

Pneumatic Press Equipped with the Vortex System for White Grapes Processing: First Results

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The interaction between mechanical, computer and electronic technologies offers nowadays highly innovative solutions to be applied to the oenological machinery industry. Grapes pressing for the extraction of must from the grapes has a fundamental role for obtaining wines with high quality. The pneumatic presses commonly used work with a discontinuous cycle, taking on average about 3 hours for the extraction of the juice from the grapes. During this period, the presence of oxygen in contact with grapes can modify the qualitative characteristics of the future wine. The aim of the research was to study the "Vortex System" applied to a pneumatic press and to evaluate the quality of wines obtained in reduction. The study was carried out in a modern winery in the province of Palermo (Italy) using cv. Catarratto lucido grapes. The machine used in the tests was a pneumatic press with a capacity of 1,900 / 2,500 kg by Puleo Srl company (Italy), equipped with the patent "Vortex System". It consists in the recovery of the inert gas by means of a passage and recirculation apparatus during grapes pressing allowing the must extraction in inert and controlled atmosphere, the non-oxidation of the product and a re-use of the gaseous component. Two operating modes were applied: AP (Air Pressing) mode, the traditional pressing mode in presence of oxygen, and NP (Nitrogen Pressing) mode with the Vortex System, performed under inert gas with nitrogen recovery. The following analytical determinations were performed on wines in triplicates: alcohol [%/vol], density [g/l], sugar [g/l], pH, total acidity [g/l], volatile acidity [g/l], malic acid [g/l], citric acid [g/l], tartaric acid [g/l], potassium [g/l], glycerin [g/l], ashes [g/l], absorbance at 420, 520 and 620 nm, polyphenols [mg/l], catechins [mg/l], free sulfur dioxide [mg/l], total sulfur dioxide [mg/l]. The use of the pneumatic press equipped with the Vortex System allowed to obtain excellent values of volatile acidity, absorbance at 420 nm, catechins in white wines and a rich aromatic component both in primary and secondary aromas.

1. Introduction

White wines must be aromatic and fragrant, it is in fact the aromas that most affect the consumer and direct his choices. In the last decades, the production of white wines has been oriented towards processes performed under conditions of low oxygen level (Boselli et al., 2010) in order to obtain fruity wines, or applying machines and techniques that preserve all the aromatic components of the variety (Catania et al., 2016). Among "white winemaking" processes there are generally included methods of vinification characterized by a different level of contact of the must with oxygen: hyper-oxidation, controlled oxidation and the different methods of conventional winemaking until the vinification in reduction or protected, used for some varieties such as white Catarratto or Sauvignon Blanc. Catarratto Bianco is the most widespread grape cultivar in Sicily, the largest and the southern-most Italian wine region accounting for about 17.5% of the overall Italian wine production.

The pressing step plays a very important role among all the winemaking procedures for white wines (Ferreira-Lima et al., 2016). The pneumatic presses commonly used work with a discontinuous cycle, taking on average about 3 hours for the extraction of the juice from the grapes. During this period, the presence of oxygen in contact with grapes can modify the qualitative characteristics of the future wine. Antonelli et al. (2010) applied reductive winemaking on Sauvignon blanc and Trebbiano romagnolo grapes using a membrane press

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previously saturated with inert gas, obtaining higher phenolic parameters in wines resulting from reductive winemaking, a deeper yellow colour and richer and more delicate aroma tested by expert panellists. The effect of reductive pressing on colour, glutathione, total polyphenols and catechins was studied by Motta et al. (2014) on four Italian white grapes cultivars, obtaining a lowering of the main quality parameters of the musts processed in contact with air during pressing. Moreover, pressing under nitrogen on Sauvignon blanc grapes was applied by Pons et al. (2015), obtaining an increase in glutathione concentration when low pressure was applied (< 1 bar). Many important changes occur through the action of oxygen at early juice preparation stages, and pressing among these, during the time polyphenyloxidase (PPO) activity is at its highest and starts an oxidative chain reaction, as evidenced by trials using inert gas protection (Day et al., 2015).

In our study a closed tank pneumatic press was used to process Catarratto grapes in two different modes, the traditional air pressing mode and the inert pressing mode. The closed tank membrane press is equipped with the patented "Vortex system" that allows grapes pressing under inert gas with nitrogen recovery. This research aimed at investigating how the different pressing modes influence must and wine characteristics and to identify the possible improvement of wines obtained through innovative machines.

2. Materials and Methods

2.1 Must and wine samples

The trials were carried out during the 2017 vintage in the province of Palermo (Sicily, Italy). The Catarratto grapes came from a 10-year vineyard set at 300 m above sea level, 4 hectares wide. The vineyard was hedgerow trained with 4,000 plants/ha (planting layout 2.50 × 1.00 m) and Guyot pruning; the 2017 production was about 0.90 tons per hectare. Grapes were machine-harvested in the second decade of September, at their optimal ripening stage. Harvest was performed in the early hours of the day in order to maintain the quality of the product, avoid the loss of primary perfumes and aromas which are fundamentals to characterize the future wines. Grapes were transported to the cellar within three hours of harvesting to limit fermentation processes (action of PPO) and microbiological contamination due to the crushing and abrasion of the grapes, with consequent loss of cellular juices and product quality. Then, grapes were de-stemmed, crushed, and put inside the press, after passing from the heat exchanger to reduce their temperature.

2.2 Pneumatic press used for grapes processing

Grapes were loaded into a Prexa N30 pneumatic press (Puleo Srl, Italy) with capacity of 1,900 / 2,500 kg and processed with a sequential pressing cycle with a maximum working pressure of 1.5 bar. The pneumatic discontinuous closed tank press is made by a hollow AISI 304 stainless steel cylinder rotating around a horizontal axis, with a side-mounted flexible food grade PVC membrane inside opposed to a wide wall of longitudinal holed channels that allow must draining (Figure 1). The destemmed-crushed grapes are loaded through a side opening, provided with a sealed door, or an axial load valve. After loading, pressure is exerted on the other side of the membrane by compressed air to extract the must. The operation is repeated several times progressively increasing pressure, alternating with a retracted membrane rotation phase, in order to mix the progressively drier marc. At the end of the extraction phase, skins and grape seeds are unloaded through the side opening.



Figure 1: Prexa N30 pneumatic press inside view. Courtesy of Puleo srl, Italy

The initial rotations and drainage lasted 40 min, during which the pressure was <0.2 bar. In the subsequent 110 min cycle, pressure was gradually raised to 1.5 bar including pressing and rotations.

The machine is equipped with the patented "Vortex system" that allows grapes pressing under inert gas with nitrogen recovery. This inert gas recovery system is made up of a passage and recirculation apparatus throughout the pressing process, allowing the extraction of the must in an inert and controlled atmosphere, the non-oxidation of the product and a reuse of the gaseous and inert component, not simply inflating the membrane, but forcedly through a compressor that allows the purification of the gas by filters inserted in the

circuit between the compressor and the storage tank. These filters are necessary given the presence of gases brought into the tank of the machine by the grape juice and of micro-particles that make the gas heterogeneous, so requiring a purification process to perform its inert function of the circuit and the tank.

2.3 Experimental tests

Prexa N30 pneumatic press was used in two operating modes: the traditional Air Pressing mode (AP) and the Nitrogen Pressing mode (NP), according to the classification adopted in Motta et al. (2014). In our study, the AP mode is the traditional pneumatic press with closed tank. Grape must is extracted from the inner draining channels and comes out from nozzles to an external collection tray. In the NP mode, grapes contact with air is minimized and the grapes are processed in presence of nitrogen. Grapes processing was performed in the same way for the two grapes batches except for the pressing phase. The must composition was determined in the first four steps of grapes pressing, named from C1 to C4, and also on the overall must sample, named T, while the analyses on wine were performed at the end of fermentation. The following pressures were applied during grapes pressing: C1 = 0; C2 = 0.2 bar; C3 = 0.2 bar; C4 = 0.4 bar; C5 = 0.6 bar; C6 = 0.8 bar; C7 = 1.1 bar; C8 = 1.5 bar. The must fractions obtained from the successive pressing steps (from C5 to C8) have not been subjected to laboratory analysis since approximately 75% of the must was extracted in the steps from C1 to C4.

2.4 Must and wine analyses

Analytical determination in musts and wines were performed in triplicates by Foss Integrator WineScan™, (FOSS Italia S.p.A.). The must determinations were catechins [mg/l], sugar [g/l], free sulfur dioxide [mg/l], total sulfur dioxide [mg/l], pH, total acidity [g/l], absorbance at 280, 325 and 420 nm. O₂ concentration [mg/l] was also evaluated using the portable oximeter HI9146 (Hanna Instruments, Italy). The wine determinations were alcohol [%/vol], density [g/l], sugar [g/l], pH, total acidity [g/l], volatile acidity [g/l], malic acid [g/l], citric acid [g/l], tartaric acid [g/l], potassium [g/l], glycerin [g/l], ashes [g/l], absorbance at 420, 520 and 620 nm, polyphenols [mg/l], catechins [mg/l], free sulfur dioxide [mg/l], total sulfur dioxide [mg/l].

The gas-chromatographic analyses were run on a Hewlett-Packard 5890 GC system interfaced with a HP 5973 quadrupole mass spectrometer. A HP5-MS column was used (5% diphenyl – 95% dimethylpolysiloxane 30 m × 0.2 mm, 0.25 μm film, J & W Scientific, Folsom CA, USA). Ultra-high-purity helium (Praxair, Cleveland, OH) was the carrier gas. Water and oxygen traps were installed on the carrier gas lines was employed. The column temperature was held at 40 °C for 15 min and then was increased to 220 °C at 1 °C/min. The carrier gas (helium) flow rate was 1 mL min⁻¹. The spectra were recorded at an ionization voltage of 70 eV and an ion source temperature of 220 °C. Samples were analyzed by HS-SPME-GC-MS method with a PDMS-CAR-DVB fiber (Supelco). The fiber was manually inserted in a GC inlet port equipped with a specific glass liner for SPME injection (0.75 mm i.d.) Fibers were desorbed at 250 °C in splitless mode for 1 min into gas chromatograph inlet. Sample components were verified by comparison of the mass spectral data with those of authentic reference compounds. When standards were not available, the components were identified by mass spectrum matching using the NIST05 mass spectral library collection.

2.5 Statistical analysis

The t-test was performed in order to test if there were differences in the two pressing mode (AP, air pressing and NP, nitrogen pressing) in must and wine characteristics (Statgraphics Centurion, Statpoint Inc., USA, 2005). Differences were considered significant at 5% level of significance.

3. Results and discussion

3.1 Analyses on must

Must chemical composition obtained by using the two pressing procedures was affected by the different treatment. In particular, statistically significant differences were obtained for O₂ and catechins between the two pressing modes (Figure 2).

During step C1, higher concentration of dissolved oxygen was detected working in NP than AP mode while in the subsequent steps NP shows small variations compared to AP, where O₂ rises at each cycle. In the overall must sample (T), dissolved oxygen measured in NP was double than AP. These results are in accordance with those reported in Day et al. (2015). There was a significant difference between the two operating modes in catechins, with a notable increase in the must processed in NP mode from C1 to C3 cycle. Catechins, together with condensed tannins, are the most abundant flavonoids, representing up to 50% of the total polyphenols in white grapes. Their level in wine depends on cultivar and grapes processing.

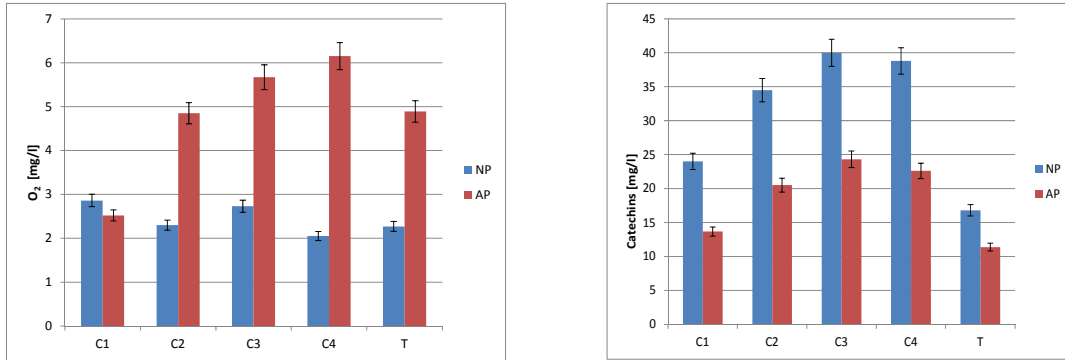


Figure 2: Dissolved oxygen and catechins measured in the must samples obtained from the different steps of pressing process in NP and AP mode

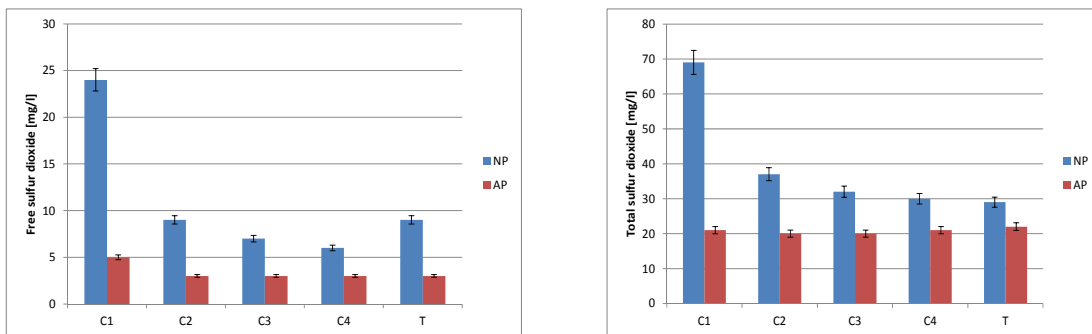


Figure 3: Free sulfur dioxide and total sulfur dioxide measured in the must samples obtained from the different steps of pressing process in NP and AP mode

Sulfur dioxide, both in free and total form, is higher in NP must samples than in AP (Figure 3), because in the NP pressing mode, oxygen is lower due to the inert atmosphere, and it has less chance of combining with O_2 , therefore sulfur dioxide remains in higher contents.

Sugar, pH and total acidity (data not shown) did not give any differences between the must obtained in presence of oxygen and the must processed in inert atmosphere as obtained by Motta et al. (2014).

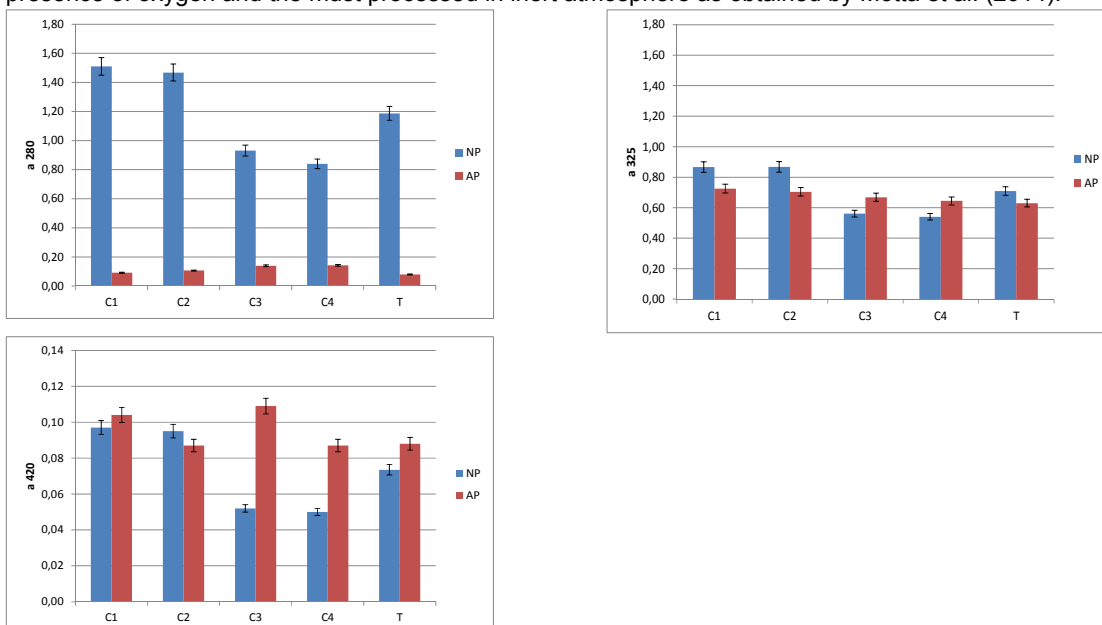


Figure 4: Absorbance at 280, 325, and 420 nm measured in the must samples obtained from the different steps of the pressing process in NP and AP mode

Absorbance at 280 (Figure 4) represents the maximum absorption of the benzene ring at the base of total polyphenols; being preserved by the effect of the inert gas from oxidation, absorbance at 280 nm is always higher in NP samples compared to AP. Absorbance at 325 nm represents the maximum absorption of the hydroxycinamyltartaric acids which are responsible for musts browning, when subject to oxidative conditions. In our case we have a higher initial preservation and a slight oxidation in the final stages of pressing (C3-C4), but the NP overall must gave 0.71 against 0.63 for AP sample. Absorbance at 420 nm is a measure of the intensity of the yellow color of white wines and provides indication about browning during winemaking. In the initial pressing phases, there were no differences between the two processes. In the last stages there was a higher absorption of the yellow component in the NP must than AP, as well as in the resulting must T. This is a positive effect due to the lower oxidation in NP sample and therefore less coloring of the yellow pigments.

3.2 Analyses on wine

The t-test performed at 5% level of significance showed statistically significant differences in most of the analytical determinations of wines obtained with the two pressing modes (Table 1). Volatile acidity was lower in NP than AP, and this is a positive effect of inert pressing as the presence of oxygen favors the formation of acetic acid. This is the major constituent of volatile acidity; all the acids that make up volatile acidity give complexity to the aroma of wine, but if the acetic acid concentration exceeds the perception threshold, it could be considered a problem in the wine (Pons et al., 2015). Malic acid value of wine obtained with NP mode showed a 20% decrease respect to AP mode, while Pons et al. (2015) did not observe any difference.

Table 1: Analyses on wines obtained from the pressing process in NP and AP mode

	NP		AP		
	mean	sd	mean	sd	
Alcohol [%/vol]	12.50	0.063	12.31	0.062	*
Sugar [g/l]	1.74	0.002	1.83	0.002	*
Glucose-Fructose [g/l]	0.77	0.001	1.04	0.001	*
Density [g/l]	0.99197	0.0001	0.99207	0.0001	ns
Total dry extract [g/l]	21.75	0.109	21.43	0.107	*
pH	3.34	0.01	3.23	0.012	*
Total acidity [g/l]	5.18	0.026	5.80	0.029	*
Volatile acidity [g/l]	0.27	0.001	0.30	0.002	*
Malic acid [g/l]	1.24	0.062	1.56	0.078	*
Lactic acid [g/l]	0.01	0.001	0.01	0.001	ns
Citric acid [g/l]	0.21	0.0011	0.24	0.0012	*
Tartaric acid [g/l]	3.15	0.0315	2.93	0.0293	*
Potassium [mg/l]	831	4.2	736	3.7	*
Glycerin [g/l]	4.62	0.0462	4.74	0.0474	*
Ashes [g/l]	2.434	0.0122	2.174	0.0109	*
a 420	0.444	0.059	0.594	0.044	*
a 520	1.461	0.146	1.092	0.109	*
a 620	0.372	0.037	0.265	0.027	*
Polyphenols [mg/l]	276	6	269	5	ns
Catechins [mg/l]	10.07	2.01	6.67	1.30	*
Free sulfur dioxide [g/l]	9	0.5	18	0.9	*
Total sulfur dioxide [g/l]	38	1.9	52	2.6	*

AP = Air Pressing; NP = Nitrogen Pressing. * indicates significance at $p \leq 0.01$ and ns indicates not significant.

The absorbance measured at 420 nm is considered as an index of total browning reaction of foods. In the wine obtained processing the grapes with inert gas (NP), a420 was significantly lower than AP (- 25%) as confirmed by Ferreira-Lima et al. (2016) for Chardonnay wines also during ageing. Catechins obtained in NP

wine have a notable increase, raising from 6.67 mg / l in the AP pressing mode to 10.07 mg / l in NP in agreement with Motta et al. (2014). Concentrations of the ethyl esters of branched acids were affected by the procedure AP and NP (Figure 5). The level of acids obtained in NP mode is favorable to the development of ester profile that determines the aromatic component of wines. Acetic acid is known to give its characteristic acid taste and pungent odor to wine. Its concentration is higher in AP sample, and this is a favorable result in our study. The octanoic acid, ethyl ester gives sweet, fruity aroma with pineapple fragrance and, together with decanoic acid ethyl ester, gives the wine freshness and elegance that is typical of the Catarratto variety. In NP wine sample it was found in higher concentration than AP sample. The decanoic acid ethyl ester instead has freshly mown grass fragrance and shows a decrease in the wine sample obtained by applying AP technique. The phenylethyl ester of acetic acid causes a pleasant smell of rose and we found it in higher concentration in NP wine. dodecanoic or lauric acid is the main component of coconut oil, palm kernel oil and other tropical oils and therefore contributes these fragrances to the wine bouquet. NP wine gave higher concentration of dodecanoic acid than AP wine. The aroma profile appears anyway fully representative of Catarratto wines.

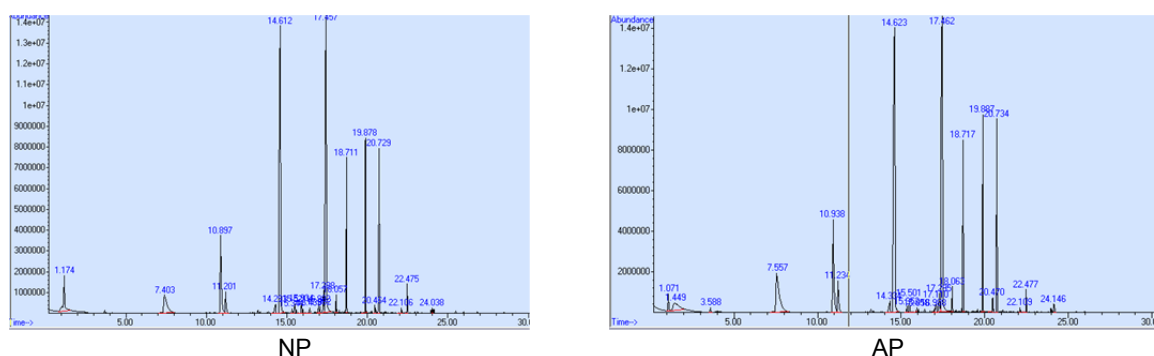


Figure 5: Gas-chromatographic analyses on wines obtained from the pressing process in NP and AP mode

4. Conclusions

Winemaking treatments play a very important role on chemical composition and quality of white wines, especially in the first stages of grapes processing. In this study, the use of a pneumatic press in NP mode, i.e. working the grapes under nitrogen, allowed to significantly preserve some qualitative aspects of the final wine such as volatile acidity, a420 and catechins. Even the aromatic component of the wines obtained at the end of the winemaking process was positively affected by the use of the innovative machine equipped with the Vortex System. In particular, some primary and secondary aromas were enhanced by the use of the pneumatic press in NP mode, allowing a better quality than using the same machine in traditional mode.

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