Qualitative evaluation of three post-harvest sorting systems after manual and mechanical harvesting

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Summary
Trials were carried out during the 2008 harvesting campaign at "Tenuta le Mortelle", Tuscany - Italy on Cabernet Sauvignon cultivar to assess the quality of grapes resulting from manual or mechanical harvesting. This research represents a part of the composite research project of "Consorzio Tuscania". After harvesting, the grapes were subjected to three different post-harvest selections. Trials were repeated in three replicates for four days. Grape quality was determined in terms of Material Other than Grape (MOG) and Low Maturation Grapes (LMG) content. The percentages of MOG and LMG in manual and mechanical harvested grapes with no post-harvest selection resulted no significantly different. Evidently, in this vineyard, the mechanical harvester worked very well, picking up a very low MOG amount, similar to that of manual harvest. Results showed that the harvester was not able to separate berries with different ripeness level, since also the percentage of unripe berries was similar for manual and mechanical harvest. With post-harvest manual selection a fraction of MOG was removed but no effects resulted on LMG amount. Finally, the mechanical selection system coupled both with manual or mechanical harvesting, worked eliminating a great part of MOG (more than manual separation) and separating grapes with different maturity degree.

Key word: *grape sorting, mechanical grape-harvest, MOG, low maturation grapes*

Introduction
In the last years, mechanical harvesting is becoming more common also in Italy, and it is applied also for the production of quality wines. Although Italy, France and Australia, despite differences in tradition, are recognized worldwide as producers of quality wines, mechanical harvesting in Australia is approaching 100% of total vine acreage (Pocock and Waters, 1998), in France it is now above 75% (Boubals, 1996) and in Italy it barely hits 8% (Intrieri and Filippetti, 2000). A simplified answer to this high variation is that mechanical harvesting in Italy is hindered by smaller farm size and larger variability in cultivars, training systems and sloping conditions (Intrieri and Poni, 1995; Parenti et al. 2007) and it is also influenced by the suspicion that mechanical harvesting could negatively influence grapes quality and consequently wines quality. So it is crucial to look objectively at how mechanical harvesting could influence wines quality. It is well-known that for a qualitative wine production it is important to use grapes under perfect conditions in terms of maturation level and crop purity (Allan 2004; Falconer et al. 2006). Harvested grapes can include substandard berries (LMG, rotten, and sunburnt) and MOG, and the possibility to obtain a crop without contaminants assumes more importance with mechanical harvesting with respect to manual harvest. Hand picking allows for selectivity, thus minimizing

harvesting of substandard berries. On the contrary, mechanical harvesting provides less control over amounts of LMG and MOG because of the non-selective nature of the process, even if modern harvester are endowed with some separating systems able to eject leaves and other foreign materials from the mechanically harvested product (Clary et al. 1990). For the reasons mentioned above, the trend is the increasing use of sorting techniques after or before the destemmer with the aim to obtain "clean" grapes and to separate grapes with different quality level. Especially for mechanical harvest, postharvest sorting is one way to eliminate unwanted material from grapes, particularly from berries used to produce high-value wines. Probably, the most used sorting system is the manual selection. This system, even if appears the easier and affordable, is very slow, it requires the presence of many workers and, since separation is based on a visual recognition of extraneous matter, it doesn't permit to separate berries with different degree of maturity. Automated sorting can theoretically inspect every berry to a degree not feasible by hand and provide a more consistent and efficient process. Many automated sorting technologies have been developed; the system used for this experimentation is composed of many levels of sorting and it is able to separate MOG, split and rotten berries, and to give the crop separated in two classes (first and second quality grape) according to the ripeness degree.
In these trials, three sorting systems (no selection, manual selection and automated selection) were applied both to mechanical harvested grapes or to hand-harvested grapes (and wholly destemmed) Cabernet Sauvignon grapes.

Materials and methods

Trials were carried out during the 2008 vintage at "Tenuta le Mortelle", Tuscany - Italy on Cabernet Sauvignon cultivar. Grapes, manually or mechanically harvested, were separated into three batches subjected to the three different types of post-harvest selection: no selection, manual selection and mechanical selection. After selection, grape quality was assessed in terms of MOG and LMG content and Brix degree of ripe and unripe berries. For mechanical selection only the completely ripe berries, i.e. the first quality grapes separated by automated sorting machine, were analyzed. Trials were repeated in twelve replicates (three replicates for four days). In Table 1 is reported the experimental design.

Table 1 Experimental design.

Harvesting system	Post-harvest sorting system	Measured parameters
Manual	No selection	
Manual	Manual selection	MOG percentage(w/w)
Manual	Mechanical selection	LMG percentage (w/w)
Mechanical	No selection	LMG Brix degree
Mechanical	Manual selection	Ripe berries Brix degree
Mechanical	Mechanical selection	

Harvesting

At the date of harvest grapes had a mean value of 22°Bx. Trials were carried out from 10 to 13 September 2008.
Manual harvest: manually harvested grapes were collected in a tipping trailer containing about 12q of bunches; before the post-harvest selections, grape was destemmed.

Mechanical harvest: mechanical harvest was done using a self-propelled harvester. Before the selection, the crop (about 20q) was emptied in a vibrating trailer used to feed the mechanical selection machine.

Post-harvest sorting systems

Batches of 4q of grape were subjected to different selections.

No selection: the grape quality was evaluated without any post-harvest selection.

Manual selection: manual post-harvest selection was done on destemmed grapes using a manual sorting table with a moving conveyor belt. The belt speed was constant at 3.2m/min. Four worker (two per side of the belt conveyor) were employed to separate green fragments and all the extraneous matter found in the grape.

Mechanical selection: mechanical post-harvest selection was done by mean of a sorting system able to split the crop into four different fractions: larger green debris (long petioles, leaves, grape clusters), small waste items (pedicels, botrytized skins, rotten berries), completely ripe grape (first quality) and not completely ripe grape and split berries (second quality).

Mechanical sorting machine: the device was able to eliminate the green debris and extraneous materials from grape (impact separation), but also to achieve a qualitative separation of the berries permitting to carry out separated vinifications according to the quality of the grapes (Densimetric separation). The operating capacity is from 8 in 10 t/h.

Measured parameters

For MOG and LMG evaluation, grapes were sub-sampled (about 8Kg).

MOG evaluation: MOG was measured by manual separation of green fragments from grapes using a sieve. MOG content was expressed as percentage (w/w).

LMG evaluation: LMG content was assessed separating unripe berries with densimetric method to simulate mechanical selection functioning. It is known that the sugar content in the berries is directly proportional to their density. Low sugar concentrations of unripe berries correspond to a lower density with respect to fully ripe ones. Putting the harvested grapes in a bucket containing a sugar solution of fixed density, it permits to separate berries with different density (at constant temperature) and so with different ripeness level. Completely ripe berries, i.e. berries with higher density with respect to the solution, plunged down on the bottom of the bucket, while unripe berries (with a lower sugar content) floated on the surface. The used sugar/water solution had 24°Bx; in this solution, grapes with a Brix lower or equal to 21°Bx (LMG) floated, while the remaining (fully ripe berries) plunged permitting their separation. LMG content was expressed as percentage (w/w).

Brix measurement: mean LMG Brix and fully ripe berries Brix were measured. About 100 berries, sub-sampled within the two fraction, were crushed; Brix was measured using a Refracto30PX Mettler Toledo.

Data analysis

Data were analyzed by two-way analysis of variance and LSD post-hoc test by using Systat Software (Inc. 2007).

Results and Discussion

Table 2 shows the mean percentages of LMG, MOG and the LMG Brix of grapes from each thesis. The percentages of MOG and LMG in manual and mechanical harvested grapes with no post-harvest selection resulted no significantly different. Evidently, in this vineyard, the mechanical harvester worked very well, picking up a very low MOG amount,

similar to that of manual harvest. This was probably due to the good trellis management. Since also LMG content (in no selection cases) results not significantly different for manual or mechanical harvesting, it is possible to conclude that the harvester was not able to separate berries with different ripeness level.

Table 2 Mean values of LMG content (%), LMG Brix degree and MOG content (%).

		Manual harvest			Mechanical harvest		
		No sel.	Man. Sel.	Mech. sel.	No sel.	Man. sel.	Mech. sel.
LMG (%)	Mean	50.75	49.16	41.49	50.00	55.14	44.98
	SD	13.05	10.98	10.26	12.23	10.11	13.55
LMG °Bx	Mean	21.20	21.42	21.07	20.90	20.70	20.92
	SD	0.87	0.96	0.65	0.75	1.03	0.89
MOG (%)	Mean	1.76	0.84	1.22	1.70	1.24	0.90
	SD	0.57	0.46	0.70	0.68	0.22	0.22

No sel.= no selection; Man. sel.= manual selection; Mech. sel.= mechanical selection

The two-way analysis of variance (Table 3), shows that only the sorting systems have some significant effects on LMG and MOG content in grapes after selection, while harvest technique doesn't affect crop purity. Moreover, in any case, no significant effect was found for harvest coupled with selection system.

Table 3 Analysis of variance (two-way anova).

Source	df	F-ratio	p-value
LMG			
Harvest	1	1.099	0.298
Sorting	2	3.858	0.026
Harvest*Sorting	2	0.501	0.608
MOG			
Harvest	1	0.005	0.945
Sorting	2	13.993	0.000
Harvest*Sorting	2	2.944	0.060

To better investigate which selection was able to give significant differences on MOG and LMG content, a LSD post-hoc test was performed. Results are reported in Table 4.

Table 4 Fisher's Least-Significant-Difference Test.

Sorting system	Sorting system	Difference	p-value
LMG			
Manual selection	No selection	1.776	0.603
Manual selection	Mechanical selection	8.918	0.011
No selection	Mechanical selection	7.143	0.039
MOG			
Manual selection	No selection	-0.694	0.000
Manual selection	Mechanical selection	-0.022	0.883
No selection	Mechanical selection	0.672	0.000

About LMG, any significant difference between no and manual selection was evidenced; the only sorting system able to separate LMG was mechanical selection that results significantly better with respect to other sorting systems. In fact, the manual sorting system, been based on a visual separation, doesn't permit to discriminate berries with a different ripeness level. On the contrary, since mechanical selection is able to separate berries with a different density, it is able to distinguish between berries at a different maturity level. As showed in Table 2, LMG had a mean degree of about 21°Bx while for fully ripe berries the mean value was about 23°Bx.This values resulted significant different ($p<0.01$; two-sample t-test), indicating that the possibility to remove a part of LMG can give grapes with a higher mean Brix degree and a more homogeneous maturity level. This will result in a production of a wine with a higher alcohol content, but probably also with a better qualitative balance due to the advantages that are generally given by grapes at fully ripeness where flavour and phenolic ripeness are reached. The effects of post-harvest manual and mechanical selection on MOG removal resulted significant (Table 4) with respect to no selection. This indicates that to eliminate green fragments and extraneous matter the manual selection could be sufficient, even if the operative capacity is lower in comparison to mechanical separation.
It is possible to conclude that to obtain grapes (manually or mechanically harvested) with a very low content of MOG, both manual or mechanical sorting systems resulted effective. On the contrary to remove LMG a more advanced sorting system is required. Specifically, the sorting system used for this experimentation could represent a further tool that gives the possibility to obtain a pre-vinification grape selection for the production of high-value wines.

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