INCREASED GRAPE VALUE BY IMPROVED EXTRACTION: RAPID-EXPANSION (PART A)

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1.1 Scientific Context

Polyphenolic components are responsible for the color of red wines and represent the support necessary for their organoleptic character. Grape juice and wine are far from containing all the constituents of the berry. Winemakers know that for a specific variety, the content of polyphenolic compounds depends on the quality of the vintage, the grape maturity, the yield and nature of the vineyard block, the sanitary condition of the grapes and the vine age. This polyphenolic potential positively affects the quality (balance, roundness, color, softness and fullness) but can also affect it negatively depending on its nature and the way it is exploited.

A number of studies have been dedicated to the anthocyanin and tannin composition of grape berries regarding the control of the evolution of these constituents during maturation, or the influence of certain climatic factors. Examples of these studies include Ribereau-Gayon (1972), Bisson (1978), Bourzeix *et al.* (1983), Roson *et al.* (1988), Aubert *et al.* (1989).

More than just the overall content of polyphenolic compounds, their distribution in the grape berry has to be taken into account (Roson *et al.* 1992). According to Glories (1988), the tannins of the skin are concentrated at maturity. They are less polymerized and less astringent than those located in the seeds. The extraction and nature of tannins has been studied in the berries, in wines and model solutions in dependence on their origin. Generally, only 30 to 60% of the tannins and anthocyanins found specifically in the grape skin are extracted (Roson, 1992). Thus, it turned out to be necessary for viticultural trials but also in enology to better grasp the quality potential of the grapes.

At the time of harvest, winemakers dispose of a raw material that is increasingly well identified. Thus, they are in charge of implementing the grapes according to well-defined enological practices in order to obtain wines with the organoleptic profiles desired. This includes the control of extraction of diverse phenolic constituents that are linked to the different enological practices applied.

1.2 Factors that favor the extraction of polyphenols

In practice, two major options are available to winemakers:

1.2.1 One option refers to the integrity of grape berries in a CO_2 saturated atmosphere. It is well known that the intracellular fermentation creates the condition for a good polyphenol extraction next to the formation of specific aroma compounds. Particularly, the parameter-pair maceration time and temperature has been studied with diverse varieties and dealt with in publications (M. Flanzy *et al.*, 1973 ; C. Flanzy *et al.*, 1987).

Complementary to these basic studies, other methods including prolonged skin contact and pumping over after anaerobic metabolism have been investigated. These methods allow increased phenolic extraction up to 20%.

1.2.2 In contrast, the other option refers to a certain cellular disorganization and diffusion phenomena. It is also about putting endogenous or exogenous microbial enzymes into contact with the juice and the solid parts of the berry.

The most developed technique is due to maceration phenomena supported by certain technological equipment that is regularly improved. (rotary fermenter, pumping over and cap punching or utilization of gas under slight pressure).

Works that have been followed with lively interest in the viticultural regions concerned have targeted the control of the maceration in these situations. Amongst the most recent can be cited: Vivas *et al.* (1992), Kovac *et al.* (1992), Gerbaux (1993).

Other technologies have recently been suggested. The final hot maceration has been evaluated under different winemaking situations (Glories *et al.*, 1980 Lamadon, 1991). The final hot maceration allows increasing the color significantly (from 10 – 20%) by increasing the temperature at the end of alcoholic fermentation to around 40 – 45°C (104 – 113°F).

In the case of a vintage with low polyphenolic reserves, the latter technique can be satisfactory. It also allows correcting for too short skin fermentations.

The addition of grape seeds during fermentation has been studied by Kovac and Bourzeix (1992). This method allows to increase around 50% the content in catechins and proanthocyanidins if, for example, the quantity of seeds from the harvest are doubled. Such as for wines made by final hot maceration, the wines produced by these methods are judged to be different, more structured and are sometimes preferred over the control wines. Other approaches have also been carried out, such as cell-cracking, for example. This technique, which was investigated at INRA, consists in putting the grapes under pressure with CO_2 gas (between 60 and 100 bars; i.e. 870-1450 PSI) for a certain time (minutes) previous to the vinification. Even though well equilibrated wines were obtained, the gain in extraction was not judged sufficiently important to justify such a method economically for the varieties studied.

Finally, next to these essentially physical methods, a more biotechnological approach involving the addition of exogenous enzymes should open numerous perspectives in the next years. Figure 1 summarizes the approaches presented.

The results of these works indicate that maceration is not a unique process and can't be generalized. The diversity of the situations and the know-how of the users make that a better global understanding of the phenomena leads everyone to suggest methods that connect the duration of skin contact, the temperature, the level of aeration in the vat, the juice/pomace contact, and eventually the realization of the pre-treatment or post-treatment.

In addition to all these methods that can be classified as cellular disorganization techniques, it appears interesting to proceed and ameliorate the utilization of the phenolic potential of the berries and, particularly, the pomace. This can be achieved by more direct new enological methods that are suitable to allow a stronger liberation of polyphenols, especially those present in the berry skins.

A new technique, which we call Rapid-Expansion, is now able to allow an increased extraction of the components contained in the berry skins. This process uses low pressure.

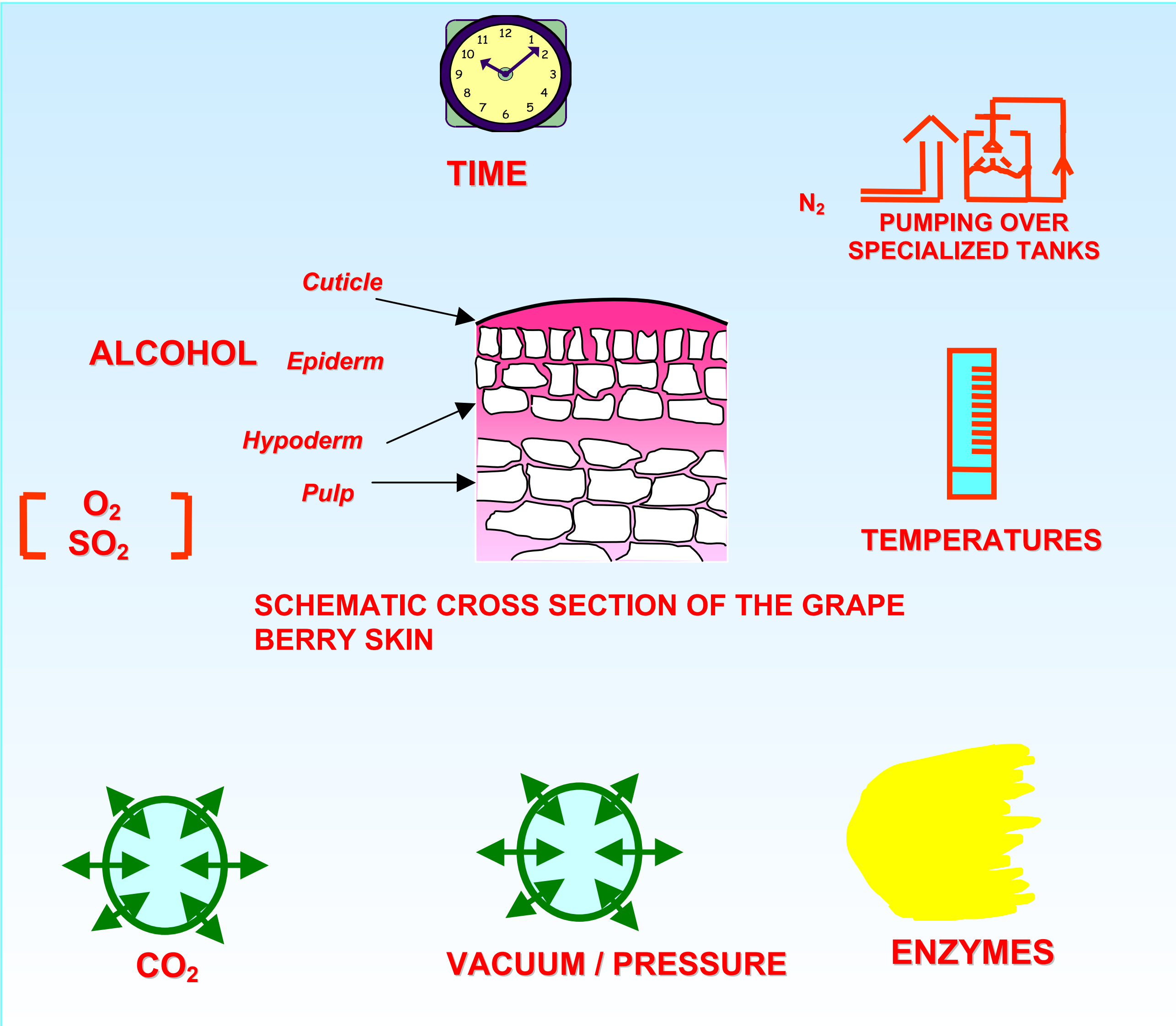

Figure 1: Factors affecting the extraction of berry constituents

1.3 Example of utilizing heat and a vacuum: pre-treatment of grapes by Rapid-Expansion under vacuum

- **Procedure Description**

The principle of this procedure is to assure continuously, and in a minimum of time, a thermal treatment of the destemmed and drained grapes, followed by a quick cooling under strong vacuum in a fraction of a second, and prolonged holding in a vat under vacuum.

- **Heating**

The objective is to heat the grapes quickly (generally 2 to 5 minutes) to 85° - 90°C (185-194°F). Various systems are suggested: heating by biological vapor coming from grape musts, by heat exchangers of tubular or co-axial design or by the juice itself using the liquid ring Thermocompact method from Imeca Della Toffola, which was developed industrially mainly in France.

- **Cooling**

The vacuum recipient is a reinforced tank held under strong vacuum (20 – 50 hPa absolute pressure; 0.3-0.7 PSI) by a vacuum pump coupled to a condenser.

The application of vacuum to the hot product leads to an instantaneous evaporation of the water present in the grapes with a simultaneous cooling in order to reach the equilibrium temperature (30 - 35°C with the vacuum used; 86-95°F).

The mass of evaporated water is given by the following formula

$$E = M \times C_s \times \frac{\Delta\theta}{\lambda}$$

with

E: Amount of evaporated water contained in the fruit

M : Weight of Fruit (kg)

C_S : specific heat coefficient of the juice (Kcal/°C x kg)

λ : evaporation temperature under vacuum

$\Delta\ \theta$: temperature difference between incoming and outgoing fruit

For example, at an absolute pressure of 50 hPa (0.72 PSI), the instantaneous equilibrium temperature is 32°C (90°F). The amount of water evaporated (*E*) from 100 kg of fruit placed under vacuum after heating to 82°C (180°F), is equal to:

$$E = 100 \times 0.875 \times \frac{50}{570} = 7.67 \text{ kg water/100 kg fruit}$$

Under the vacuum applied, 1 kg of water takes up a volume of 29 m^3.

Such a volume of vapor (7.67 × 29 = 223 m^3 for 100 kg of grapes) creates a sudden expansion that will lead to a fragmentation of cellular structures.

Utilization of a particularly strong vacuum totally avoids dissolved oxygen pickup during the process.

The grapes are continuously removed from the vacuum tank by a continuous volumetric pump in order to be fermented.

1.3.1 Technological consequences of the vacuum treatment

- Parietal material (grape skin material)

Different observations show its evolution:

-Observation of the grapes after the treatment: the must has a more viscous consistency and all berries and their skins are clearly opened

- Force of rupture of skin fragments: compared with the control, the Rapid-Expansion fragments show a significantly lower mechanical resistance when measured with rheological equipment (see table 1).

Table 1 : Force of rupture measured on skin fragments

Variety	***Treatment***	***To (N)***	***To + 10 days (N)***
Grenache	Control	1,53	1,25
	R.E.	1,41	0,55
Carignan	control	1,48	1,44
	R.E.	1,23	0,76

Control: classical vinification

R.E.: vinification after Rapid-Expansion

To: measurements made with samples taken at filling (of fermentation tanks)

To + 10 days: measurements made with samples taken 10 days after filling (of fermentation tanks)

-Electronic microscopy: while the skin surface of the control berries is uniformly smooth and regular, the Rapid-Expansion grapes are covered with a dense grid of cracks of 0.3 µm depth (Ageron *et al*., 1995)

- **Pomace Fragmentation**

Granular meter measurements at filling and devatting have shown the difference between the size distribution of berries of a classic harvest (destemmed Grenache as control) and a Rapid-Expansion treated harvest (Escudier *et al.*, 1995). Photos 1 and 2 were taken 8 days after filling (with daily pumping over) and illustrate this effect.

The Rapid-Expansion pomace has a significantly higher amount of small particles (<4 mm) and fewer large particles (>8 mm).