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Research Article

Quality study of PDO (Protected Designation of Origin) Greek white wines of the grape variety 'Debina'

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Abstract

In this study 'Debina' (Zitsa, Ioannina, Greece) wines (WD: white dry and WDS: white dry sparkling) were examined in terms of their quality (chemical, physicochemical and sensory) parameters. The concentration of alcohol in both wines was practically stable ($p>0.05$) from the stage of fermentation to packaging and specifically, the rates were 12 and 11.4% vol for WD and WDS wines, respectively. Total sugar concentrations were equal to 1.4 g/l and 1.2 g/l in WD and WDS wines, respectively. WD wine had final total acidity, volatile acidity and pH values of 4.9 g/l tartaric acid, 0.19 g/l acetic acid and 3.15, respectively. While, WDS wine had final total acidity, volatile acidity and pH value of 6.0 g/l tartaric acid, 0.15 g/l acetic acid and 3.11, respectively. Total sulfite content of wine samples decreased and final values of 90.6 mg/l and 99.8 mg/l, in the last production stage, for the WD and WDS wines, were recorded, respectively. According to the data of the study, all wines received a high acceptability sensory score, as judged by the panellists. It must be reported that the sensory scores were on average, 1 point higher for the WDS wines, as compared to the WD wines.

Keywords: chemical; 'Debina'; organoleptic parameters; PDO wines; quality
Abbreviations: FS: Free or Sulfite Free $S0_2$ (mg/l), S: Reducing Sugars (g/l), TA: Total Acidity (g/l), TS: Total Sulfite or Total $S0_2$ (mg/l), VA: Volatile Acidity (g/l), Vol: alcohol (%vol), WD: White Dry Wine, WDS: White Dry Sparkling Wine

Introduction

'Debina' is a thorough bred Greek white wine grape variety, delicate and crispy. Its origin is located on the hilltops of the famous wine region of Zitsa. It is considered to be unique in its kind due to the fruity, classy and elegant aromas of apple, pear and peach, which certainly can seduce the most demanding wine lover. A few hundreds of years back, it was the basic indigenous variety from which the wine makers of the area made the famous sparkling and semi-sparkling wines of Zitsa. Based on this fact, it is considered ideal for the production of sparkling wines. However, it is also suitable for the production of elegant, youthful dry white wines and so, it has rightly been designated as a P.D.O. variety (Protected Designation of Origin) with the unique name 'Debina', as known among wine connoisseurs of Greece.

WD and WDS white wines both are made of 100% 'Debina' variety, having an elegant and youthful wine with aromatic potential. The relatively low alcoholic strength, and its typical acidity of this variety, have

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made it ideal for the production of sparkling and semi-sparkling wines. The intense freshness, the refreshing acidity, the aroma and its long duration are unique characteristics of the 'Debina' variety. This variety gives wines that have bright golden yellow color, aromas of citrus, apple, pear and hints of white peach, with a rich natural sparkling activity. Finally, wines are rich and round in the mouth, a fruity lasting aftertaste.

WD and WDS white wines are made by grapes of 'Debina' variety, cultivated on the slopes of mountainous Zitsa area dating back in the 16th century. The formality of this variety is predefined by the soil and the microclimate of the area. The vinification at low temperatures highlights this white wine's superior quality.

Materials and Methods

Wine samples

Wines were provided by a local processing wine company "Zoinos" Winery, located in Zitsa area in the prefecture of Ioannina, Epiros. The winery runs as a cooperative organized in North West of Greece, established in 1974 and continues even today to add value to the Greek vineyards. While, the vinification of its wines is made through innovative growing and wine-making methods, the wine still maintains its original character, that gives the unique character in the 'Debina' variety. The flow diagram of two wines examined in the present study is shown in Table 1.

Table 1. Manufactory protocols of white dry and white dry sparkling wines

Flow diagram of white dry wine making process	**Flow diagram of white dry sparkling wine making process**
Grapes receival ↓ Pressing of the grapes ↓ Sulphiting ↓ Cold extraction (T≤8° C) ↓ Must cleaning with static settling ↓ Alcoholic fermentation (T=14° C) ↓ Wine clarification ↓ Stabilization of wine ↓ Filtration ↓ Packaging (glass bottles 0.75L) ↓ Storage (T≤15° C)	Grapes receival ↓ Pressing of the grapes ↓ Sulphiting ↓ Cold extraction (T≤8° C) ↓ Must cleaning with static extortion ↓ Alcoholic fermentation (T=14° C) ↓ Wine clarification ↓ Stabilization of wine ↓ Second alcoholic fermentation (T=20-22° C) ↓ Filtration ↓ Packaging (glass bottles 0.75L) ↓ Storage (T≤15° C)

Chemical analysis

For the chemical analysis three samples of each wine were analysed in triplicate. Total acidity, volatile acidity and pH were determined by volumetric analysis, steam distillation and pH meter, respectively. Alcohol was determined pycnometrically and reducing sugars were determined by the Lane-Eynon method. Finally, the total SO_2 and free SO_2 measured iodometrically. Color hue (A_{420} nm/ A_{520} nm) and color intensity (A_{420} nm+A_{520} nm) were evaluated by spectrophotometric measures.

Sensory analysis

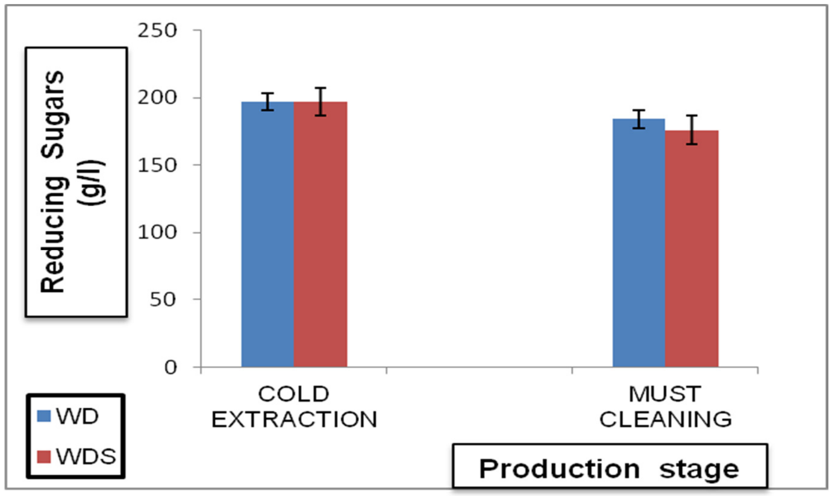
Sensory analysis was carried out by 11 specialists from wine industry (ZOINOS WINERY) and Chemical Department of University of Ioannina (Greece) in a well-lit wine tasting room under controlled temperature conditions. Sensory analysis was conducted one month after bottling the wines. White wines were stored at 8-12 °C until the sensory analysis. Was conducted. Wine samples were poured (served) into a clean glass each time, at 6-8 °C and covered with a Petri dish before the sensory evaluation. White tables with white napkins were used during the sensory analysis. Wine sensory panellists, being experts having previously participated in numerous wine tasting sessions, did not communicate during the sensory evaluation procedure. Water was provided to rinse the mouth between samples. Experts evaluated each sample in triplicate. The sensory evaluation results of wine quality were expressed with a 100-point rating scales, as described previously (Etaio *et al*., 2012; Khalafyan *et al*., 2021), according to the following points: appearance: 10, odour/aroma: 30: taste: 40, and overall impression: 20.

Statistical analysis

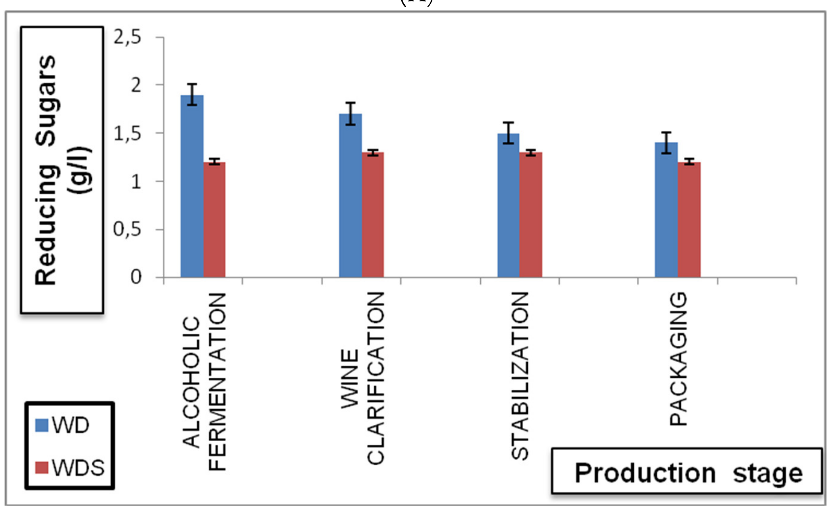
Experiments were replicated twice (n=2) on different occasions with different wine samples. Analyses were run in triplicate for each replicate. Results are reported as mean values ± standard deviation (S. D.). Data were subjected to analysis of variance (ANOVA). The least significant difference (LSD) procedure was used to test for differences between means ($P<0.005$). Chemical and organoleptic counts were subjected to analysis of variance (ANOVA) using the software Stat graphics (Statistical Graphics Corp., Rockville, MD, USA).

Results and Discussion

The measurement of reducing sugars (S) is one of the most important analyses, as it is the only measurement that can certainly give a clear proof of the degree of dryness of a wine. Dry wine must contain ≤4 g/l total sugars. Sensitivity to sugar-containing wines has also been shown to be bacterial, which is proportional to their sugar content. Also, wines with a high sugar content are susceptible to bacteria. Initially, the must of both WD and WDS wines had a total sugar content of 197 g/l. It was observed that sugar content of WD and WDS wines was significantly reduced, until the alcoholic fermentation stage (Figure 1). After the alcoholic fermentation stage, the concentration of the sugar content dropped to <2 g/l in both wines, and in the following stages of production, there was no significant difference ($p>0.05$). Finally (inside the bottle) the concentration of the total sugar content was equal to 1.4 g/l and 1.2 g/l, in WD and WDS wines, respectively. Similar results were previously reported in the study of Vaimakis and Rousis (1993; 1995) for the must and and for the white 'Debina' wine. In another recent study (Martinez-Garcia *et al*., 2021) a concentration of reducing sugars of <1 g/l for sparkling wines, was reported.



(A)



(B)

Figure 1. Reducing sugars (g/l) of white dry (WD) and white dry sparkling (WDS) Wines
(A) Reducing sugars (g/l) in the first and second production stages, (B) Reducing sugars (g/l) in third to last production stages.

The ethyl alcohol (ethanol, % vol) content is expressed by the alcoholic grade. Ethanol as a rule, comes from the alcoholic fermentation of grape sugars and characterizes a wine, so it is a basic analysis in a winery before bottling. The concentration of alcohol in both wines was practically stable ($P>0.05$) from the stage of alcoholic fermentation to packaging, and specifically its alcohol content values were 12 and 11.4 % vol for WD and WDS wines, respectively (Figure 2). Similar results were reported in the study of Vaimakis and Rousis (1993; 1995) for the white 'Debina' wine, whereas in another recent study (Martinez-Garcia *et al.*, 2021) ethanol content of 10.8% vol in a sparkling wine.

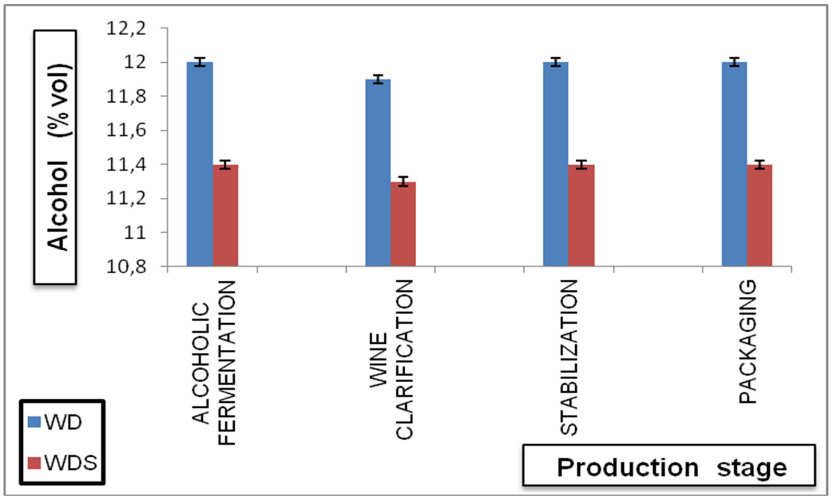


Figure 2. Alcohol (ethanol, % vol) of white dry (WD) and white dry sparkling (WDS) wines

Total acidity (TA) did not undergo any significant (p>0.05) changes during the production of WD wine (its initial value was 4.8 g/l, expressed as tartaric acid and final value was 5.5 g/l, Figure 3). The initial TA (total acidity) of the WDS wine was 4.65 g/l in the "cold extraction" processing of wine, and increased significantly (P<0.05) during processing, until it stabilized at a value of 6.0 g/l (Figure 3) during the "Wine clarification" stage and remaining virtually constant until the packaging stage of the product (Figure 3). In the study of Sandez *et al*. (2019) total acidity values in white wines ranging from 4.5 to 6.85 g/l were obtained. Also, Tufariello *et al*. (2021) recently reported that the total acidity in sparkling wines ranged from 5.11 g/l to 5.97 g/l, whereas Martinez-Garcia *et al*. (2021) reported a total acidity of 6.4 g/l for tartaric acid in a sparkling wine.

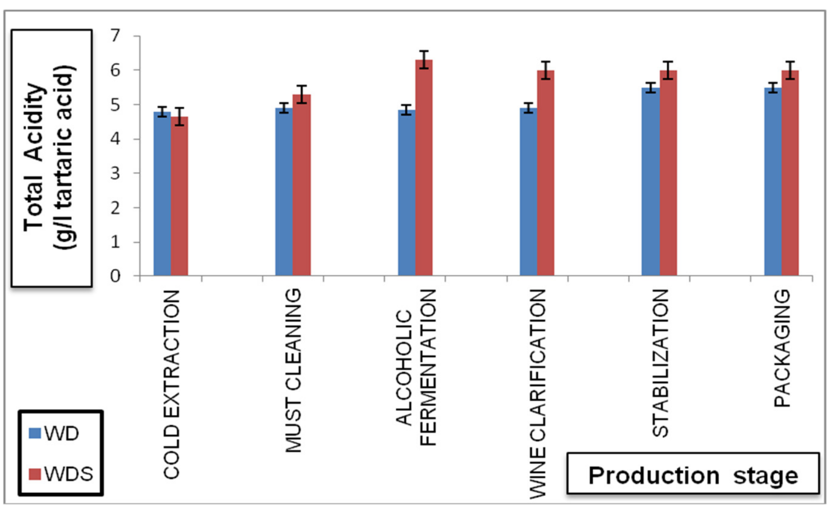


Figure 3. Total acidity (g/l tartaric acid) of white dry (WD) and white dry sparkling (WDS) wines

The acidity is a chemical parameter that decisively affects the character and the quality of the wine as a final product. Total acidity (TA) as a chemical parameter may be used to denote (express) the presence of potential acids in a wine. Most of the acids found in wine are odorless but can be detected in the mouth, while volatile acids are detected organoleptically by odor. Volatile acidity (VA) consists of the various acids, of which the predominant acid is acetate acid. Volatile acids contribute to the overall olfactory balance, participating in the olfactory complexity, which is the basis of wine quality, and the predominant acetate (volatile acidity) is usually expressed in g/l of acetic acid.

A similar profile is observed in the evaluation of volatile acidity (VA) between two wines (Figure 4). VA values in WD wines did not fluctuate significantly ($p<0.05$) and ranged between 0.19 g/l and 0.20 g/l acetic acid during all the stages of wine processing. In contrast, VA values in WDS samples decreased significantly ($P< 0.05$) giving average values of 0.28 g/l to 0.15 g/l of acetic acid in the packaged product (Figure 4). In the study of Vilela-Moura *et al.* (2010) there was reduction in acetic acid in an ("acidic") white wine. Mataix and Luque de Castro (1999) reported values of 0.22 – 0.23 g/l of acetic acid in white wines. Also, Raposo et al. (2016) reported a similar value (0.24 g/l) of acetic acid in white wine. Furthermore, Tufariello *et al.* (2021) measured a low level of volatile acidity (<0.3 g/l) in bottled sparkling wines, which is really important for sparkling wines quality, as it affects the development of yeasts in the secondary stage of alcoholic fermentation (Vigentini *et al.*, 2017). Likewise, a volatile acidity value of 0.23 g/l in a sparkling wine was recently reported by Martinez-Garcia *et al.* (2021).

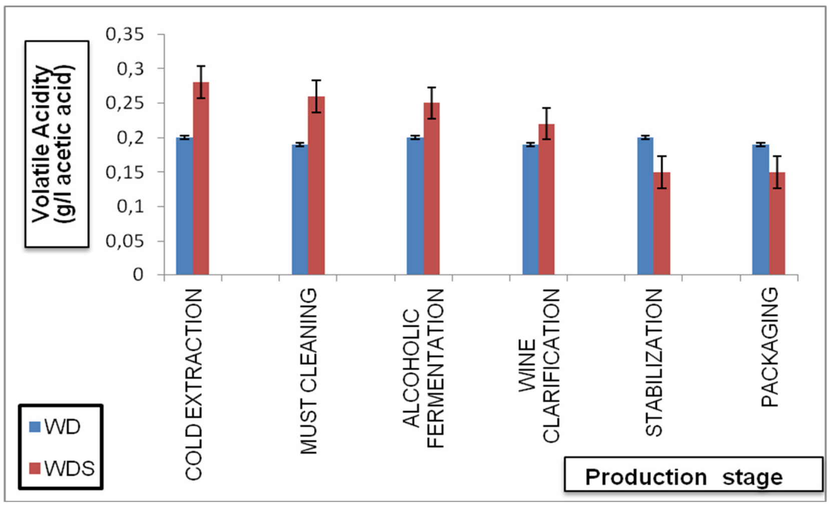


Figure 4. Volatile acidity (g/l acetic acid) of white dry (WD) and white dry sparkling (WDS) wines

The measurement of pH relates to the strength of acids present in wine. It is well known, that enzymes exhibit an optimal activity, in low pH values (2.8-3.8), and in conjunction with the microbial culture that is used for alcoholic fermentation, both play an important role in maintaining an optimum wine quality. Wines that do not have the right acidity, are in danger of clouding and of degradation (organoleptically) due to its infestation by microorganisms. The lower the pH of the wine, the less likely is for it to be affected by either spoilage or even pathogenic microorganisms. It must be noted that two wines, having the same volumetric acidity, may have different active acidity at the same time.

In terms of pH, values of both WD and WDS wines followed a similar pattern, decreasing from an initial the value of 3.36 to 3.15 and 3.21, respectively (Figure 5). Present results of pH for both WD and WDS wines are in agreement with those reported by Karabagias *et al.* (2020) in prickly pear wine. Tian *et al.* (2021) recently reported pH values in the range of 2.9-3.3 in greengage wine, whereas Martinez-Garcia *et al.* (2021) recently reported a pH value of 3.1 for a sparkling wine.

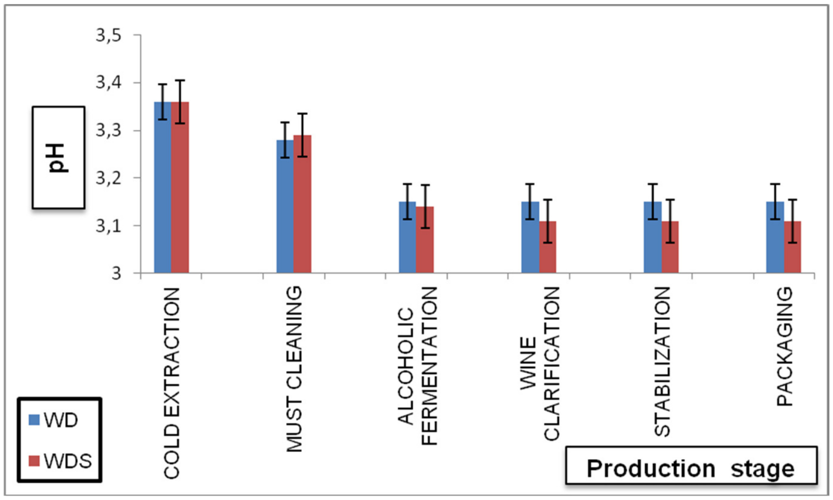


Figure 5. The pH of white dry (WD) and white dry sparkling (WDS) wines

Sulfur dioxide (SO_2) or in the form of its salt (sulfite) is one of the most widely used preservative in the wine and the dried fruits processing industries. The addition of SO_2 (sulfation of grape mass), aims to protect wine from certain undesirable biological and physicochemical phenomena. SO_2 has been used to inhibit polyphenol oxidase activity during winemaking, as well as to control the onset of undesirable secondary fermentations, such as acetic or malolactic (Raposo *et al*., 2016). SO_2 is also used, due to both its antioxidant and antimicrobial properties, in wine making as a key preservative agent, to control undesirable spoilage (due to lactic acid bacteria or other bacteria such as *Oenococcus* spp). In the present study added SO_2 was added at a concentration of 150 mg/kg in both wines. It is noteworthy, that the International Organization of Vine and Wine (OIV) has set a maximum SO_2 recommended (threshold) concentration, in the final white wine product to be 210 mg/L (OIV, 2021). The reason for such a threshold SO_2 upper limit value is due to the ability of SO_2, in certain individuals to trigger allergic reactions, and in some cases, accompanied by headaches, asthma and abdominal pain (Wyk *et al*., 2018).

The total sulfite content of both WD and WDS wines decreased over time (Figure 6), namely from initial values of 149.4 mg/l and 147.2 mg/l (in the first production stage) to 90.6 mg/l and 99.8 mg/l (in the last production stage), respectively. A similar reduction in total sulfite was reported by Vaimakis and Rousis (1993) in wine of 'Debina' grapes. Also, Martinez-Garcia *et al*. (2021) reported a total SO_2 content of 90 mg/l in a sparkling wine. Total sulfite in the WDS wine was significantly higher ($p<0.05$) than in the WD, due to the fact that WDS wine had undergone a secondary alcoholic fermentation in the closed wine tank, in the absence of oxygen.

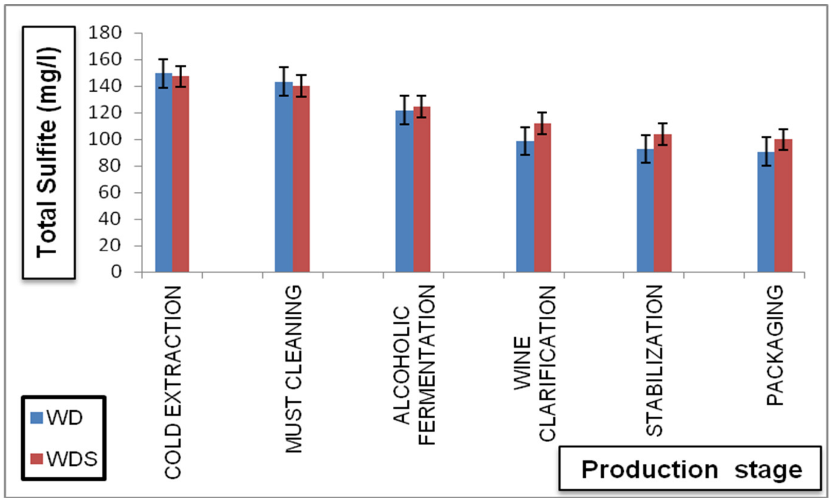


Figure 6. Total Sulfite (mg/l) of white dry (WD) and white dry sparkling (WDS) wines

SO_2 in wines has the property to react with carbonyl groups-containing compounds to form unstable or stable compounds. Thus, SO_2 could potential react with sugars, volatiles, proteins and anthocyanins to give unstable compounds, whereas with acetaldehyde forms stable compounds. Bound SO_2 is inactive as a preservative, while free sulfite is the active one, which still acts as an antimicrobial and antioxidant agent in wine (Ribereau- Gayon *et al*., 2006). Free sulfite content of WD and WDS wines had the same profile, with those of total sulfite. Free sulfite content of both wines decreased over time (Figure 7). Initial free sulfite content of WD and WDS wines were 44.4 mg/l and 43.7 mg/l (in the first production stage), decreasing to 20.2 mg/l and 23.3 mg/l (in the last production stage) for the wines WD and WDS, respectively. Izquierdo-Canas *et al*. (2021) reported value of 121 mg/l and 29 mg/l for total and free SO_2, respectively, in white wine from grape musts, treated with 100% CO_2 and 50 mg/l SO_2. Also, Almeida Santos *et al*. (2020) found values of 108 mg/l and 11 mg/l for total and free SO_2, respectively, in white wine, treated with 100 mg/l of SO_2.

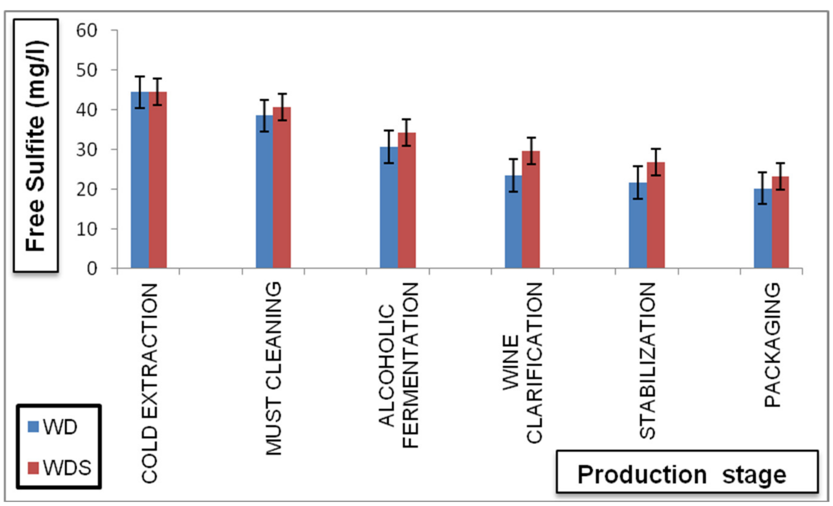


Figure 7. Free sulfite (mg/l) of white dry (WD) and white dry sparkling (WDS) wines

Color (chromatic) parameters (color hue and color intensity values) were evaluated in the final WD and WDS products, in which three measurements were made for each parameter and their average values are presented in Figure 8. For, WD wine absorption values A_{420} nm and A_{520} nm recorded were 0.040 Abs and 0.012 Abs, respectively, whereas for WDS wine samples, absorption values for A_{420} nm and A_{520} nm were 0.061 Abs and 0.064 Abs, respectively. Color hue (A_{420} nm / A_{520} nm) and color intensity (A_{420} nm / A_{520} nm) values were as 3.33 and 0.052 for WD wine samples, whereas for WDS the respective values for color hue and color intensity were 0.95 Abs and 0.125 Abs. In other studies, conducted on sparkling wines, absorption values for A_{420} nm and A_{520} nm were 0.080 Abs 0.046 Abs, respectively (Martinez-Garcia *et al*., 2021a), and these results are not significantly different ($p>0.05$) from those obtained in the present study. Raposo *et al*. (2016) reported values ranging from 0.44 to 0.72 for color intensity, and ranging from 3.80 to 6.29 for color hue in white wines. Date of our study present show that, the color hue is significantly higher ($p<0.05$) for WD wine, whereas interestingly, the color intensity is significantly lower ($p<0.05$) for the WDS wine. These findings suggest that WD wine resulted in having a darker color, and also being of lower clarity, as compared to the WDS. This may be due to the secondary alcoholic fermentation that WDS wine had undergone and also to the presence of CO_2, being present in it.

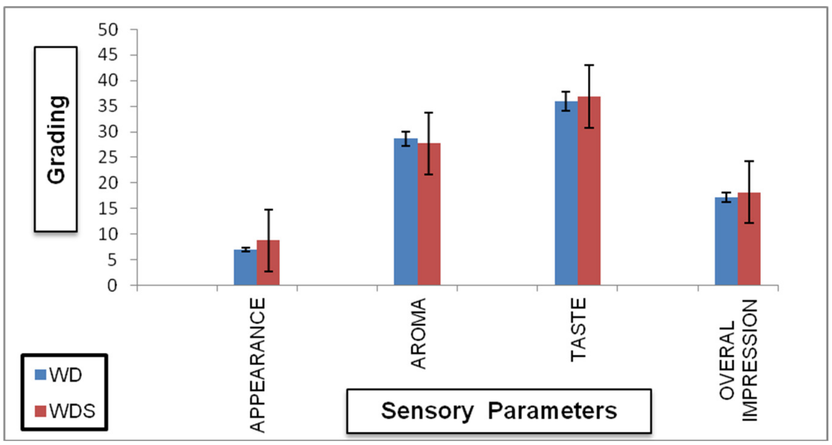


Figure 8. Sensory analysis of white dry (WD) and white dry sparkling (WDS) wines

The score in all parameters of the sensory analysis (about appearance, aroma, taste and overall impression of wines) for both wines are shown in Figure 8. Namely, the average score of the appearance, odour/aroma, taste and overall impression was 6.92 (max 10 points), 28.63 (max 30 points), 35.94 (max 40 points) and 17.21 (max 20 points) for WD wine, respectively. While, the average score of the appearance, odour/aroma, taste and overall impression was 8.79 (max 10 points), 27.74 (max 30 points), 36.88 (max 40 points) and 18.16 (max 20 points) for WDS wine. In addition, to the appearance attribute, WDS wine was also assessed for foam creation and its stability, an assessment that was not conducted for the WD wine.

The score in all parameters of the sensory analysis was, on average, about 1 point higher in WDS wine than the score in WD wine. This may be due to the CO_2 that exists in the WDS wine, which obviously created a more pleasant satisfaction to the panellists (wine experts). After all, the extra score of the foam creation and its stability affected (in addition to the overall score of the appearance) and that of the overall impression in WDS wine. Furthermore, the measurement of color (color hue and color intensity values, which have been mentioned above) showed objectively that the WD wine has a darker color and was of less purity and clarity than the WDS, this fact certainly playing a decisive role by the specialists/testers in evaluating each wine's appearance.

Moreover, in a previous study it has been found that ethyl alcohol concentration and pH play a direct role in determining most aspects of mouthfeel perception, and provide an overall framework on which the other minor wine components can interact to influence white wine mouthfeel (Gawel *et al*., 2018). In the present study the concentration of ethyl alcohol was 12.0 and 11.4% vol in packaged wines WD and WDS, respectively. While, the pH was equal to 3.15 and 3.21 in the packaged WD and WDS wines, respectively. Perhaps these differences influenced the overall impression of the wine tasters about each wine.

Nonetheless, according to the results of our study, both WD and WDS wines had a high acceptance by the tasters during the sensory analysis (Figure 8). Expert tasters noted that WD wine has a golden yellow color with green reflections, also characterized by delicate fruity aromas of apple, pear, citrus and peach. Wine tasters also admitted that the WDS wine is characterized by rich natural foaming, mild acidity and fruity aftertaste (aromas of citrus, apple and pear) having a bright golden yellow color. Martinez-Garcia *et al*. (2021b) in a sparkling wine identified 67 metabolites, all of which are considered volatile compounds in wine. Demyttenaere *et al*. (2003) analyzed a white wine, that was made from 'Debina' grapes (Zitsa area, Greece) and they reported that inalool, citronellol and a- terpineol contributes to a flowery aromatic profile accompanied with pleasant, sweet, and citrus odors.

Conclusions

In this study, two 'Debina' (grape variety) white wines, one of them being a sparkling one, were assessed in terms of their oenological quality parameters (chemical, physicochemical and organoleptic). As judged by the present data, both wines (WD and WDS) were acceptable having chemical values, withing the limit values for quality wines, and retained optimal sensorial characteristics, that were well received by the wine experts/panellists.

Authors' Contributions

A: Maria Tsiraki; B: Ioannis Savvaidis.

Data curation: A; Formal analysis: A; Investigation: A; Methodology: A; Project administration: B; Supervision: B; Validation: B; Visualization: B; Conceptualization: AB; Writing - original draft: A; Writing - review and editing: B.

Both authors read and approved the final manuscript.

Ethical approval (for researches involving animals or humans)

Not applicable.

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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