Effect of high hydrostatic pressure on selected red wine quality parameters

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Abstract. The aim of this work was to examine the possible use of High Hydrostatic Pressure (HHP) as an alternative method for wine preservation, which could also lead to the production of wines with reduced amounts of SO_2. For this purpose, red wine samples containing 0 ppm, 30 ppm, 60 ppm and 100 ppm of sulphur dioxide (SO_2) were subjected to pressure of 350 MPa for 10 min at 8 °C. A second set of samples containing only SO_2 was used as control. Colour parameters, acetic acid, total anthocyanin and phenolic contents and antioxidant activity were determined over a period of twelve months. During the first four months, most of the differences observed regarding the chemical composition of the pressurized and unpressurized wines were not statistically significant. However, after the period of six months, the pressurized samples in general were characterized by higher average values % yellow colour and acetic acid and lower of % red colour, total anthocyanin and phenolic content compared to the non-pressurized ones. The results obtained could be a possible indication that HHP could accelerate the polymerization reactions reducing the time needed for wine ageing. HHP combined with reduced SO_2 contents might be a promising technology for wine industry.

1. Indroduction

Sulfur dioxide (SO_2) is used as food preservative since the 18^{th} century and it has been validated as an exemplary choice for food with low pH such as wine. Due to its potent and multifaceted character acquired an important role in wine industry as an antioxidant and antiseptic additive. This compound also prevents the wine browning and colour loss, by inactivation of enzymes and inhibition of Maillard reaction, and by reducing the rate of phenolic polymerization respectively [1]. However SO_2 have been related to allergic reactions in some consumers [2], generating a range of symptoms. Consequently, the legislated maximum concentration of SO_2 allowed in wines has been gradually reduced (Regulation (EC) No 607/2009), and a great interest in the search for other preservatives and/or innovative technologies for its replacement has aroused. Methodologies such as addition of compounds (dimethyl dicarbonate, bactiriocins, phenolic compounds, lysozyme etc) and physical technics (pulsed electric fields, ultrasounds and ultraviolet) have been already studied to substitute or reduce the use of SO_2 in winemaking. High hydrostatic pressure (HHP) is considered to be a promising alternative and has already been tested as well, in the enological sector.

Primary studies, were related with the sustainability of wine in terms of microbial contamination [3]. Different sensitivity in pressurization was observed between aerobic bacteria, yeast and lactic acid bacteria [4,5]. After ensuring the microbial stability, research interests translocated to the effects of HHP treatment on the physiochemical and sensorial properties of wines. Numerous studies redounded on the same prevailing conclusions, regardless the different pressure and pressure holding time treatments. Decrease of wine colour intensity and increase of its tint, in conjunction with the augmentation in the CIELab parameters revealed a comparable behaviour between HHP-treated and naturally aged in oak barrels wines [6–8]. In addition, HHP-treated wines were characterized by reduced contents of different types of phenolic families, and lower antioxidant activity. HHP-treated wines had more aged-like characteristics (cooked fruit and spicy aromas, weaker sour and fruity odor, higher brownish colour), compared to non-treated wines [6–9]. However, despite a range of food products (fruit juices, meats, sea foods etc.) available on market shelves, no HHP treated wine has been introduced in the market so far. This is mainly due to the lack of detailed studies regarding the influence of HHP on the quality parameters of wine. This work aims to a detailed examination of the potential use of HHP in red wine making.

2. Materials and methods

Addition of 0 ppm, 10 ppm, 20 ppm, 40 ppm and 100 ppm SO_2 took place in red wine after alcoholic fermentation. All samples were subjected to HHP for 10 min (8 °C), at 350 MPa. Another group of samples containing the same concentration of SO_2 but without HHP treatment served as controls. Colour characteristics of the wines were measured according to Glories (1984) [10]. Concentrations of anthocyanins, polyphenols and acetic acid were measured using "One Wine analyser" (Steroglass SRL), while the antioxidant activity was determined as described before [10]. All assays were performed in duplicate after 0, 2, 4, 6 and 12 months of storage.

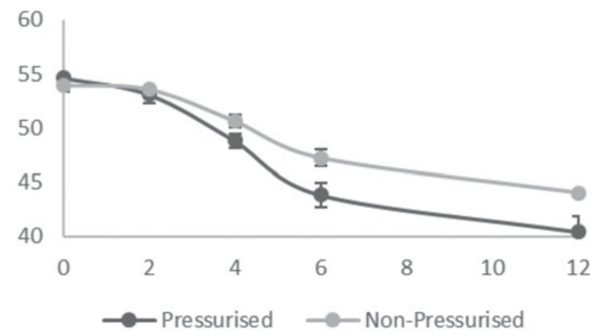

Figure 1. Evolution of % red color in pressurized and non-pressurised wine samples.

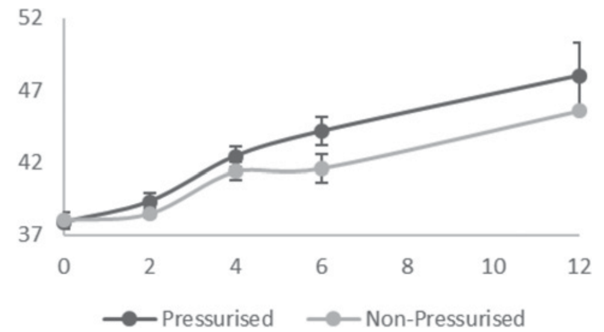

Figure 2. Evolution of % yellow colour in pressurized and non-pressurised wine samples.

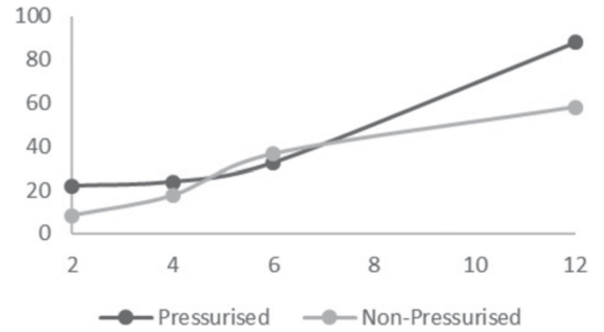

Figure 3. Evolution of % acetic acid in pressurized and non-pressurised wine samples.

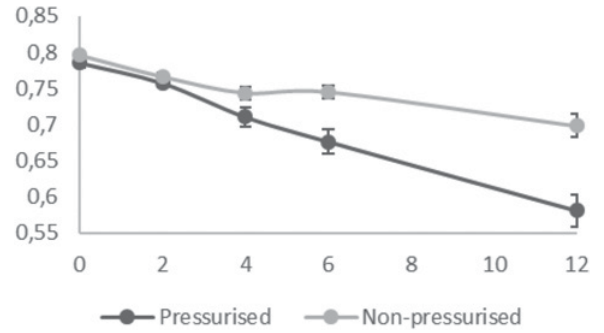

Figure 4. Evolution of the total polyphenolic content (g/L) in pressurized and non-pressurised wine samples.

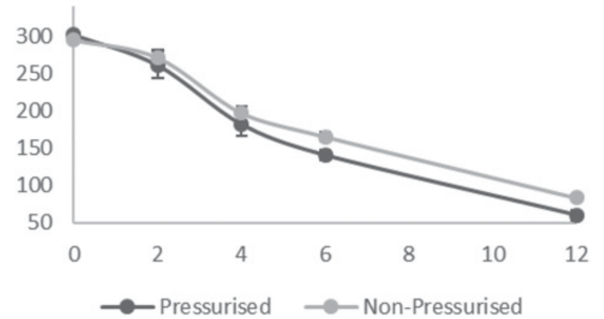

Figure 5. Evolution of the total anthocyanins (mg/L) in pressurized and non-pressurised wine samples.

3. Results and discussion

3.1. Colour

The evolution of the colour parameters (%yellow and red) calculated for the wine samples (without the HHP treatment and pressurised) is presented in Figs. 1 and 2.

At the beginning of storage, no significant differences were observed among the different treatments of the wine samples indicating that pressure treatment did not affect the colour parameters of the wines immediately after the pressure treatment and up to a period of 4 months. This is in agreement with the findings of Santos et al. (2016) [8] who observed that the physicochemical characteristics of the pressurised red wines started showing significant differences after five months in storage. In accordance with the findings of other researchers [7,8] the percentage of red colour decreases while that of yellow increases with time in both sample groups. However, after six months the pressurised wines were characterized by significantly lower percentages of red and higher of yellow colour.

3.2. Acetic acid

Figure 3 shows the evolution of the acetic acid content of the wines during the twelve months storage period. Significant differences were observed only after 12 months of storage with the pressurised wines containing higher amounts of acetic acid compared to the unpressurised.

3.3. Phenolic compounds

3.3.1. Total Plenols

Figure 4 presents the evolution of total phenolic concentration of the pressurised and unpressurised wine samples. As it can be seen, there is a decreasing trend in the total wine phenolic content with time in agreement with other authors [8].

However, after six months of storage the pressurised samples contained significantly less polyphenols when compared with the non-pressurised samples in agreement with Santos et al. (2016) [8] and Tao et al. (2012) [11]. The decrease of these polyphenolic compounds may be related with the enhancement of chemical oxidation, polymerization and/or precipitation of phenolic compounds during storage [7].

3.3.2. Total Anthocyanin content

Figure 5 presents the evolution of total anthocyanin content of the pressurised and unpressurised wine samples. As it can be seen, there is a decreasing trend in the total anthocyanin content with time in agreement with other authors [8].

Generally, the contents of total phenols and anthocyanins decrease during storage due their potential polymerization, condensation and precipitation [11].

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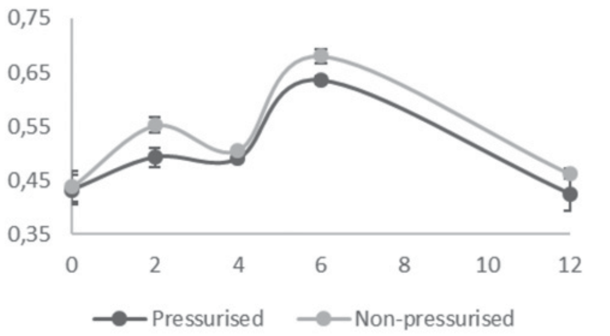

Figure 6. Evolution of the antioxidant activity (mM trolox equivalents) in pressurized and non-pressurised wine samples.

However, this tendency is significantly enhanced when pressure is applied to the wines probably due to specific chemical reactions among the phenolic compounds that take place during pressurization.

Tao et al. (2012) [11] reported a similar higher decrease in monomeric anthocyanin content of pressurised wines in comparison with the non-pressurised ones. However, at the same time the content of copigmented and polymerized anthocyanins increased indicating that the HHP treatment of the wines may accelerate anthocyanin condensation reactions and promote the formation of more complex and stable anthocyanin pyruvic acid adducts. Thus, the decrease of total monomeric anthocyanin content in HHP treated wines may be associated with the condensation reactions induced by HHP.

3.4. Antioxidant activity

Figure 6 showes the evolution of antioxidant activity of the pressurised and unpressurised wine samples.

As it can be observed, wine antioxidant activity in both wine groups, did not show a clear trend. Both increasing and decreasing trends were observed through the period of 12 months. After six months the pressurised wine samples had significantly lower antioxidant activity when compared with the unpressurised ones. A similar increase in wine antioxidant activity after 9 months of storage was observed by Kallithraka et al. (2009) [12] and was attributed to the oxidative transformation of the phenolic compounds. The lower antioxidant activity observed in the pressurised samples is in accordance with the lower content of total phenols reported previously.

4. Conclusions

This work demonstrated that high pressure treatment influence the phenolic composition of red wines leading probably to simultaneous alterations in wine organoleptic characteristics. Most of these effects are only noticeable after 4 months of storage. The lower content of total phenols and monomeric anthocyanins observed in the pressurized samples after 6 months of storage is probably due to an increase of condensation and oxidation reactions. Moreover, the pressurised samples were characterised by lower antioxidant activity. This is also confirmed by the decrease in % red colour and the increase in % yellow and acetic acid content. It seems possible that HHP increased the reactions that are associated with those observed during the ageing of the wine. HHP could be potentially applied to the production of young red wines accelerating the wine ageing process and giving a distinct organoleptic character.

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