COMPOSITIONAL CHARACTERISTICS OF LOW-ALCOHOL WINES OBTAINED BY STAGGERED GRAPE HARVESTING TECHNOLOGY

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Abstract

Excessive alcohol consumption has many negative effects on human health and society itself. Climate change and the improvement of viticultural technologies have gradually led to an increase in the alcoholic concentration of wines, a trend that has become contrary to the current requirements of consumers inclined to a healthy diet. The aim of the study was to obtain wines with low alcohol concentration through a simple and accessible technology, by staggered grape harvesting, at 100 and 150 g/L sugars ("in green") and at full grape maturity (Muscat Ottonel and Pinot gris varieties), in the ecopedoclimatic conditions of Copou-Iasi wine center, NE of Romania. By blending the experimental wines were obtained improved beverages in terms of physico-chemical characteristics, phenolic composition and chromatic parameters, with alcohol concentrations between 6.5 and 8.5% vol. Sensory properties changed significantly, being produced more acid wines, with less full bodied perception and reduced persistence as detracting characteristics.

Key words: blending wines, grapes, "green" harvest, low-alcohol wines, sensory properties.

Although the current legislation defines wine as the food product obtained exclusively by the alcoholic fermentation of fresh grapes or grape must with an ethanol content of at least 8.5% (v/v), usually, the alcoholic concentration of wines is always much higher. Throughout time the alcoholic concentration of wines has increased gradually, a trend attributed to climate change (a gradual increase in average temperatures), together with advanced viticultural practices leading to elevated sugar levels in grapes and implicitly to an increase in the alcohol content of obtained wines. Has been proven that in warmer regions, over the last 30 years, the average alcohol content has risen by approximately 2% vol. (Varela C. *et al*, 2015).

Alcohol is one of the unhealthiest components of the wine and, many times it is the main cause of rejection by the consumer (Martinez de Toda F., Balda P., 2011). Moreover, consumer demand is apparent for wines with lower ethanol levels, perceived as healthier, ensuring food security and nutritional value. While light-to-moderate alcohol consumption has been reported to be cardio-protective, excessive alcohol consumption led to many negative effects on human health (neurological, gastrointestinal and cardiovascular conditions) (Ding C. *et al*, 2021).

Although ethyl alcohol produces negative psychological and physiological effects in humans, it is indispensable for ensuring microbiological stability, balancing organoleptic characteristics and increasing the aging capacity of wine. Considering all these aspects, the production of low-alcohol wines has become a huge challenge for vinegrowers, winemakers and field researchers, who have to initiate a new series of strategies in order to reduce the alcoholic concentration of wines, affecting as little as possible their organoleptic parameters.

Most of the currently known methods (reverse osmosis, vacuum concentration, dialysis, distillation, ultrafiltration, enzymatic or microbiological processes) have limited use due to inconveniences related to high initial costs, energy consumption, manipulation of large liquid volumes, showing uncertain yields and affecting the physico-chemical composition of the wines. Winemakers need flexible, easy to implement and cheap strategies to obtain low alcohol wines. The staggered harvesting of grapes, before reaching full maturity ("green" harvest), is a simple and accessible technology to reduce the alcoholic concentration of the final wines. Previous research concluded that harvesting grapes in the early stages

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of development can lead to low-alcohol wines with distinct sensory characteristics ("green" flavours and high acidity), being necessary that grapes to reach a certain degree of maturity (Pickering G.J., 2000). The aim of the present study was to obtain experimental low-alcohol wines by staggered harvesting of grapes at different sugar concentrations and blending the produced wines. The physico-chemical and sensorial characteristics of the low-alcohol wines were analysed. Experimental data can be useful to grape producers, winemakers and consumers for a easier implementation of the “green” harvest technology and a better understanding of the concept.

MATERIAL AND METHOD

Based on the maturity dynamics, grapes of Muscat Ottonel and Pinot gris varieties, 2020 harvest, growing in the plantations of Research - Development Station for Viticulture and Winemaking Iasi (SCDVV Iasi), Copou-Iasi wine center, NE of Romania, were staggered harvested according to their sugars concentration, at 100 and 150 g/L sugars (in “green”) and at full maturity of grapes. Grapes were crushed and destemmed in the industrial winemaking system. The alcoholic fermentation of musts (2×25 L) was initiated by the inoculation with selected *Saccharomyces cerevisiae* yeasts (Fermactive CB, Sodinal; 20 g/hL), at 20±1℃, being obtained three wines with alcoholic concentrations of 5.50 (V_1), 8.50 (V_4) and 12.30% (Muscat Ottonel), respectively 13.80% vol. (Pinot gris). Wine obtained at the first “green” harvest (V_1) was blended with the wine obtained at grape full maturity (Control), obtaining intermediate wines with alcoholic concentrations of 6.5 (V_2) and 7.5% vol. (V_3) (*figure 1*).

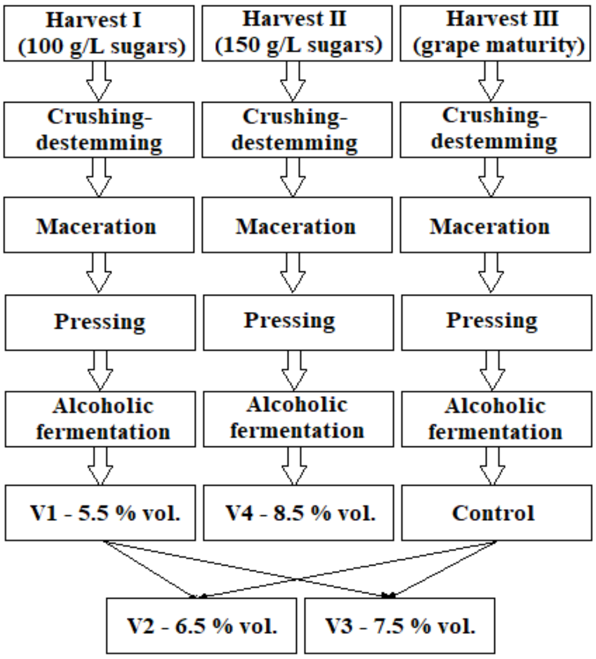

Figure 1 **Technological scheme for obtaining low-alcohol wines by staggered grape harvesting**

Apart from a sterile filtration (0.45 μM) and sulphite addition no other treatment was applied to the wines. The main physico-chemical parameters of grape musts and wines were analyzed acording to the OIV Compendium of international methods of wine and must analysis. The assimilable nitrogen in the must (ammoniacal nitrogen + amine nitrogen) was determined according to Gump B.H. *et al* (2001). Total concentration of phenolic compounds in wine was determined according to the OIV-MA-AS2-10:R2009 method. The results were expressed as gallic acid equivalent ($y=1.1317x-0.0451$; $r^2=0.9910$). Procyanidins (monomers) were assessed by reaction with vanillin, while condensed tannins (oligo /polymers) were determined by Bate-Smith reaction (Caceres-Mella A. *et al*, 2013). Wine color components, respectively color intensity (I), color hue (H) and the percentage of red (%R), yellow (%Y) and blue (%B), were analysed according to Glories Y. (1984), by directly measuring the absorbance of the wine at wavelengths 420, 520 and 620 nm, in a 1 cm glass cuvette, after filtering the samples. The CI was calculated as the sum of the absorbances at 420, 520 and 620 nm and H as the ratio between the absorbances at 420 and 520 nm. All spectral determinations were performed using a 1700 series Shimadzu monofascicular UV-vis spectrophotometer (Japan). Wine samples were sensorially analyzed by a panel of 13 initiated and expert tasters, being given scores from 1 to 10 for each analyzed characteristic. The results were digitally recorded using sheets generated by Google Forms. Data were reported as mean of two replicates, with standard deviation (±). Analysis of variance (ANOVA) test (Microsoft® Excel, Data Analysis) was initiated to investigate significant differences between data. *p-values* < 0.05 were considered to be significant (* indicating significant differences). Coefficient of variation (CV% = ±/mean) was calculated (CV<10%, indicate that analyzed data are very homogeneous in terms of dispersion; 10% <CV<20% indicates homogeneous data; CV>20% the data are not homogeneous, so it does not behave unitary in relation to the studied characteristic). Regression analysis was performed to look for relationships between data.

RESULTS AND DISCUSSIONS

The assimilable nitrogen content of grapes influences the yeast development and fermentation dynamics. The absence of these compounds in the must can lead to slowing down the process of alcoholic fermentation or even blocking it. The assimilable nitrogen content of the musts obtained by the staggered grape harvest was ranging between 118.78 and 130.20 mg/L for the Muscat Ottonel variety (MO) and between 140.80 and 151.20 mg/L for the Pinot gris variety (PG), with values that decreased during grape ripening. Thus, only the must obtained from PG grapes (regardless of the time of harvest) was provided the necessary assimilable nitrogen for the proper conduct of alcoholic fermentation, in the case of MO grapes being necessary the addition of assimilable nitrogen (Vinovit, Enoitalia), up to a reference value of 140 mg/L.

The alcoholic fermentation of musts was initiated by their inoculation with *Saccharomyces cerevisiae* yeasts and monitored by the analysis of sugar metabolism and ethyl alcohol synthesis. For both varieties, the highest alcoholic concentration was reached after 6 days of fermentation for the must of early harvested grapes (V$_1$), 8 days for the grape must of the second harvest (V$_4$) and 10 days for the must obtained from the grapes harvested at full maturity. Thus, the alcoholic concentration of the three base wines was 5.58, 8.58 and 12.30% vol. for the MO variety (*figure 2*) and 5.55, 8.55 and 13.80% vol. for the PG variety (*figure 3*).

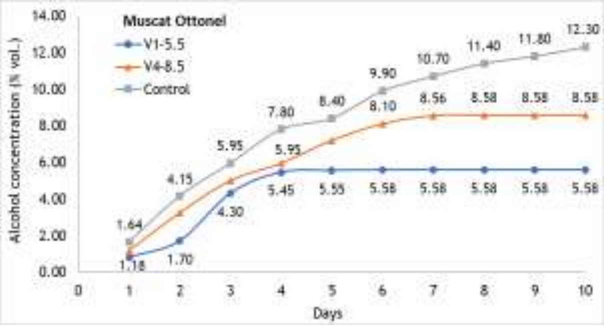

Figure 2 **Dynamics of the alcoholic fermentation of Muscat Ottonel grape must**

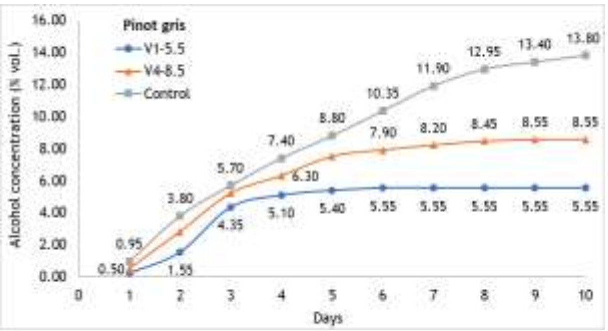

Figure 3 **Dynamics of the alcoholic fermentation of Pinot gris grape must**

By using controlled volumes of the V$_1$-5.5 wine and the control wine, two more experimental wines were obtained with 6.5 and 7.5% vol. alcohol. Wine quality, stability and organoleptic parameters depend mainly on its physico-chemical composition. Physico-chemical characterization of wines obtained by staggered grape harvest and their blending is shown in *table 1*.

Ethyl alcohol or ethanol is the main product of alcoholic fermentation and after water is the component with the highest proportion in wine, being indispensable for ensuring microbiological stability and balancing organoleptic characteristics. Ethanol gives wine viscosity, reduces the acid taste and increases the olfactory sensitivity, modifying the sensory perception of aroma compounds (Cotea V.V. *et al*, 2021). In the experimental wines the alcohol content was low (5.55 - 8.58% vol.) depriving the wine of certain characteristics necessary to ensure its stability and superior organoleptic features. Moreover, total acidity was high, especially in the wines obtained from grapes harvested in "green", reaching 12.38 g/L in MO V$_1$-5.5 wine and much more in PG V$_1$-5.5 wine, 18.15 g/L as tartaric acid. The lowest values were registered in control variant (5.78 - 6.30 g/L). The acidity ensures the physico-chemical stability of the wine, gives a more shine color and fresh taste. The lack of acidity makes the wine more easily attacked by microorganisms (bacteria in particular), while the excess acidity imprints a harsh, crude taste. According to current legislation, the total acidity of wine should be at least 3.5 g/L as tartaric acid, but a maximum limit is not mentioned. However, the acidity of the wines obtained from grapes harvested at low sugar concentrations (V$_1$) showed excess acidities. A much improved total acidity was obtained in V$_3$-7.5 and V$_4$-8.5 variants of MO variety (6.48-10.16 g/L).

Table 1

Physico-chemical characterization of wines obtained by staggered grape harvest

Variety	Sample	Alcohol (% vol.)	Total acidity (g/L tartaric acid)	Volatile acidity (g/L acetic acid)	Free SO$_2$ (mg/L)	Total SO$_2$ (mg/L)	Sugars (g/L)	pH
Muscat Ottonel	V1-5.5	5.50 ± 0.05*	12.38 ± 0.12*	0.48 ± 0.02	24 ± 0	119 ± 2*	0.94 ± 0.12*	2.81 ± 0.01*
	V2-6.5	6.55 ± 0.05*	11.48 ± 0.14*	0.46 ± 0.02	22 ± 1*	120 ± 3*	0.96 ± 0.10	3.09 ± 0.02
	V3-7.5	7.55 ± 0.05	10.16 ± 0.10	0.43 ± 0.06*	20 ± 1*	100 ± 2*	0.84 ± 0.10*	3.11 ± 0.02
	V4-8.5	8.58 ± 0.04	6.48 ± 0.08*	0.56 ± 0.04*	22 ± 2	102 ± 3*	1.06 ± 0.10	3.17 ± 0.02
	Control	12.30 ± 0.05*	5.78 ± 0.09*	0.48 ± 0.02	30 ± 2*	100 ± 2*	1.48 ± 0.10*	3.38 ± 0.01*
	Mean	8.10 ± 2.61	9.26 ± 2.97	0.48 ± 0.05	24 ± 3	108 ±10	1.06 ± 0.25	3.11 ± 0.20
	CV%	32.29	32.10	9.99	16.30	9.57	23.63	6.56
Pinot gris	V1-5.5	5.55 ± 0.05*	18.15 ± 0.10*	0.40 ± 0.09*	19 ± 1*	118 ± 2*	1.00 ± 0.10*	2.70 ± 0.02*
	V2-6.5	6.58 ± 0.03*	16.58 ± 0.10*	0.42 ± 0.08	19 ± 1*	115 ± 4	1.08 ± 0.10	2.96 ± 0.02
	V3-7.5	7.50 ± 0.05*	15.71 ± 0.08*	0.45 ± 0.07	18 ± 1*	120 ± 3*	1.04 ± 0.10	2.98 ± 0.02
	V4-8.5	8.55 ± 0.05	10.28 ± 0.06*	0.52 ± 0.04*	21 ± 1	109 ± 1*	1.10 ± 0.10	2.95 ± 0.01
	Control	13.80 ± 0.02*	6.30 ± 0.10*	0.57 ± 0.10*	26 ± 2*	110 ± 3*	1.20 ± 0.10*	3.21 ± 0.02*
	Mean	8.40 ± 3.22	13.40 ± 4.95	0.47 ± 0.07	21 ± 3	114 ± 5	1.08 ± 0.08	2.96 ± 0.18
	CV%	38.33	36.96	15.09	15.58	4.22	6.95	6.10

Note: Control – wine obtained from grapes harvested at full maturity; CV% - Coefficient of variation (CV% = ±/mean); * - indicates significant differences to the mean at p<0.05 (ANOVA test).

In the case of the PG variety none of the experimental variants corresponded to the concept of “balanced” acidity.

The real (ionic) acidity represents the concentration of free ions of hydrogen (H^+), which is expressed by the pH index. In theory, the sum of the acids and cations determines must or wine pH. The pH of the wines increased gradually, along with the evolution in ripeness of grapes, starting from the value of 2.81 for MO wines and of 2.70 for PG. The wines obtained at the grape ripening (control) showed a pH characteristic to high quality wines (3.21-3.38), with lower value for PG. Blending the wines led to an adjustment of the pH, thus, to the variants with 7.50% vol. alcohol (V_3) the real acidity was fair, close to the value of 3.0.

Volatile acidity is a measure of the wine's volatile acids. The primary volatile acid in wine is acetic acid, which is also the primary acid associated with the smell and taste of vinegar. Volatile acidity is an indicator for the evolution of wines, being able to appreciate their health and difficulties that may occur during the storage. According to EU legislation, the volatile acidity cannot be higher than 1.08 g/L acetic acid for white or rosé wines. The experimental low-alcohol wines obtained by staggered grape harvest showed an adequate volatile acidity, within the range of 0.40 - 0.57 g/L acetic acid.

Sulfur dioxide (SO_2) is widely used in the wine industry as a chemical preservative and antioxidant. The role of SO_2 as an antioxidant in grape must and wine lies in its competition with oxygen. As a reducing agent, SO_2 can inhibit oxidation caused by molecular oxygen (Zoecklein B.W. *et al*, 1995). Due to the lower alcohol concentrations the total amount of SO_2 necessary to achieve microbial stabilization in wines obtained by staggered grape harvesting may approach to the legal limits for white wines (200 mg/L SO_2). Considering the low pH and in order to ensure the antioxidant protection and to prevent the development of the wine alteration microbiota, the total SO_2 concentrations were set to 100-130 mg/L, with free SO_2 concentrations up to 30 mg/L.

All wines fermented without impediments, even at pH < 3, the residual sugar concentrations being below 1.5 g/L (dry wines).

After sugars and acids, the grapevine synthesizes important amounts of phenolic compounds which accumulate in the solid parts of grapes (stalk, seeds) and in the berry skin. Phenolic compounds are secondary metabolites that can be formed and transformed during the winemaking process (Merkytė V. *et al*, 2020). The alcohol synthesized during fermentation contributes to the extraction of phenolic compounds from grapes to wine. These compounds are critically important for wine quality, due to their contribution to the sensory properties: color, taste, mouthfeel, flavor, astringency and bitterness (Hornedo-Ortega R. *et al*, 2020). They contribute to the flavor and body of the wine, giving astringency when found in large quantities and influencing the chromatic parameters. The total content of phenolic compounds expressed in gallic acid equivalent was higher in the wines obtained at the first harvest (V_1-5.5), in both varieties, with high values for MO wine (1.29 g GAE/L) (*table 2*). During grape maturation the accumulation of phenolic compounds showed a fluctuating dynamics. Thus, in PG wine obtained at grape maturity (control), the total phenolic content was higher (1.09 g GAE/L), compared to MO wine (0.78 g GAE/L), mainly due to the gradual accumulation of anthocyanins (up to 319.75 mg/L in control wine).

Table 2

Polyphenolic composition of wines obtained by staggered harvest of grapes

Variety	Sample	TPC (g GAE/L)	Anthocyanins (mg/L)	TPI (D_{280})	Procyanidins (monomers) (g EC /L)	Tannins (polymers) (g EC/L)
Muscat Ottonel	V1-5.5	1.29 ± 0.04*	N/A	21.00 ± 0.20*	0.47 ± 0.02*	1.19 ± 0.11
	V2-6.5	1.21 ± 0.02*	N/A	17.29 ± 0.29*	0.44 ± 0.04*	1.25 ± 0.09*
	V3-7.5	1.11 ± 0.03	N/A	18.70 ± 0.22*	0.31 ± 0.06	1.29 ± 0.12*
	V4-8.5	0.98 ± 0.02	N/A	13.85 ± 0.12*	0.21 ± 0.02*	1.30 ± 0.06*
	Control	0.78 ± 0.01*	N/A	8.72 ± 0.09*	0.13 ± 0.02*	1.09 ± 0.04*
	Mean	1.07 ± 0.20	N/A	15.91 ± 4.78	0.31 ± 0.15	1.22 ± 0.09
	CV%	18.72	N/A	30.06	46.69	7.07
Pinot gris	V1-5.5	0.96 ± 0.02	96.88 ± 1.80*	15.00 ± 0.48*	0.16 ± 0.03	1.21 ± 0.08*
	V2-6.5	0.76 ± 0.04*	117.50 ± 2.14*	13.91 ± 0.36	0.16 ± 0.02	1.24 ± 0.04
	V3-7.5	0.78 ± 0.02*	190.63 ± 2.82	14.50 ± 0.66*	0.15 ± 0.04*	1.19 ± 0.04*
	V4-8.5	1.01 ± 0.01*	221.25 ± 3.44*	10.27 ± 0.21*	0.15 ± 0.02*	1.24 ± 0.04
	Control	1.09 ± 0.04*	319.75 ± 3.61*	11.62 ± 0.20*	0.16 ± 0.02	1.34 ± 0.02*
	Mean	0.92 ± 0.14	189.20 ± 89.07	13.06 ± 2.03	0.16 ± 0.01	1.24 ± 0.06
	CV%	15.73	47.08	15.51	3.51	4.64

Note: Control – wine obtained from grapes harvested at full maturity; TPC (GAE) – total phenolic compounds (gallic acid equivalent); TPI – total polyphenolic index (optical density at 280 nm); EC – catechin equivalent; N/A – not applicable; * - indicates significant differences to the mean at p<0.05 (ANOVA test).

Singleton V.L. and Esau P. (1969) concluded that during the maturation of grapes, the largest amounts of phenolic substances accumulate in the epicarp and seeds, the accumulation dynamics showing variations depending on their nature. The benzene cycles, characteristic to phenolic compounds, strongly absorbs ultraviolet light, with a maximum around 275-280 nm. Total polyphenolic index (TPI or D_{280}) represents the absorbance of wines at 280 nm and expresses the content of total phenolic compounds (phenolic acids, tannins and anthocyanins) in wines. At full grape maturity, this index shows values between 3 and 15 for white white and larger for red wines. Measuring absorption at 280 nm seems preferable to the Folin-Ciocalteu test, as it presents a number of advantages, including speed and reproducibility. However, certain molecules, such as cinnamic acids and chalcones, have no absorption maximum at this wavelength. According to Ribereau-Gayon P. *et al* (2006) the optical density at 280 nm should remain under 10 - the upper limit generally accepted for white wines.

In the experimental low-alcohol wines the values of D_{280} were high at early harvest due to initial accumulations of tannins in immature seeds, which are easily passed into must during maceration-fermentation process. After veraison, proanthocyanidins (monomers) showed a gradual decrease through ripening, especially in the MO wines, while tannins (polymerized) showed a slow increase in concentration (up to 1.09 g EC/L in MO control and 1.34 g EC/L in PG control wine) (*table 2*). The procyanidin(P)/tannin(T) ratio is an indicator of the degree of tannin polymerization. P represents the optical density of the colored combinations with vanillin, T is the optical density of the anthocyanidins formed by heating in acidic medium (Bate-Smith reaction). The lower the value of the ratio, the higher the degree of polymerization of the tannins. Intermediate low-alcohol wines (V_2 and V_3) showed a moderate degree of tannin polymerization (3-6) (data not shown), some condensation reactions between tannins and other phenolic compounds (e.g. anthocyanins in PG samples) and various precipitation reactions could be involved in wines.

In the choice and consumption of food, color plays an important role along with taste being associated with food quality and safety. Chromatic parameters can be used in the objective description of different types of wine and in analysing the differences between them. Chromatic parameters of wines obtained by staggered harvest of grapes are presented in *table 3*. Wine color characteristics varied widely depending on the variety. In the case of the PG variety, the color intensity increased with the accumulation of anthocyanins (6.82). The wine obtained from the PG grapes harvested in "green" (V_1) showed a very low proportion of the red color, while in the wine obtained at the full maturity of the grapes (control) the value of this parameter was the highest (37.27%).

For MO wines, the variability of the chromatic parameters was lower, without important differences depending on the degree of grape maturity. However, in the case of PG wines, based on the specific properties of anthocyanins, some color variation may appear according to the pH value and sulfur dioxide bleaching reaction.

Should be mentioned that the yellow color (%Y) was predominant in wines of both varieties, higher values being recorded for MO wines (about 80%), as in the case of the color hue (H).

Descriptive analysis is the most well-known and regularly used method of sensory analysis, being used to identify sensory characteristics of a wine and score their intensities. 16 main characteristics of the experimental wines were analyzed, including aroma compounds, full bodied perception and taste persistence.

Table 3

Chromatic parameters of wines obtained by staggered harvest of grapes

Variety	Sample	Color intensity (I)	Color hue (H)	d 420% (%Y)	d 520 % (%R)	d 620 % (%B)
Muscat Ottonel	V1-5.5	3.85 ± 0.41*	4.54 ± 0.40*	80.61 ± 2.20	17.75 ± 0.84	1.64 ± 0.10*
	V2-6.5	3.62 ± 0.26	4.18 ± 0.22*	77.53 ± 2.16	18.53 ± 1.02*	3.95 ± 0.12
	V3-7.5	3.60 ± 0.22	4.12 ± 0.20*	76.88 ± 1.84	18.65 ± 0.96*	4.47 ± 0.10*
	V4-8.5	3.52 ± 0.44*	4.41 ± 0.42	77.54 ± 2.60	17.60 ± 1.42	4.86 ± 0.14*
	Control	3.76 ± 0.24 *	4.77 ± 0.22*	78.69 ± 1.54	16.50 ± 0.98*	4.82 ± 0.14*
	Mean	3.67 ± 0.13	4.40 ± 0.27	78.25 ± 1.47	17.81 ± 0.86	3.95 ± 1.34
	CV%	3.61	6.04	1.88	4.85	33.96
Pinot gris	V1-5.5	2.62 ± 0.26*	1.69 ± 0.24*	60.59 ± 1.04*	35.93 ± 1.00	3.48 ± 0.21*
	V2-6.5	3.80 ± 0.32*	1.64 ± 0.30*	59.33 ± 1.20*	36.15 ± 0.96	4.52 ± 0.18*
	V3-7.5	4.10 ± 0.28*	1.56 ± 0.24	57.39 ± 1.64	36.82 ± 1.10	5.78 ± 0.26
	V4-8.5	5.95 ± 0.28*	1.54 ± 0.26*	56.90 ± 2.00	36.92 ± 1.41	6.19 ± 0.30*
	Control	6.82 ± 0.20*	1.43 ± 0.18*	53.43 ± 1.22*	37.27 ± 1.02	9.30 ± 0.19*
	Mean	4.66 ± 1.70	1.57 ± 0.10	57.53 ± 2.73	36.62 ± 0.56	5.85 ± 2.20
	CV%	36.47	6.35	4.75	1.53	37.63

Note: %Y, %R, %B represent the percentage of yellow, red, and blue color; * - indicates significant differences to the mean at $p<0.05$ (ANOVA test).

The low-alcoholic wines obtained from the MO grapes were appreciated as highly acid, with good aromas of hay and citrus, but with low body and taste persistence, better rated being the intermediary wine with 7.5% vol. (V_3) (*figure 4*).

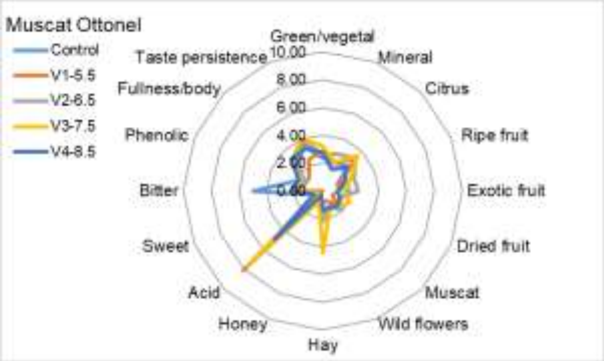

Figure 4 **Sensory analysis of low-alcohol wines of the Muscat Ottonel variety**

The low-alcoholic wines of PG variety were characterized as more acidic compared to MO wines, varietal aromas being more present in the control wine. As in the case of MO, the PG wines with 6.5 and 7.5% vol. alcohol were more suitable for consumption, showing subtle citrus aroma, low body and medium taste persistence (*figure 5*).

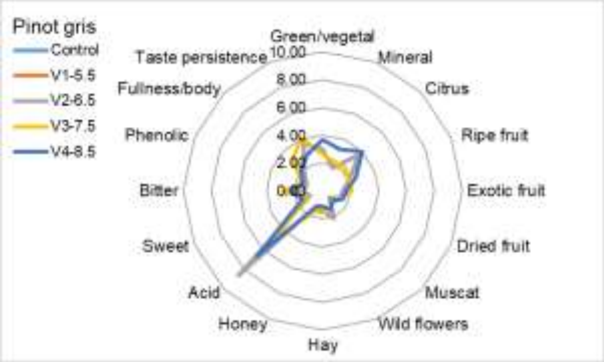

Figure 5 **Sensory analysis of low-alcohol wines of the Pinot gris variety**

CONCLUSIONS

From the practical and economical perspectives the staggered grape harvesting technology represent the simplest method to avoid excess alcohol in wine, by harvesting grapes when they reach the correct and necessary amount of sugars. Wines obtained from early harvested grapes were of a lighter style, with less color and higher acidity. Blending the wines obtained by staggered grape harvest with full grape maturity wine may be a feasible option to obtain improved beverages in terms of physico-chemical and organoleptic characteristics, but the alcohol concentration should be above 7.5% vol., in order to avoid excess acidity and further compositional corrections. Sensory analysis of low-alcohol wines indicates a less full-bodied perception, reduced persistence and more "green" aromas, as detracting characteristics. Further studies are necessary in order to establish the optimal time for grape harvest and to optimize the wine blending process.

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