranking of analysed wine samples was achieved and the most appreciated wine sample submitted to the tasters' sensory evaluation from each variety of wine was identified.
As a result, the treatments applied to the samples of musts from which the most appreciated wines are originating and the doses of antioxidants added prior the initialization of the alcoholic fermentation of samples have been determined.

RESULTS AND DISCUSSIONS

Physic-chemical parameters of the Sauvignon Blanc wine samples produced with experimental protocols proposed for research that have correspondent with the wines characteristics evaluated on the sensory analysis sheets are listed in Table 3.
The Muscat Ottonel wine samples' physic-chemical parameters that have correspondence with the wines characteristics evaluated on the sensory analysis sheets are presented in Table 4.

Table 3. Physico-chemical parameters of the Sauvignon Blanc wines determined before bottling

Wine sample code	Total acidity (g/L tartaric ac.)	Sugar (g/L)	Nonreducing dry extract (g/L)
SBControl			
SBGSH00AA00 R1	7.8	2.6	22.4
SBGSH00AA00 R2	8.1	3.1	22.9
SBGSH00AA00 R3	8.2	7.8	18
SBGSH20AA00			
SBGSH20AA00 R1	7.6	2.7	22
SBGSH20AA00 R2	6.84	2.3	18
SBGSH20AA00 R3	6.31	2.37	19.53
SBGSH20AA50			
SBGSH20AA50 R1	6.31	2.37	20.83
SBGSH20AA50 R2	7.74	2.6	22.7
SBGSH20AA50 R3	6.39	4.1	19.5
SBGSH40AA00			
SBGSH40AA00 R1	6.39	2.62	21.48
SBGSH40AA00 R2	6.4	3.18	22.02
SBGSH40AA00 R3	6.54	1.6	18.1
SBGSH40AA50			
SBGSH40AA50 R1	6.31	1.81	20.19
SBGSH40AA50 R2	6.3	3.56	19.2
SBGSH40AA50 R3	6.24	2.37	19.83

Table 4. Physico-chemical parameters of the Muscat Ottonel wines determined before bottling

Wine sample code	Total acidity (g/L tartaric ac.)	Sugar (g/L)	Nonreducing dry extract (g/L)
MOControl			
MOGSH00AA00 R1	8.4	6.5	21.6
MOGSH00AA00 R2	7.74	8.1	17.6
MOGSH00AA00 R3	8.1	7.5	20
MOGSH20AA00			
MOGSH20AA00 R1	8	7.6	19.5
MOGSH20AA00 R2	7.9	7.12	19.78
MOGSH20AA00 R3	7.9	5.87	20.83
MOGSH20AA50			
MOGSH20AA50 R1	7.74	5.87	20.1
MOGSH20AA50 R2	7.8	5.43	20.67
MOGSH20AA50 R3	8.5	6.5	19.7
MOGSH40AA00			
MOGSH40AA00 R1	8.4	6.87	20.33
MOGSH40AA00 R2	8.9	5.8	23.4
MOGSH40AA00 R3	8.7	8.31	20.39
MOGSH40AA50			
MOGSH40AA50 R1	8.7	6.25	19.85
MOGSH40AA50 R2	8	2.6	25
MOGSH40AA50 R3	7.2	5.87	20.63

The scores awarded by tasting jurors on the OIV UIOE unified card and the average marks calculated for the Sauvignon Blanc wine samples are shown in Table 5.

Table 5. The scores on the OIV UIOE unified card and the calculated average scores for Sauvignon Blanc wines

Wine sample Code/ Judge Name	Visual		Odour			Taste				Harmony/ Overall judgement	Total
	Limpidity	Aspect	Genuiness	Intensity	Quality	Genuiness	Intensity	Persistence	Quality		
SBControl	3.77	6.35	4.41	6.41	12.64	5.00	6.91	7.00	17.22	10.00	79.70
Judge 1	4	7	5	7	13	5	7	7	18	10	81
Judge 2	4	6	5	7	13	5	7	7	18	10	81
Judge 3	4	6	4	6	12	5	7	7	16	10	77
SBGSH20AA00	3.67	7.33	5.00	7.00	13.33	5.00	6.67	7.00	19.00	10.00	84.00
Judge 1	3	6	5	7	14	5	7	7	19	10	83
Judge 2	4	8	5	7	14	5	7	7	19	10	86
Judge 3	4	8	5	7	12	5	6	7	19	10	83
SBGSH20AA50	3.33	6.00	5.00	6.33	13.33	5.00	7.00	7.00	17.00	10.00	80.00
Judge 1	3	6	5	6	14	5	7	7	19	10	82
Judge 2	3	6	5	6	12	5	7	7	16	10	77
Judge 3	4	6	5	7	14	5	7	7	16	10	81
SBGSH40AA00	3.67	8.00	5.00	6.33	14.00	5.00	7.00	7.67	19.00	10.00	85.67
Judge 1	4	8	5	7	14	5	7	7	19	10	86
Judge 2	3	8	5	6	14	5	7	8	19	10	85
Judge 3	4	8	5	6	14	5	7	8	19	10	86
SBGSH40AA50	3.00	6.00	4.33	6.00	12.00	4.33	6.33	6.67	16.00	9.00	73.67
Judge 1	3	6	5	6	12	4	6	7	16	9	74
Judge 2	3	6	4	6	12	4	6	7	16	9	73
Judge 3	3	6	4	6	12	5	7	6	16	9	74

After the UIOE regulations awards are granted to wines receiving the following scores: over 90 points - Gold Medal, between 85 and 90 points - Silver Medal, between 80 and 85 points - Bronze Medal and between 75 and 80 points – Certificate of merit (Stoian, 2011).

The grille used in the last years at the international wine contests organized in Romania under the supervision OIV for awarding the wines which will be valid also for the 2017 contest is a bit harsher than the UIOE grille: over 92 points - Great Gold Medal, between 85 and 91.99 points - Gold Medal, between 82 and 84.99 points - Silver Medal (IWCB 2017 Regulations).

By analyzing the average scores for the Sauvignon Blanc wines (Table 5) we can observe that scores between 73.67 points and 85.67 points have been resulted. If we consider the grille used according the ICWB regulations, then both wine samples treated only with GSH could reach awards, the sample SBGSH40AA00 with 85.67 points – Gold Medal and the sample SBGSH20AA00 with 84.00 points – Silver Medal. The control sample SBControl without any treatment and the samples treated with GSH and AA have been evaluated with lower grades (80.00 points, 73.67 points respectively) and would not have been qualified for any distinction.

From the graphic representation of the total average scores of Sauvignon Blanc wine samples evaluated freshly before bottling (Figure 4) it is easy to remark that wine samples produced only with GSH received higher scores, even if compared with the control sample SBControl without treatment or to wine samples produced with GSH and AA.

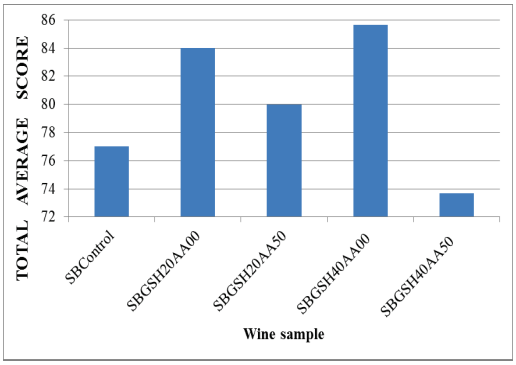

Figure 4. Graphic representation of the total average scores calculated for Sauvignon Blanc wines

The wine sample SBGSH40AA00 produced with a dose of 40 mg/L GSH and without AA was considered the best by all the judges. AA caused a deterioration of the wines' sensory profile and samples thus treated were downgraded properly by the wine tasters. This deterioration is more obvious if the dose of GSH increases.

If we follow the same reasoning for the Muscat Ottonel samples scores' (Table 6), we can conclude that the samples containing GSH, both with or without AA, obtained higher grades (from 82.67 to 86.67 points) than the control sample (79 points).

The samples treated only with GSH, MOGSH40AA00 and MOGSH20AA00 could qualify for the gold medal and silver medal (86.67 and 84.33 points respectively). Muscat Ottonel samples treated with GSH and the fixed dose of 50 mg/L AA were less downgraded by judges (82.67 and 83.33 points respectively) than the similar treated Sauvignon Blanc samples (80.00 and 73.67 points respectively).

In this case the sample MOGSH20AA50 was scored similarly with MOGSH20AA00 and would qualify for the silver medal.

Table 6. The scores on the OIV UIOE unified card and the calculated average scores for Muscat Ottonel wines

Wine sample Code/ Judge Name	Visual		Odour			Taste				Harmony/ Overall judgement	Total
	Limpidity	Aspect	Genuiness	Intensity	Quality	Genuiness	Intensity	Persistence	Quality		
MOControl	**4.00**	**7.00**	**5.00**	**6.50**	**13.00**	**4.50**	**6.50**	**6.50**	**16.00**	**9.00**	**78.00**
Judge 1	3	6	5	6	12	4	7	7	16	9	75
Judge 2	5	8	5	7	14	5	6	6	16	9	81
Judge 3	5	8	5	7	12	5	7	6	16	10	81
MOGSH20AA00	**4.50**	**8.00**	**5.00**	**6.50**	**13.00**	**5.00**	**6.50**	**6.50**	**19.00**	**9.50**	**83.50**
Judge 1	4	8	5	7	14	5	7	7	19	10	86
Judge 2	5	8	5	6	12	5	6	6	19	9	81
Judge 3	4	8	5	7	14	5	7	7	19	10	86
MOGSH20AA50	**4.50**	**9.00**	**5.00**	**7.00**	**13.00**	**5.00**	**6.00**	**7.00**	**17.50**	**9.50**	**83.50**
Judge 1	4	8	5	7	14	5	6	7	19	10	85
Judge 2	5	10	5	7	12	5	6	7	16	9	82
Judge 3	4	8	5	6	12	5	6	6	19	10	81
MOGSH40AA00	**4.00**	**9.00**	**5.00**	**7.00**	**14.00**	**5.00**	**7.00**	**6.50**	**19.00**	**10.00**	**86.50**
Judge 1	4	8	5	7	14	5	7	7	19	10	86
Judge 2	4	10	5	7	14	5	7	6	19	10	87
Judge 3	4	10	5	7	14	5	7	6	19	10	87
MOGSH40AA50	**4.00**	**8.00**	**5.00**	**6.50**	**14.00**	**5.00**	**6.50**	**6.50**	**17.50**	**10.00**	**83.00**
Judge 1	4	8	5	7	14	5	7	7	16	10	83
Judge 2	4	8	5	6	14	5	6	6	19	10	83
Judge 3	5	10	5	6	14	5	7	6	16	10	84

The control sample MOControl and the sample MOGSH40AA50 treated with 40 mg/L GSH and 50 mg/L were less appreciated by the wine tasters and would not have been qualified for any distinction.

From the graphic representation of the total average scores of Muscat Ottonel wine samples

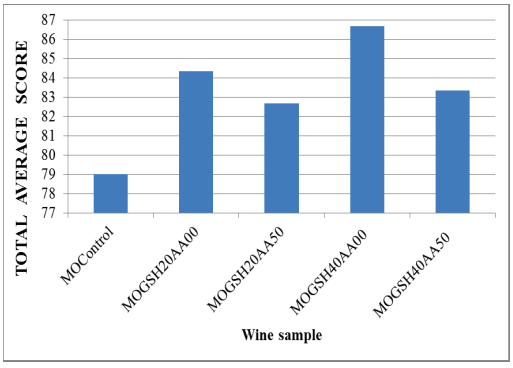

Figure 5. Graphic representation of the total average scores calculated for Muscat Ottonel wines

evaluated freshly before bottling (Figure 5) we can immediately notice that in this case the sample treated with 40 mg/L GSH and without AA obtained the highest score and was most appreciated by the jury as for the Sauvignon Blanc wine samples.

Average scores of the numerical values determined from the measurement of each tasters' marks have been calculated the for each parameter and each wine sample (Table 7 and Table 8).

Table 7. The calculated average scores on the second evaluation form for Sauvignon Blanc wines

Wine characteristics	SBControl	SBGSH20AA00	SBGSH20AA50	SBGSH40AA00	SBGSH40AA50
Acidity	4.3	4.7	4.7	4.2	4.3
Sweetness	0.5	0.8	0.3	0.5	1.2
Astringence	4.0	3.0	4.5	3.8	4.7
Extract	4.7	4.3	4.7	4.0	4.5
Colour intensity	4.3	4.5	4.8	4.7	6.2
Aroma persistence	2.8	4	4.3	5.5	3.3

Table 8. The calculated average scores on the second evaluation form for Muscat Ottonel wines

Wine characteristics	MOControl	MOGSH20AA00	MOGSH20AA50	MOGSH40AA00	MOGSH40AA50
Acidity	4.7	4.5	4.5	4.7	4.3
Sweetness	0.3	0.5	1.0	0.5	1.0
Astringence	4.0	3.3	3.7	3.7	4.5
Extract	4.2	4.0	4.0	3.7	4.3
Colour intensity	4.5	4.7	4.5	4.3	4.3
Aroma persistence	4.8	4.3	4.3	5.0	4.2

Based on these numerical values the sensory profile of each evaluated sample was built for both varieties of wine and represented as a spider web chart (Figure 6 and Figure7).

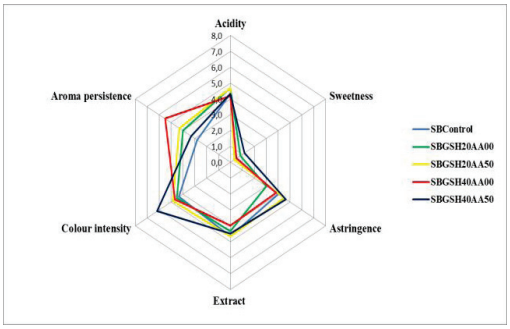

Figure 6. Graphic representation of the sensory profile determined for Sauvignon Blanc wine samples

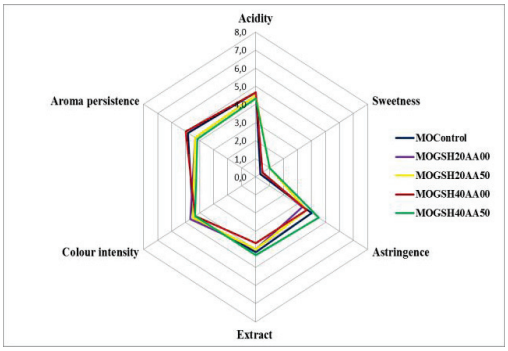

Figure 7. Graphic representation of sensory profile determined for Muscat Ottonel wine samples

By analyzing the sensory profile of Sauvignon Blanc wine samples of resulting from sensory analysis performed by experts we can see that all wines originating from Sauvignon Blanc musts treated with GSH, with or without AA, have a level of persistence of flavor and color intensity higher than the tasters reported for the control sample. The tasters have assessed wines produced from musts treated with GSH as balanced, structured and with a more complex sensory profile. AA presence determined an increase of the astringency and the intensification of bitter note, both compared to the control sample and samples produced only with GSH, the last ones being characterized as soft and velvety. The SBGSH40AA00 sample treated with 40 mg/L GSH has been evaluated as the sample with the best aroma persistence level and with the most balanced characteristics compared with all other Sauvignon Blanc samples (Table 9).

Table 9. Wine characteristics evaluation on the second tasting form for Sauvignon Blanc wines

Wine characteristics	SBControl	SBGSH20AA00	SBGSH20AA50	SBGSH40AA00	SBGSH40AA50
Acidity	average acidity, balanced	average to high	average	average	average
Sweetness	slightly sweet	absent	slightly sweet	weak, slightly sweet	weak, slightly sweet
Astringence	structured, slightly bitter	velvety soft, slightly bitter, less astringent than SBControl	structured to tannic	structured to tannic	structured to tannic with bitter notes that bother and more astringent than the other samples
Extract	structured, balanced, long	more balanced compared with SBControl, but less long	structured, balanced, long, intense	structured, balanced	too extractive and thick
Colour intensity	average to high	average to high	average to high, more intensely colored than SBGSH20AA00	average to high	high to very high
Colour nuance	oxidized, spotted to light pink	greenish yellow with golden shade	greenish yellow, more oxidised than SBGSH20AA00	greenish with yellowish shade	oxidized, spotted to light pink
Total aroma intensity	low to average	average	average	average to high	low to average
Flavor description	neutral, weak floral and fruity nuance , intense shades of oxidized apple and quince	weak shades of elderflower, mint and citrus flowers, lime flowers; intense fruity shades of citrus (lemon, grapefruit, orange peel), relatively thiolic	intense shades of citronella, light shades of green cucumber and yogurt, low shades fruity melon and intense citrus nuances (lime and lemon, and then grapefruit). AA intensifies citrus note	moderate nuances of spring flowers, floral nuances and average fruity citrus nuances; more terpenic, less thiolic	weak floral nuances; weak fruity nuances (melon and citrus); average vegetal notes, oxidized, phenolic, quinonic

The same improvement of the sensory profile determined by the treatment with GSH resulted also for the Muscat Ottonel variety, but MOGSH40AA00 sample has been particularly distinguished.

In the Table 10 the characteristics' evaluation on the second tasting form for Muscat Ottonel wine samples are presented.

We can notice that the Muscat Ottonel wines had the same behavior like the Sauvignon Blanc wines. The Muscat Ottonel samples produced with GSH and AA have been evaluated also with a higher level of astringency and a bittersweet note more intense than that perceived by tasters in the samples produced only with GSH. The sample wines MOGSH20AA00 and MOGSH40AA00 have been characterized as structured, elegant, soft and velvety. Also in this case the wine sample MOGSH40AA00 was declared the best by wine tasters.

Table 10. Wine characteristics evaluation on the second tasting form for Muscat Ottonel wines

Wine characteristics	MOControl	MOGSH20AA00	MOGSH20AA50	MOGSH40AA00	MOGSH40AA50
Acidity	average to high	average to high	average to high	average to high	average to high
Sweetness	slightly sweet	slightly sweet	slightly sweet	slightly sweet	slightly sweet
Astringence	structured, slightly bitter	velvety soft	structured, AA intensifies bitter notes	structured, but velvety soft , the less bitter and astringent	structured to tannic with more pronounced bitter notes that MOGSH40AA00, but more long; AA gives corpolence to wine.
Extract	balanced	balanced	balanced	balanced, the most vinous	balanced
Colour intensity	average to high	average to high	average to high, more intensely colored than SBGSH20AA00	average to high	high to very high
Colour nuance	greenish yellow with golden shade	greenish yellow with golden shade	greenish yellow with golden shade	greenish yellow with golden shade	greenish yellow with golden shade
Total aroma intensity	average to high	average	average	average to high	average
Flavor description	weak flower shades of elderflower, linden and roses, honey; terpenic, unoxidized	weak flower shades of linden and acacia, more pronounced flower scents comparing with MOControl, smoother smell, quince jam shades	weak flower shades, vegetal notes, poorer as aroma comparing with MOGSH20AA00, but rounder taste; light aroma of green apple, but unoxidized	weak nuances of spring flowers, floral nuances and more intense apple fruity nuances, low shades toasted walnuts; terpenic, but more elegant comparing with MOGSH20AA00, beautiful citrus notes	weak floral nuances; moderate fruity nuances (citrus); low roasted nuances, more neutral than MOGSH40AA00, mineral with a certain hardness

CONCLUSIONS

All wine samples either originating from Sauvignon Blanc or Muscat Ottonel musts treated with GSH, with or without AA, led to a persistence of flavour and colour intensity

higher than those reported by wine tasters for the control samples. The wines were characterized as balanced, structured and with a complex sensory profile. AA presence caused the intensification of bitter notes, both in comparison with the control samples and samples produced only with GSH. This wine damage by AA was more evident as the dose of GSH increased. Samples of wines produced only with GSH have been described as soft and velvety and received higher scores from the tasters, both compared with the controls and the wines samples produced with GSH and AA. The samples produced with a dose of 40 mg/L GSH and without AA were considered the best by tasters for both wines varieties and have received the highest scores.

In conclusion, the AA administration in grape musts seems to have less beneficial influence on the sensory profile of obtained wines from both varieties. Treatment with GSH especially the one without AA led to the achievement of better wines with more complex sensory profiles. The study clearly demonstrates that the type and the doses of antioxidants used have an important influence in terms of protecting the varietal aromas of wines. The dose of 40 mg/L GSH, higher than the approved dose by OIV of 20 mg/L for addition in musts, could be more suitable for use in the primary winemaking. This direction must be confirmed by further research that could demonstrate the benefits of treatment with GSH and may lead to the optimal dose establishment for administration in grape musts prior the inoculation with selected yeasts.

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