

OPERATIVE AND TECHNOLOGICAL EVALUATION OF AN ELASTIC MEMBRANE PRESS

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PREAMBLE

The attention and respect of the qualitative aspects of wine production has brought about an ever increasing respect for the products utilised in all phases of transformation. In particular, the interaction of mechanical influences is considered one of the possible critical points in the wine making process (De Vita, De Vita 2004). There are numerous technological innovations aimed at reducing the effects of direct contact with mechanical influences; recent examples refer to the diffusion of a particular type of oenological pumps (peristaltic, mohno, etc.), pumpover systems (carbon air type, rotary, etc.) and the general utilisation of polymeric or elastic materials (De Vita, De Vita 2004).

The more important technical innovation could very well regard the introduction of pneumatic presses (Eynard I, 1986) that up until the 70's permitted a significant improvement in the initial phases of grape processing. The current availability of pneumatic presses able to work efficiently, with pressure levels that rarely exceed 2 bar, may lead one to believe that the evolution of this machinery has reached its maturation. This is absolutely not the case if one thinks of new construction principles and the utilisation of new materials.

A recent innovation, still not widely embraced or diffused, is the central tubular membrane press built entirely of elastic materials. This solution was created with the intention of uniting the prestige qualities of a central membrane (improved relationship between drainage surface and pomace thickness) with the advantage of an elastic membrane (improved cleaning and homogeneous distribution of pressure when low pressure is utilised).

This new pressing technology has been evaluated analytically to define the operative and developmental influence.

MATERIALS AND METHODS

A) MACHINE DESCRIPTION

The machine under examination is a pneumatic central elastic membrane press, with a horizontal cylindrical cage of 0,8 m³ capacity. The cage has a diameter of 0,75 m and is 1,5m in length. The holes are rectangle (1,5x20 mm) along the entire surface, with a empty/full rapport of 7%. The machine is equipped with a rectangular hatch for whole grape loading and pomace runoff and an axial screw feed system.

The membrane, the most characteristic part of the machine, is of the tubular elastic type manufactured in pure non-toxic rubber with a thickness of 7,5mm, internally supported by three longitudinal tension rods placed in a triangle formation. Its elasticity prevents any bending even when retracted and occupies a minor volume, and dilates during inflation until it fills the cage. The combined action of membrane inflation and cage rotation at the beginning of each cycle distributes the mass across the entire syneresis surface.

Work cycles (pressing, inflation and rotation) are controlled and set by a PLC that interacts with the pressure switch, electric motor for the rotation and the compressor. Via the PLC the following parameters may be set: final pressure (max 1,7 bar), the number of phases, pressure increases, maintenance times and repeat cycles for improved pomace exhaustion.

Machinery is equipped with a protective lateral sheet and a gravitational must recovery system.

The choice of small capacity machinery is motivated by the requirement to prepare homogeneous masses for the possibility of repeat processes.

B) RAW MATERIALS

Grapes utilised in the 2 series of test were harvested manually and transported to the cellar in 500kg containers. In the first series of tests 1000 Kg of Albana grapes per test were utilised (total 3000 Kg). In the second series of tests Trebbiano grapes were utilised in the following quantities 1090 Kg + 3100 Kg + 1060 Kg + 5300 Kg for a total of 10,550 Kg. In both series of tests the grapes, with respect to the quality utilised, had a good level of maturity, good sugar levels and balanced acid levels.

C) ANALYTICAL METHODS

The findings of the tests have been set following methodologies already been tried and tested in other similar types of research (Cuenat and Crettenand, 1986).

For each machine and programme in operation phase, load and pressing times have been revealed, including partial times corresponding to pressure increases.

As far as the exhaustion possibilities are concerned, grapes were weighed for each single test and, during machine operation, the volume of must extracted during the load and pressing phases was measured (volume revealed at each pressure increased). The exhausted pomace was then weighed and dried in ovens to measure the residual humidity.

a) sugars (in g/L): Feeling method (Lane J.H. and Eynon L., 1923); b) pH, total acidity (in g/L of tartaric acid): in accordance with official methods (EEC Official Gazette, 1990); c) suspended solids (in % p/p): via centrifugal treatment and differential weighing; d) total polyphenols (in mg/L of gallic acid): Singleton and Rossi (1965); optical density (o.d.) at 320 nm and optical density (o.d.) at 420 nm: via spectrophotometric readings; polyphenoloxidase activity (ppo) in milliunits of absorbency per minute): Guerzoni *et al.*, (1977).

D) TEST DEVELOPMENT

Research was developed in two phases:

- 1. control of the effects of regulation to machine performance;
- 2. comparison with other pneumatic pressing systems.

The test was set up to obtain an evaluation in terms of extracted must characteristics, exhaustion possibilities, execution times.

The control over the effects of the regulations was carried out on the Albana grapes, suitable for evidencing differences in pressing programmes for its elevated susceptibility to oxidation and must browning. The test was divided into three sets according to the table here below (Table 1), revealing two hypotheses of maximum achieved pressure with identical increases (set 1A Vs Set 1B) and the pressure achieved with different pressure increases and times (Set 1B V Set 1C).

Set	1A	1B	1C
Load time (min.)	10	10	10
Pre-pressing phase (no.)	3	3	3
achieved pressure (bar)	0,3	0,3	0,3
Pressing pressing phases (no.)	7	13	7
pressure increases (bar)	0,10	0,10	0,20
maximum pressure (bar)	1,0	1,6	1,6
Total time (min.)	50	70	58

The comparison with other pneumatic pressing technology was carried out on the Trebbiano Romangolo grapes, chosen for their medium-high resistance to mechanical influence and oxidation. There were two presses utilised in the comparison: a semi-circular open cage membrane press and semi-circular closed cage low pressure membrane press. Regulations were carried out in response to the typical characteristics of the two machines and the type of grape utilised.

The elastic membrane press was utilised with two regulations similar to that used for the comparison machine.

The principal characteristics of the presses and the cycles adopted are reported here below in Table 2.

TABLE 2. Description of the cycles utilized with the different pressing methods.				
Set	2A	2B	2C	2D
Press type	Central elastic membrane	Open membrane	Central elastic membrane	Low-pressure open membrane
Cage Capacity (m³)	0,8	2,3	0,8	3,5
Hole surface area (cm²)	2555	918	2555	1200
Single syneresis surface area (cm²/m³)	3192	399	3192	343
Grapes utilised (Kg)	1090	3100	1060	5300
Maximum pressure (bar)	1,6	1,6	0,8	-0,8
Number of Phases	7	4	6	6
Load time (min)	10	31	10	60
Pressing time (min)	45	105	40	136

RESULTS

1. Regulation comparison

From an operative point of view the importance of the press load is evident. During this phase a significant extent of extraction is verified. In the case in question, the initial syneresis represented 45-58% of the total extracted volume, influenced by partial must creation caused by loading with a peristaltic pump, together with the time of the operation itself.

The influence of the work cycles on the extraction is summarised in Figure 1 and 2, where the volume extracted with the applied times and pressing is reported.

As far as the effect of phase numbers is concerned (set 1A Vs set 1B), with the resulting increase of final pressure, an increase in the extraction from 66 to 76% was obtained, as a result of the lengthening of pressing time by 20 minutes (+29%).

However, comparing the cycles that foresee the same final pressure (1,6 bar), achieved via different times and methods (set 1B Vs set 1C), the total extracted volumes were similar (76 and 80%). This highlights the major importance of pressure over the number of phases completed. This is evident even when correlating the extraction values with the applied pressure (Fig. 2). Considering the values of all the sets, independently of the number of phases and the operative times utilised, there is a strong correlation between applied pressure and extracted volume ($r^2 = 0,97$)

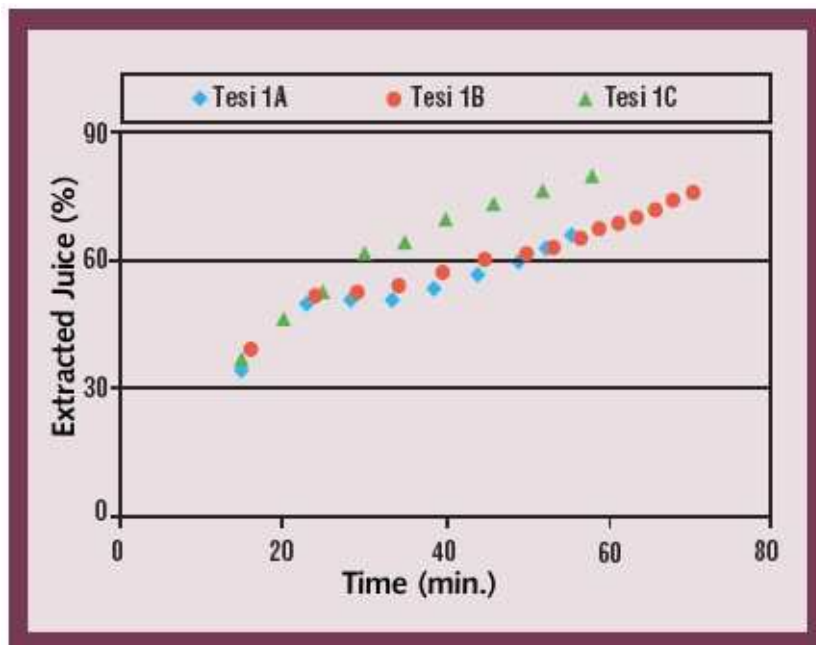


Figure 1. Extraction trends as a function of time.

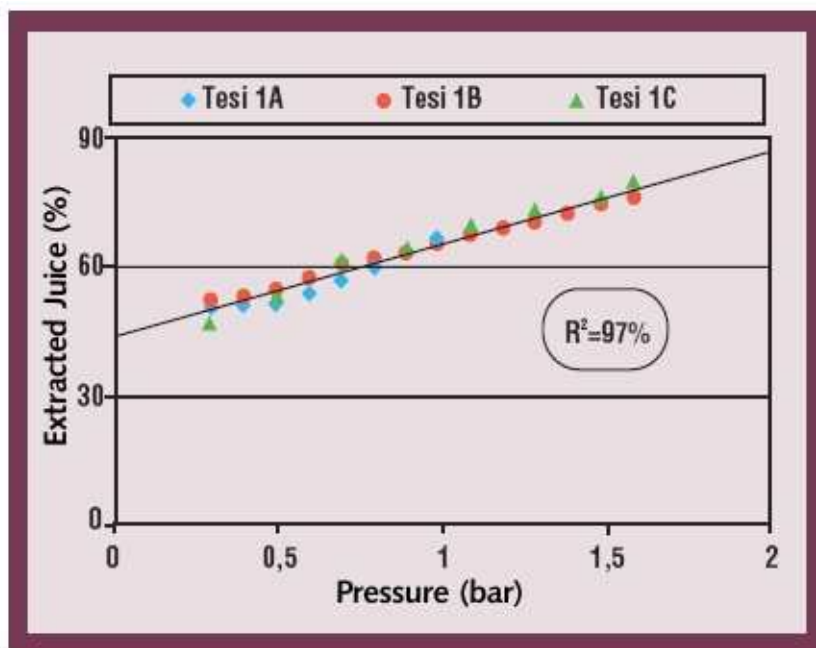


Figure 2. Extraction trends as a function of applied pressure.

TABLE 3. Oenological results obtained with the three different pressing methods

	Sugars g/L	Total Acidity g/L	pH	Total polyphenols mg/L	o.d. 320 nm (abs)	Ppo Activity mU.A./min.	Suspended Solids %	Juice Extracted %
1A	218.0	7.51	3.10	310	8.50	5.0	1.41	66.1
1B	214.7	8.14	3.08	347	8.08	5.3	1.98	76.3
1C	215.8	7.51	3.09	354	9.08	6.7	2.05	80.1

The tests carried out on the Albana grapes have permitted us to highlight, over and above the processing data as described above, an interesting difference between the musts produced as a result of sets with different regulations to the pressing programme.

Firstly, one can observe in Table 3 how juice rendered is already high even with inferior pressure (maximum 1 bar) and how this raises with an increased applied pressure not necessarily related to time. Further, one can see how juice rendered with minor pressure is already adequate for a high quality finished product, in line with certain production regulations that impose maximum limits to juice rendered (**RIF**).

With major pressure, the attempt to reduce work times contrasts with the quality of the obtained must. In effect, the 1C test demonstrated a higher standard in polyphenols, suspended solids and polyphenoloxidase activity. This clearly indicates how a major maceration of the solid parts and a minor drainage effect of the pomace has taken place.

In summary, a good compromise between juice rendered and quality of same is given to test 1B, where the pressure was 1,6 bar was reached via gradual increases to applied pressure and to which a minor polyphenoloxidase activity (ppo) is attributed.

It is important to note how among the 3 tests, the differences are never excessive and the standard of suspended solids, polyphenols and polyphenoloxidase activity are good, considering the critical aspects of the raw material utilised.

Comparison between extraction techniques

The influence of different techniques on extraction trends as a function of time is summarised in Figure 3; in Table 4 specific data is reported regarding the operation of the presses and the must quality.

By evaluating work times, the machinery utilised makes a significant difference, passing from inferior values/hour, revealed with a central membrane, to values that more than double or triple with the two semi-circular membrane machines. Even excluding load times, even forming part of the extraction activity they are widely influenced by cage capacity, extraction times are still different.

Extracted quantities were similar for test 2A, 2B and 2C. In the first two cases the result was attributed to a higher applied pressure, while in the third case this was attributed mainly to work times. The lower extraction level was obtained in test 2C and this confirms the sensitivity of elastic membrane presses to pressure regulations. **Elastic membrane** presses, in both regulations, demonstrate higher extraction speeds (trends evident in Fig. 3) even in the final cycle. The two semi-circular membrane presses on the other hand, evidence decreasing extraction efficiency in the final phases.

In relation to higher exhaustion speed of the central elastic membrane press, the homogeneous device for distributing the pomace around the entire cage circumference surely plays a major role. This results in a reduced panel thickness. Said distribution is, in fact, always evident during cage opening prior to the pomace run-off.

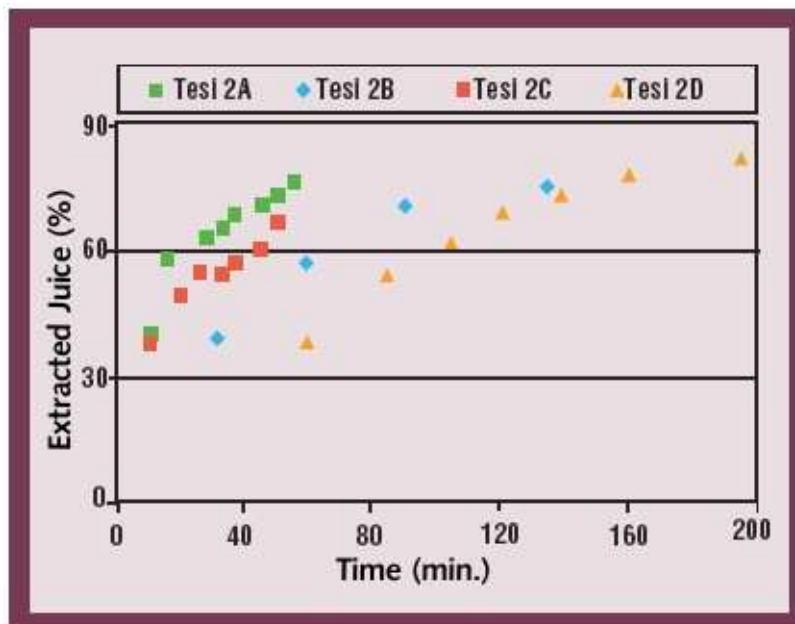


Figure 4. Extraction trends in the 4 compared techniques.

	Press. (bar)	Sugars g/L	Total Acidity g/L	pH	Total polyphenols mg/L	d.o. 320 nm (abs)	d.o. 420 nm (abs)	Suspended Solids %	Juice Extracted %
2A	1.6	198.9	6.19	3.13	127	7.96	0.73	0.6	76.9
2B	1.6	191.7	6.33	3.19	139	7.55	0.81	1.26	75.9
2C	0.8	200	6.03	3.15	113	7.80	0.76	0.6	67
2D	0.8	200	6.97	3.21	193	7.99	0.89	0.56	82.2

Table 4. Obtained values on extracted must with different pressing techniques.

As a result of the two different presses being compared with that having an elastic membrane, the latter utilised different pressures (2A and 2B (1,6 bar); 2C and 2D (± 0.8 bar)) in order to carry out a fairer comparison with the normal operating pressure of the other two. The tests necessitate evaluation as couples.

In cases of **higher pressure** (1,6 bar set 2A and 2B) it can be noted (Table 4) how the **elastic membrane press** (2A) induces a minor must colouration, together with lower suspended solid and total polyphenols values, even if the latter parameter is simple with respect to test 2B. Therefore, a minor maceration of the skin occurs, a percentage of extraction slightly superior to that of the elastic membrane press with minor oxidation, given that the chromatic difference is only partially attributable to the different standard of total polyphenols.

In cases of **lower pressure** (0,8 bar set 2C and 2D) it can be noted (Table 4) how the **elastic membrane press** results in (2C), even in this case, a minor must coloration, together with a lower total polyphenols value. The standard of suspended solids is similar among the 2 compared sets. Minor skin maceration with the elastic membrane press, as a result of the lower standard on extracted substances, can be noted (total polyphenols and more in particular cinnamil tartaric acids). The juice rendered in this case is unfavourable to elastic membrane presses, even if the levels reached are interesting and the times are significantly lower with respect to presses operating on low pressure (2D).

In the light of the above it can be maintained that elastic membrane presses lead to good quality must production, for certain parameters even better than those obtained with the comparison presses.

It can be further noted that, owing to the characteristic of the grapes and the elevated technology of the machinery utilised in the comparison, in all cases the resulting must was of good quality.

CONCLUSIONS

The constructive characteristics of the examined presses (elastic central membrane and the large syneresis surface area) significantly influence machinery operation, permitting a high index of extraction in reduced times. The machinery has revealed to be particularly sensitive to regulations regarding applied pressure and less influenced by the number of pressing cycles (and the consequent exhaustion times). This peculiarity is attributed both to the elasticity of the membrane (useful for uniform applied pressure) and the distribution of the pomace panel across the entire cage in a limited layer and the large draining surface area. These considerations may also explain the good results obtained in the comparison with the other examined membrane presses. To these results one must not underestimate the difference in cage capacity with more favourable forms being those with reduced volumes. However, one must take into consideration the fact that improved performance is mainly attributable to a more facilitated drainage of the central membrane press, at an advantage for its more ample surface area and more evident holes.

From an oenological point of view the must analyses indicate how the quality of the examined presses' performance is analogous and often markedly improved to those of the more traditional machines utilised in the comparison, even if with shorter work times.

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