

THE INFLUENCE OF PHYSICAL-CHEMICAL PARAMETERS ON THE SENSORY EVALUATION OF SPARKLING WINES

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Abstract

Sparkling wines are wines obtained through the second fermentation of still wines, and they contain an overpressure of carbon dioxide formed during this process. Champagne is the most famous sparkling wine in the world, produced exclusively in the Champagne region of France using the bottle fermentation method, also known as the traditional or champenoise method. Another widely known sparkling wine is Prosecco, which is produced in the Treviso region of Italy using the Charmat-Martinotti method of fermentation in pressurized tanks. This article aims to provide an overview of the physico-chemical characteristics of sparkling wines made using the traditional method (such as Cava, Crémant, and Champagne) and some sparkling wines made using the tank method (such as Prosecco and Spumante), and to correlate these characteristics with the tasting notes specific to each type of sparkling wine.

Keywords: sparkling wines, sensory evaluation, physical-chemical characteristics, Champagne, Cava, Prosecco

1. INTRODUCTION. SPARKLING WINES HISTORY AND CLASSIFICATION. SPECIFIC WORDS

Sparkling wine is an alcoholic beverage bottled under pressure created by the presence of carbon dioxide obtained through fermentation.

Fizzing wine is an alcoholic beverage obtained by adding carbon dioxide through a process of pressure impregnation at low temperature.

In the sparkling wine industry, a series of established terms are used, most of which are borrowed from the French language. The most commonly used terms are:

Tirage liqueur: This is a mixture of base wine, sugar (or concentrated must), and yeast needed for the second fermentation. It is added to the wine before the second fermentation.

Expedition liqueur: This is a mixture of wine and sugar syrup (or concentrated must), which determines the sweetness (degree of sweetness) of the sparkling wine and is added before bottling.

Riddling (Remouage in French): This refers to the automatic agitation of bottles in vibrating racks or their manual turning on inclined wooden supports to move the yeast towards the neck of the bottle.

Disgorging: This is the process of removing the ice plug formed from the yeast sediment by freezing the neck of the bottle. The disgorging operation is applied only to sparkling wines produced by the traditional method and can be done manually or automatically. Along with the stopper, some of the sparkling wine is removed due to the pressure.



Figure 1. Manual disgorging in Champagne region (personal archive)

In Figure 1, a group of disgorgers can be seen performing manual disgorging in 1900 in the Champagne region of France. The picture was acquired from one of the antiquarian booksellers in Paris.

1.1. Small history of sparkling wines

1531 is the year when the first recorded sparkling wine in the world, named *Blanquette de Limoux* and was produced by the *Benedictine monks* of Saint Hilaire Abbey, near Carcassonne (France).

In 1668, the Benedictine monk from the Champagne region, *Dom Perignon* developed the method of obtaining sparkling wine. After visiting the monastery in Limoux, he introduced the process of disgorging, earning the title: *Father of champagne*.

In 1895, *Federico Martinotti* patented a method for producing sparkling wine in pressurized tanks. This technique was further refined in 1907 by the French inventor *Eugène Charmat*, resulting in the modern Charmat-Martinotti Method.

In 1919, *The Treaty of Versailles* established that the term "*Champagne*" could only be used for sparkling wines produced in the Champagne region of France.

1.2. Classification of the sparkling wines

The classification of sparkling wines can be made according to several physical-chemical parameters, a series of such classifications being presented below.

Depending on the carbon dioxide pressure in the bottle, measured at a temperature of 20°C, considered the temperature at which the physical-chemical values are stable, there are:

- Standard sparkling wine - pressure min 3 bar
- Quality sparkling wines - minimum pressure 3.5 bar
- Petiant (frizante) wines - pressure 1-2.5 bar

Depending on the sugar content, sparkling wines can be classified as in table 1.

Table 1. The sugar content of sparkling wines

English language	French language	Residual sugar (g/l sugar)
Brut Nature	Dosage Zero	under 3g
Extra Brut	Extra Brut	until 6g
Brut	Brut	until 15g
Extra Dry	Très Sec	12-20g
Dry	Sec	17-35g
Medium Dry	Demi Sec	33-50g
Sweet	Doux	over 50g

Depending on the style of the base wine, Figure 2 illustrates the quantities associated with the type of wine used to produce these sparkling wines.



Figure 2. Classification according to the type of base wine

The most complex classification is the one according to the method of obtaining the sparkling wine and the origin of the carbon dioxide (exogenous-endogenous).

- 1. The Rural Method (Ancestral Method)** Carbon dioxide is produced during fermentation in the bottle, without removing the yeast. The grape juice is kept sweet before the fermentation is complete and is then placed in bottles where it ferments and is delivered without removing the yeast. (Moscato Spumante, Clairette de Die, Blanquette de Limoux)
- 2. The Charmat-Martinotti Method (Tank Method)** Carbon dioxide is produced during the second fermentation in pressurized tanks. Young wines are enriched with sugar and yeast (*liqueur de tirage*) in a pressure-resistant tank where the second fermentation occurs. The resulting carbon dioxide is retained in the wine. (Prosecco, Frizzante, Lambrusco)
- 3. The Traditional Method (Champenoise Method)** Carbon dioxide is produced during the second fermentation in the bottle, with the yeast being removed. (Crémant, Cava, Franciacorta, Champagne)

4. The Method for Producing Fizzing Wine with added Carbon Dioxide. Carbon dioxide is added during the pressurized impregnation process, directly into the bottle.

2. SPARKLING WINES PRODUCTION METHODS

The production method of sparkling wines involves several applied methods, shown concise in Figure 3, namely:

- Classical fermentation in the bottle or Champenoise method (traditional)
- Fermentation in the bottle then transfer to the technological vessel and then re-bottling in the bottle or the Transvasier (transfer) process
- Fermentation in tanks or the Charmat Martinotti method

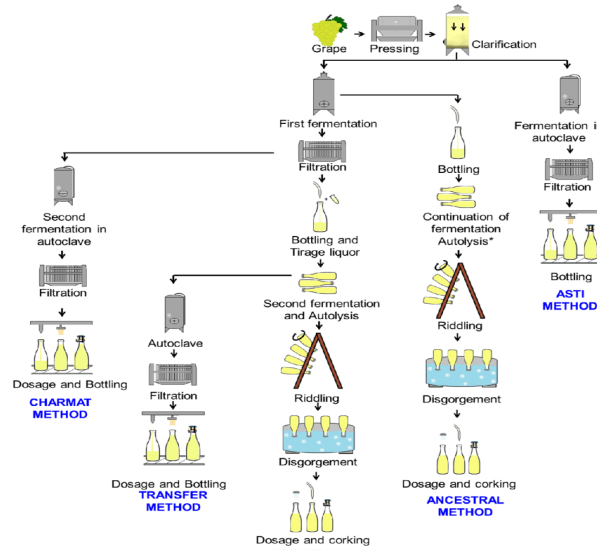


Figure 3 Sparkling production methods

3. SPARKLING WINES CHARACTERISTICS

Below will be described some types of sparkling wine on the world market and their main characteristics:

Champagne - the grape varieties allowed to be used to make champagne are: Pinot Noir, Pinot Meunier, Chardonnay, and the base wines come only from the Champagne region. The 2nd fermentation takes place in the bottle, by the traditional method with keeping at least 15 months in the bottle. The pruning of the wine and the maximum yield per hectare must be respected, as well as the pressing yield.

Cremant is produced in other production regions from France, namely: the Loire Valley, Bordeaux, Bourgogne, Limoux and Alsace. The 2nd fermentation takes place in the bottle, by the classic method with at least 9 months of storage on the yeast. There are Cremantes with different designations of origin: Appellation d'Origine Contrôlée (AOC) and Appellation d'Origine Protégé (AOP).

Prosecco is obtained by the Charmat method, in the Treviso production area (DOC designation) near Valdobbiadene, Asolo (DOCG designation). The local Glera grape variety is used in proportion to a minimum of 85% to produce a lighter sparkling wine (11% vol alc) that has become famous throughout the world.

Cava is a sparkling wine obtained by the 2nd fermentation in the bottle, by the traditional method. It is made in different regions of Spain, most often in the region of Penedes, Catalonia (DO Cava). Local grapes are used as grapes: Xarel-lo, Parellada, Macabeo, Grenache.

3.1. Physical-chemical characteristics of sparkling wines

Physical-chemical characteristics of some sparkling wine made by traditional method or by Charmat method are presented in the tables below. These results were taken from bulletins of analysis from some producers of such sparkling wines and were carried out in specialized and accredited laboratories in their countries of production (France, Italy, Spain).

Table 2 Physical-chemical characteristics of sparkling wine made by traditional method

Traditional method	Cava	Champagne Premier Cru	Champagne Grand Cru	Crémant Loire Valley
Alcoholic strenght by volume, % vol alc	11.3	12.39	12.66	12.1
Total acidity exp in sulphuric acid, g/l	3.7	4.2	3.81	5.3
Volatile acidity exp in acetic acid, g/l	0.1	0.17	0.26	0.19
pH	3.1	2.97	3.15	3.27
Sugar level (glucose+ fructose), g/l	7	9.1	2.1	31.5
Total sulphur dioxide mg/l	90	67	57	72
Overpressure of carbon dioxide at 20 °C, atm	6.2	6.2	7.8	4.7

Table 3 Physical-chemical characteristics of sparkling wines made by Charmat method

Charmat Method	Pinot Grigio Spumante	Prosecco Rose Millesimato	Prosecco Brut D.O.C.G.	Prosecco Extra Dry D.O.C.
Alcoholic strenght by volume, % vol alc	12.03	10.87	11.21	11.09
Total acidity exp in tartaric acid, g/l	6.71	5.56	5.68	5.35
Volatile acidity exp in acetic acid, g/l	0.18	0.18	0.17	0.15
pH	3.35	3.2	3.2	3.24
Sugar level (glucose+ fructose), g/l	10.6	12.3	9.4	14.35
Total sulphur dioxide mg/l	122	150	164	163
Overpressure of carbon dioxide at 20 °C, atm	4.5	5.5	4.7	5.9

For deeply analysis of these parameters there are drawn some graphics which are presented mirror like, for a better understanding:

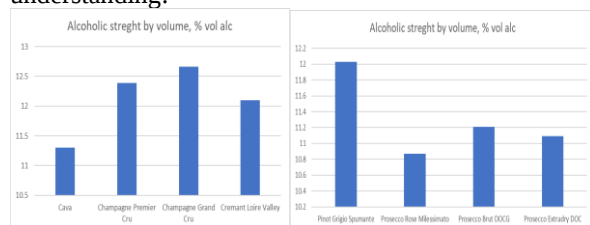


Figure 4. Alcoholic strength by volume, % vol alc.

As you may see the alcoholic strength of both types of sparkling wines are quite appropriate being spread between 10,8 and 12,5% vol alc, values which cannot influence much the sensory properties of these wines.

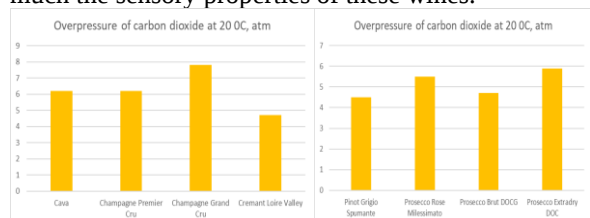


Figure 5. Overpressure of carbon dioxide at 20°C in atm

The overpressure of carbon dioxide measured at 20°C ranges between 4.7 and 7.8 atm, being higher for sparkling wines made using the traditional method compared to those made with the Charmat method. This parameter

influences the sensory characteristics, such as the smoothness and creaminess of the bubbles. When the pressure is higher, the bubbles are smaller and more numerous, whereas, when the pressure is lower, the bubbles are larger.

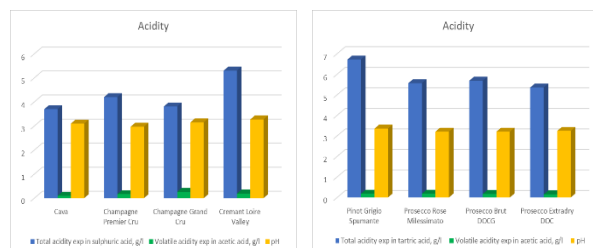


Figure 6. Acidity expressed in different parameters

In Figure 6, the acidity of sparkling wines is expressed as total acidity in sulfuric or tartaric acid, volatile acidity in acetic acid, and pH units. These values are very close for volatile acidity and does not significantly influence the sensory characteristics. The pH values range between 2.97 and 3.27 for sparkling wines made using the traditional method, and between 3.20 and 3.35 for sparkling wines made using the Charmat method. This indicates that the pH can be more easily controlled during the Charmat method. The total acidity is lower in the case of sparkling wines with a higher sugar level and higher for sparkling wines with a lower sugar level, in order to maintain the optimal palatability sensation.

3.2. Sensory characteristics of the sparkling wines

The sensory characteristics of the sparkling wines obtained by the 2 methods are presented in the 2 figures below, depending on their method of production.

The maximum rating scale used for this sensory evaluation was 20 points for each analyzed parameter, with a total of 100 points for each sparkling wine.

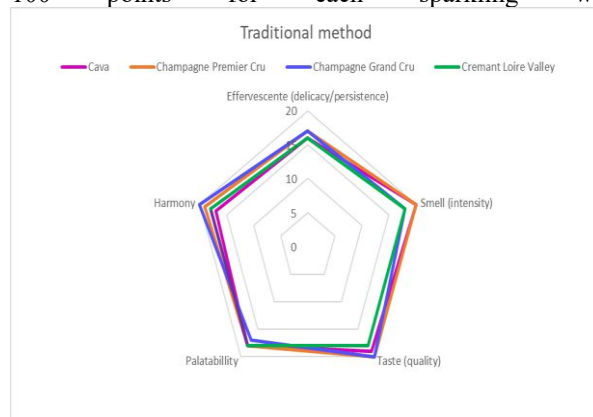


Figure 7. Grafic representation of sensory characteristics for sparkling wines made by traditional method

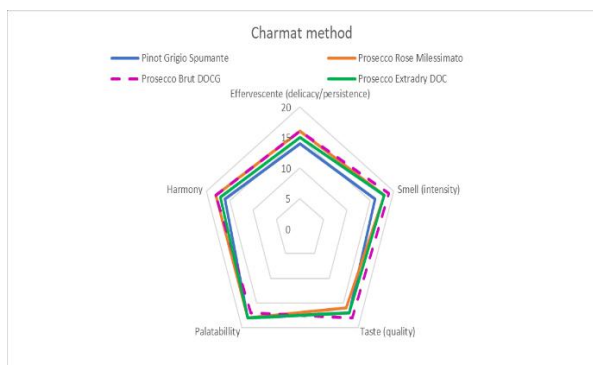


Figure 8. Grafic representation of sensory characteristics for sparkling wines made by Charmat method

The sensory analysis of sparkling wines produced by these two methods was conducted by trained tasters, participants in international-level specialized juries.

From these two figures, it can be observed that the sensory characteristics of the two types of sparkling wines are not significantly different, just as the physico-chemical parameters presented in the previous chapter were not.

Taste, aroma, and overall harmony were the most appreciated sensory characteristics of sparkling wines made using the traditional method. This can be attributed, in part, to the physico-chemical values, such as acidity and sweetness, but these characteristics also depend on the length of time the yeast remains in the bottle. The longer this period, the greater the aromatic and taste complexity. For sparkling wines made using the Charmat method, the values of sensory characteristics are lower, but much closer to one another due to the better homogenization achieved with this method, making the parameters more consistent. In this case, there is no talk of aromatic complexity, but rather a freshness of taste and aroma—qualities that are highly appreciated in these sparkling wines. The parameters are particularly influenced by their acidity, which is usually higher.

4. CONCLUSIONS

Sparkling wine is an alcoholic beverage bottled under the pressure created by the presence of carbon dioxide, which is obtained through fermentation.

The first sparkling wine in the world appeared in France in 1531, and since then, it has delighted us with its bubbles—more or less pronounced—its bright white and sparkling rosé colors, and sometimes even red, as well as a taste with increasing complexity depending on the number of years the yeast ages in the bottle.

The alcoholic strength of both types of sparkling wines is quite appropriate, ranging between 10.8% and 12.5% alcohol by volume, values that do not significantly influence the sensory properties of these wines.

The overpressure of carbon dioxide, measured at 20°C, is higher in sparkling wines made using the traditional method compared to those made using the Charmat method. This parameter influences the sensory characteristics, particularly the smoothness and creaminess of the bubbles, which are smaller and more numerous when the pressure is higher, and larger when the pressure is lower.

Volatile acidity values are appropriate for both types of sparkling wine and do not influence the sensory characteristics.

Total acidity is lower in sparkling wines with a higher sugar content and higher in sparkling wines with a lower sugar content, in order to maintain an optimal sensation of palatability.

Taste, aroma, and overall harmony—being the most appreciated sensory characteristics of sparkling wines made using the traditional method—are influenced to a small extent by physical-chemical factors such as acidity and sweetness. However, these characteristics also depend on the length of time the yeast is kept in the bottle.

The longer this period, the greater the aromatic and taste complexity.

In the case of sparkling wines made using the Charmat method, we cannot speak of aromatic complexity, but rather of a freshness in taste and aroma—qualities that are highly appreciated by consumers and can be directly influenced by their acidity, which is usually higher.

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