Flotation — achieving success

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The authors explain the principles of flotation, some of the key parameters that influence the process and offer some advice on achieving success.

INTRODUCTION

Flotation is an alternative method of clarifying white or rosé must to traditional cold settling (Ferrarini *et al.* 1995, Mierczynska-Vasilev & Smith 2015). Juice lees contain suspended material that forms a compact cake or floc which is lifted to the top of a tank via the injection of a gas. Once the cake has lifted, clear juice is run off the bottom.

This practice has been available to winemakers for more than 30 years and has many advantages in terms of processing time and minimising the risk of oxidation and microbial spoilage. Flotation has the additional advantage of being conducted at ambient temperature, therefore eliminating the costs associated with refrigeration.

Despite all these advantages it can still be a source of concern for many wineries and the cause of many headache phone calls from winemakers during vintage. Flotation is used for high quality must all over the world and has been extensively developed as a process in conjunction with potato/vegetal protein for use in Spanish cava wine base. The type of gas, variety, grape maturity and health status, must temperature, percentage of solids, the pectin load and the physio-chemical properties of flotation adjuvants are some of the many parameters that can influence the outcome of a float. The intention of this article is to discuss the various parameters that affect flotation and what can go wrong.

Since flotation was first introduced, the use of animal proteins in the process has been widespread due to their versatility, efficacy, yields and the results obtained. With the constant pressure from international markets towards eco and vegan-friendly products, the development of flotation proteins of vegetable origin has been necessary. However, the behaviour of plant proteins is very different to animal proteins, and only specific plant proteins or a combination of these, together with a good knowledge of the flocculation mechanism and the parameters of flotation will lead to satisfactory results.

AT A GLANCE

- Flotation has been available to winemakers as an alternative to traditional cold settling for more than 30 years.
- It remains a cause of concern for winemakers given many parameters influence the outcome of the flotation process.
- The health of grapes, variety and the maturity of fruit are among the influencing factors, along with the depectinisation enzymes and adjuvants used, the turbidity and temperature of the flotation, the type and amount of gas injected and the size of tanks.

PRINCIPLES OF FLOTATION

Flotation is a suitable clarification process for white and rosé juices in both small and large wineries. Grapes are pressed in the same manner as with traditional cold settling, but the time frame is shorter. Enzymes are added as soon as possible to commence the depectinisation process, often in the press if not earlier in grape bins. Once grapes have been crushed/pressed, a cocktail of depectinisation enzymes begin to break down the large complex pectin chains present which can take two to four hours (Table 1).

Must is not chilled or racked here — as soon as it is confirmed that must is pectin negative, it is ready for flotation. Many types of flotation pumps and setups are available. The principle of flotation remains the same, but the flow rate, pressure and time frame may change. Batch flotation can either happen in one tank, or from tank to tank. Many larger wineries use continuous flotation whereby enzyme-treated juice is continuously fed in and clear juice is continuously recovered. Cake formation here is critical to achieving efficiencies as it is continuously skimmed off the top (Figure 1).

Adjuvants such as bentonite and proteinaceous fining agents may be dosed into the tank directly and homogenised or dosed in-line. Gas is injected into the tank either simultaneously in-line or subsequently through the saturation chamber of the flotation system. The pressure and the amount of gas dosed are variables that can be controlled in the process. The amount of time that juice is floated for will depend on the speed of the pump. After the gas has been injected into the tank, flocs will take time to migrate to the top. The clarity in batch flotation systems can be checked by periodically measuring the turbidity. After two to six hours the tank is ready to be reverse racked and be inoculated without the need to warm the clarified juice.

ENZYMES, GRAPE HEALTH AND MATURITY

Depectinisation enzymes are critical to breaking down the large pectin fractions which impede flotation. Clarification by flotation involves migration of the particles of must to the surface of a tank. This migration is prevented in the presence of pectins. Additionally, the presence of pectin can slow down the formation of the flocs in the first place. The addition of a pectolytic enzyme directly after grape pressing is necessary to accelerate the process.

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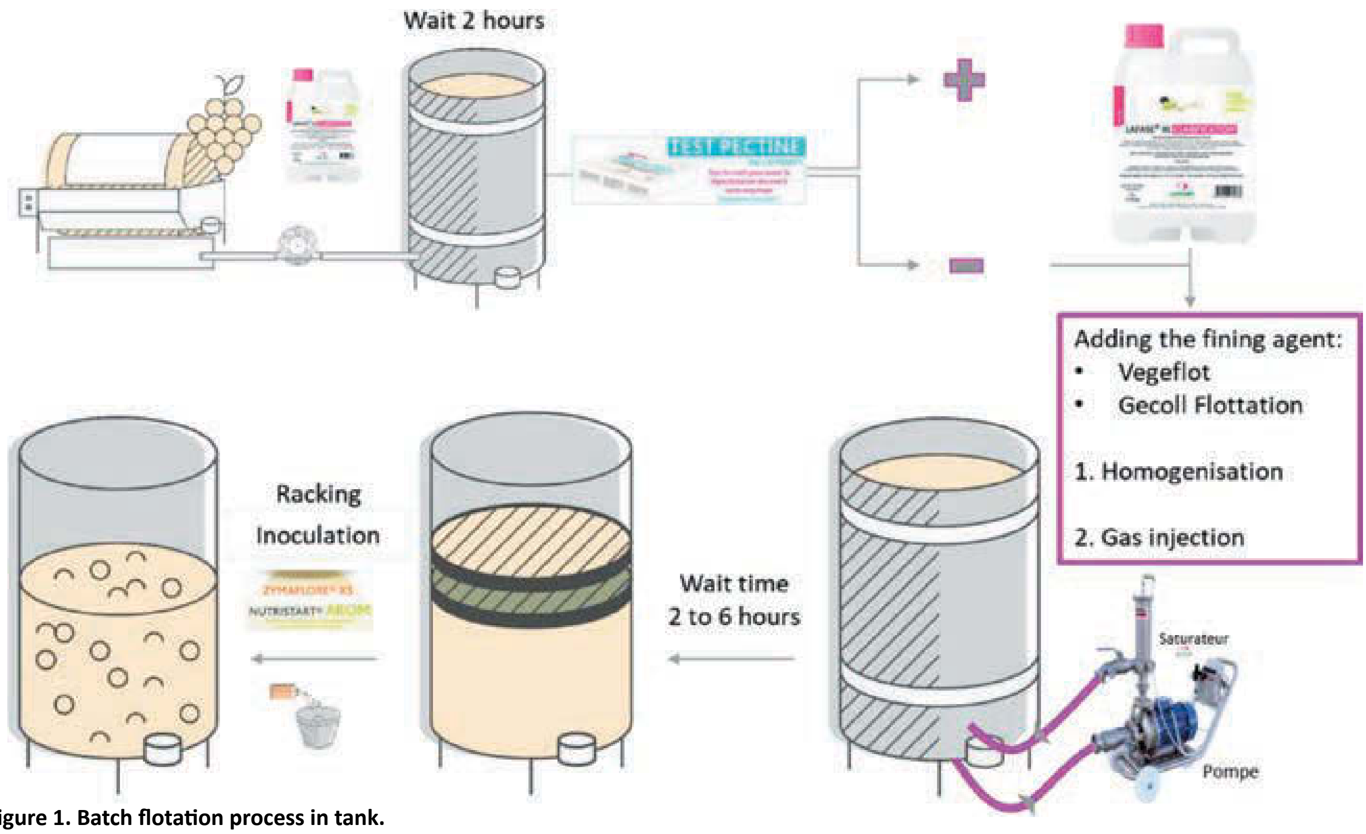

Figure 1. Batch flotation process in tank.

Laffort has developed Lafase® XL Flot, an enzyme specifically tailored to flotation. For must that is particularly difficult to clarify (due to variety, grape maturity, etc.), or to accelerate depectinisation, the use of specific depectinisation enzymes, like Lafase Boost, to eliminate side chain pectolytic activities is recommended.

Depectinisation enzymes for flotation are a cocktail of enzymes best suited to the process. Enzymes used in cold settling are able to cut the pectin into finer fragments best suited to compact lees, whilst for flotation it is more critical to have a quick and efficient depectinisation. Compromised grape health may lead to the presence of various types of rot, increased spoilage microorganisms and the production of glucans which may impact the colloidal load and the ability of the enzymes to access their substrate. Complete depectinisation is required to achieve an efficient flotation. An acidified enzyme test is an easy way of assessing the pectin status.

Anything that inhibits enzymatic activity will affect the efficacy of the flotation process. The structure of the pectins changes as grapes mature (Gao *et al*. 2016). The riper the grapes, the more challenging the depectinisation may become. Often it can be observed that a liquid enzyme preparation may appear to work more efficiently at the beginning of vintage than at the end of vintage for this reason. If liquid enzymes are stored incorrectly, they may also lose some of their key activities, thus contributing to a less efficient depectinisation at the end of the harvest period.

Table 1. Properties of flotation adjuvants. These recommendations are based on Laffort fining agents and may vary greatly to other adjuvants.

Adjuvent	Practical commentary	Typical dosage for floatation	Fining activity
Bentonite	Bentonite is very important in continuous flotation systems as speed of clarification is critical. Bentonite may also be used to decrease the resulting turbidity of the juice.	100-400 ppm	Binds to proteins depending on the pH of the juice. It will also bind to colloidal load and facilitate clarification
PVPP	PVPP is often used in conjunction with a proteinaceous fining agent and can be used successfully during flotation.	100-200 ppm	PVPP binds to specific phenolic compounds before they oxidise thus reducing the risk of oxidation in the must and wine.
Silica gel	Silica gel is mainly used to facilitate flocculation and to accelerate sedimentation during fining operations	5/10 mL/hL	Silica gel is a negatively charged particle which is mostly used in conjunction with a positively charged fining agent such as gelatin.
Decolouris-ging carbon	Carbon may be used to remove colour from juice destined for rosé that have extracted too much colour from the skins.	200-800 ppm	Decolourising carbon removes a broad spectrum of phenolic compounds including anthocyanins responsible for colour.
Gelatine	Animal based proteinaceous fining agent. This may be used by itself in flotation.	100-1000 ppm	Gelatins vary greatly in specificity. They are a protein and positively charged and will bind to phenolic compounds
Vegeflot (Patatin and pea protein)	Vegetable based proteinaceous fining agents made up of patatin (potato) and pea protein. Vegan friendly and PVPP free fining agent.	100-200 ppm	Vegetable proteins vary greatly in their reactivity and specificity towards phenolic compounds. The nature of the floc formed is significantly different to many gelatines in flotation.

DESIRED TURBIDITY AND TEMPERATURE

Desired turbidity can be achieved through the use of adjuvants and gas. The temperature of juice will impact how quickly flocs are lifted and thus affect the resulting turbidity after a set amount of time. The optimal temperature of flotation is between 15°C and 20°C. The colder the juice the higher the viscosity. Depectinisation enzymes have much lower activity below 15°C and the formation and lifting of flocs takes longer. Low juice temperature is often a contributing factor to floats not working or taking much longer than desired.

ADJUVANTS

As mentioned previously, an adjuvant may be added to increase the size of the floc, remove undesirable phenolic compounds and other colloidal load as required, as well as lead to more compact lees. Often clarification is the primary goal, and any fining that occurs during the process is a bonus. If the primary goal is fining, then the flotation process will have to suit. For example, if the fining objective requires high levels of carbon, bentonite and gelatine as opposed to gelatine alone, the amount of gas required to lift the flocs may be much greater.

Fining agents used in flotation vary greatly in their physio-chemical properties. The winemaker needs to be happy with the fining effect of the chosen adjuvants as this will impact the remaining phenolic load in the wine. Gelatine has been traditionally used for flotation but is now being replaced with vegetable options in many instances. Some commentary about the different flotation adjuvants is presented in Table 2.

LINKING THE SCIENCE OF FINING WITH FLOTATION WITH VEGEFLOT

Vegeflot® is a combination of a pea and patatin (potato) protein developed for flotation without bentonite. The patatin is highly reactive and has a very specific fining activity whilst the pea protein has a complementary fining activity. Laffort has dedicated several years to linking the physio-chemical properties of Vegeflot with the process of flotation as this is often a missing piece of the puzzle on high quality musts all around the world. The following protocol was developed with batch flotation in one tank with a discontinuous flotation pump. This has since been adapted successfully using many flotation pumps in both batch, tank-to-tank and large commercial continuous flotation systems. Every flotation pump needs a specific protocol.

1. Ensuring the must is pectin negative and above 15°C.
2. Preference for flotation in one tank (rather than from tank to tank). This allows time for the floc to form.
3. For the best results, hose lengths should not exceed 3m (both inflow and outflow).
4. Dosing the Vegeflot at 100-200ppm as slowly as possible, and allowing it to circulate in tank for 25% of the volume of the tank.
5. Circulate for 30 minutes at 2 bar pressure without gas injection.
6. Increase pressure to 5 bar with 20-60L /min of gas injection. Turn the tank over 1-1.5 times. The amount of time this takes will depend on the size and capacity of the pump.
7. Allow at least two hours before racking clear juice off the bottom after an NTU determination.

Table 2. Types of gas used in flotation.

Gas	Advantages	Comments
CO_2	Protects musts against oxidation	CO_2 bubbles are large in size — bubbles that have difficulties bringing the lees to the surface. CO_2 can cause significant agitation on the surface.
N_2	Good bubble size for flotation. No risk of oxidation.	Excellent for flotation
Compressed gas	Economical	Requires an oil filter / deodoriser in the compressor. Regular cleaning of the filter.

TYPE OF GAS AND AMOUNT OF GAS INJECTION

The type of gas injected will impact the efficiency of the flotation. Trials with Vegeflot around the world have found 5-5.5 bar of pressure to be optimal. Above 7 bar of pressure the bubbles can lift too quickly and may not have time to fix to the solids. The bubbles themselves need to be big enough to allow them to adhere to the solids without causing excess aeration and a 'foamy' cake. Nitrogen is more commonly used as this is an optimal bubble size for adhering to flocs without the risk of oxidation. Sindou *et al*. (2008) found that musts floated with nitrogen had a similar concentration of phenolic substances, browning capacity and sensory qualities as that of the control wines and recommended its use for premium wine production. Oxygen is not listed as a gas for flotation as the cost and hazardous nature of storing it onsite limits its suitability to the process. The flow rate will depend on the flotation machine in question.

OTHER FACTORS

Tank size plays a role in the dynamics of the flotation process. The taller the tank, the longer the distance the gas has to push flocs to the surface. A shorter tank will have less distance to push flocs up. Filling the tank up to 85-90% of the final volume will allow for flotation cakes that are particularly aerated.

CRITICAL POINTS TO ACHIEVING A SUCCESSFUL FLOTATION

- Ensure juice temperature is between 15-20°C and not below
- Pectin negative – juice must be pectin negative before it can be floated
- Choose a shorter and wider tank rather than a tall narrow tank
- Adequate pressure and gas supply in the winery
- Factor in the level of solids present including adjuvants
- Adequate flotation time based on tank volume
- Adjuvant selection – rate and type may impact the flotation process.

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