Multi-method sensory approach to describe the effect of microwave-assisted extraction and addition of stems on the mouthfeel sensations of Bonarda wines from Mendoza (Argentina)

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Abstract

The Bonarda variety has been used as a base for common red wines due to its contribution to color and low level of astringency as a consequence of its relative low tannin concentration. The use of Microwave-Assisted Extraction (MWE) accelerates the maceration process, improving the diffusion of grape compounds into the must, while the stems addition during maceration/fermentation constitutes a sustainable technological alternative for increasing tannins at no additional cost. The present experimental design consisted of ten treatments (in triplicate), obtained combining both technologies. Two maceration strategies were applied: Control must (C) which was not treated, and must treated with microwaved-assisted extraction after grape crushing. These were combined with five Stem-contact conditions (ST): C without ST, 50% ST addition, addition of 50% ST previously treated with MWE, 100% ST addition, and addition of 100% ST previously treated with MWE. The effect of the winemaking technologies on wine mouthfeel sensations was evaluated by different (static and dynamic) sensory methods: Sorting Task; Check-All-That-Applies (CATA) with different textiles as trans-modal references; and Temporal Dominance of Sensations (TDS). CATA evaluation revealed that three of the wine samples differed in their description. These were then dynamically described showing subtle differences in their TDS curves. The sequentiality of dominant sensations showed that the MWE treatment of the grapes and the combination ST with MWE did not modify dramatically mouthfeel sensations in Bonarda wines.

Introduction

Red wine is a complex matrix rich in phenolic compounds, extracted from the skins and seeds of grapes during the maceration process.[1] These compounds are active in biochemical processes and have nutraceutical effects on human health and contribute highly to the sensory characteristics of the wine.[2] The grape variety and the winemaking process are key factors in determining the phenolic profile which, in turn, largely influences wine quality indicators such as color, flavor and mouthfeel.[3]

Mouthfeel encompasses multiple sensations including taste, viscosity, warmth, trigeminal perception, and astringency.[4] Astringency is a tactile sensation and it has been generally described as a combination of drying (lack of lubrication or moistness resulting in friction between oral surfaces), puckering (drawing or tightening sensation felt in the mouth, lips, and/or cheeks), and roughing (un-smooth texture in the oral cavity marked by inequalities, ridges, and/or projections felt when oral surfaces come in contact with one another).[5] In wine, these sensations are affected and modified mainly by the ethanol content,[4] tannins and phenolic compounds,[3] and their interaction with the oral components such as salivary proteins.[6]

Tannins are extracted from the solid parts of the bunch (skins, seeds, and stems) during winemaking, depending on enological variables like maceration techniques and ethanol content, among others.[7,8] Several thermal and non-thermal strategies have been developed to improve extraction before fermentation.[9] Microwave-assisted Extraction (MWE) is a technological alternative which accelerates and improves the removal of phenolic and volatile compounds from grape skins, with the advantages of being eco-friendly and low-cost.[10,11] The addition of Stems (ST) during winemaking is another sustainable alternative to increase tannins in wine without additional cost.[12,13]

In Argentina, Bonarda (*Vitis vinifera* L.) is the second most important red grapevine cultivar after Malbec. There are 18,153 ha cultivated with this variety, representing 8.5% of the total vineyards in the country.[14]

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Bonarda is increasingly used for high-quality wines due to its deep red color. However, it has a lower quantity of tannins in comparison to Malbec, Cabernet Sauvignon and Merlot.[15] This low tannin concentration can result in low astringency and weak mouthfeel sensations, which are sometimes rejected by consumers. Tannins could be increased by different maceration processes but, so far, there are no scientific reports on the sensory effect generated using ST and MWE during winemaking of Bonarda cv. grapes.

Mouthfeel sensations are usually described by traditional sensory analysis techniques such as Descriptive Analysis (DA).[16] However, temporal sensory evaluation methods could enable the characterization of perception throughout the whole consuming experience and establish differences based on the sequence of the perceived sensations.[17] Temporal Dominance of Sensation (TDS) is a multi-attribute descriptive method which consists in presenting a predetermined list of attributes to the panelists who will indicate the one which is perceived as dominant (*i.e.*, most striking perception at a given time) at each instant of the evaluation.[18] This method has been used in several previous works to describe wine and particularly on the temporal perception of mouthfeel in wine.[19,20] Recently, Rinaldi and Moio (2018)[21] proposed the use of transmodal references using different touch patterns in order to improve the train panelists on the different subqualities of mouthfeel. This type of transmodal training can also be applied to temporal descriptive methods.

The aim of the present work was to evaluate the combined effect of MWE technology with ST addition in different conditions, before fermentation, on the final sensory perception and mouthfeel sensations of Bonarda wines, evaluated by successive sensory methods.

Materials and Methods

Wine samples obtained with application of Stems (ST) and Microwave-assisted Extraction (MWE) during winemaking

Bonarda grapes were obtained from a commercial vineyard located in Lavalle (32°40’36”S, 68°21’31”W) Mendoza, Argentina, during 2019 vintage. Grapes were hand-picked when they reached optimum phenolic maturity and these technological parameters: 23.8°Brix, 4.3 g/L of titratable acidity, pH 3.89. A sample of 25 bunches was randomly taken to determine general technological parameters in hand-picked grapes, as well as to calculate the proportion of stems to be used in the corresponding treatments. It is important to note that the stems showed no signs of lignification, being green and turgid at the time of harvest. The winemaking process was carried out at Mendoza Agricultural Experimental Station (EEA Mendoza INTA), in Mendoza, Argentina, following a standard protocol.

The experimental design consisted of ten treatments (two factors) applied, before fermentation. Each was done in triplicate. Two maceration strategies were applied: control must (C), which was not treated, and must treated with microwaved-assisted extraction after grape crushing (MWE; 2450 MHz, 7600 W, 15 min, 45-50 °C). These were combined with five stem-contact conditions (ST): C without ST, 50% ST addition, addition of 50% ST previously treated with MWE (2450 MHz, 7600 W, 20 min, 60 °C), 100% ST addition, addition of 100% ST previously treated with MWE. The ten evaluated treatments are shown in Figure 1.

Consequently, 30 vinifications were conducted in 25-L food-grade plastic tanks by inoculation of the commercial yeast EC1118 (0.3 g/L; Lallemand, Montreal, QC, Canada), at 25±2°C, with a maceration length of 13 days. Tartaric acid additions were performed to adjust the acidity of all the musts at 7.0 g/L. For cap management, two daily punch-downs (morning and afternoon, 1 min each) were applied. All tanks were controlled daily through the measurement of temperature and the weight loss of the fermenting systems. Once fermentation-maceration was completed, free-run wines were collected in 10 L glass carboys fitted with airlocks and stored at 22±2°C. Malolactic fermentation was induced with a commercial Oenococcus oeni culture VP-41 (0.01 g/L; Lallemand, Montreal, Canada). After that, the finished wines were adjusted to 35 mg/L of free SO_2 and stored at 1–3°C for 15 days to allow tartaric stabilization. Finally, the wines were racked off the lees, free SO_2 adjusted again to 35 mg/L, bottled with screw caps (750 mL), and stored under controlled conditions until physicochemical and sensory analysis.

Chemical analytical parameters of Bonarda wines

Standard parameters including titratable acidity (tartaric acid, g/L), volatile acidity (acetic acid, g/L), pH and alcohol content *(% v/v*) were determined as described by International Organization of Vine and Wine.[22] For all wines the residual sugars were <1.8g/L. Absorbance measurements for phenolic parameters were made with a Perkin-Elmer UV–Visible Spectrophotometer Model Lambda 25 (PerkinElmer, Hartford, CT, USA). Tannins [(+)-catechin equivalent, mg/L] were analyzed by Protein Precipitation Assay according with Harbertson, Kennedy, & Adams (2002).[23] Iron-reactive phenolics (total phenols) were analyzed following the method described by Heredia *et al.* (2006).[24]

Sensory analysis

All sensory tasting was conducted in Buenos Aires at the Sensory Laboratory of the Facultad de Ingeniería y Ciencias Agrarias, Universidad Católica Argentina. Over the different evaluations, the sensory panel (described in section Sensory panel) tasted 10 mL of wine served in transparent tulip glasses, coded with random three-digit numbers at room temperature in individual booths illuminated with red light. Between samples, panelists rinsed their mouth with water or with carboxymethylcellulose solution (0.55 % w/v), depending on the tasting technique, to avoid residual effect of astringency.[25]

The different sensory evaluation methods which were used in each session are described in detail in sections Sorting Task through Temporal Dominance of Sensations.

All sensory data acquisition was done using TimeSens software (INRA, Dijon, France).

Sensory panel

The sensory panel was composed of 20 voluntary panelists (ten female; 25–60 years old), students of *Sommelier* at the Argentine Wine School (Escuela Argentina de Vinos, EAV). They were selected based on their experience on wine evaluation and their willingness to take part of the experiment. They participated in six evaluation sessions, one hour long each. They were trained on the tasting method before every session.

Sorting Task

The sorting task procedure was performed in duplicate over sessions 1 and 2. The aim was to find global differences among the ten wine treatments. The samples were randomly presented across the panel in each session. Panelists were asked to focus their attention on the mouthfeel sensations, but they could base their judgement on all the different sensory modalities. The task consisted of grouping together the samples that were perceived alike. Panelists were free to make as many groups as they wanted with as many samples as they wanted in each group.[26]

Mineral water was available for panelists to rinse between samples. All wines were expectorated.

Check All That Applies (CATA)

Based on the results obtained after the sorting task, five wine samples (S1, S2, S4, S8 and S10; more details in the results section) were described by CATA[27] over sessions 3 and 4, performing the task in duplicate. A list of 23 terms related to flavor and mouthfeel sensations was presented. Panelists were explained the different attributes and were requested to mark all the ones that they considered suitable to describe the wines. Given that the main aim of the experiment was to find the impact of the technological treatments on mouthfeel, the CATA method was coupled with the use of touch standards as described by Rinaldi & Moio (2018).[21] Panelists were given touch standards as transmodal references to help them in the description. The mouthfeel attributes (and references) were: silk (silk), adhesive (double-sided tape), soft (fur), corduroy (corduroy), aggressive (sandpaper 1000 grade), satin (satin), puckering (burlap), mouth coat (suede) and astringent. The terms used for the other modalities were: sweet, fresh, woody, alcoholic, spicy, unctuous, fruity, bitter, sour, vegetal, dryness, greasy, film, viscous and cooked fruit.

Temporal Dominance of Sensations (TDS)

Considering the CATA results, three wines samples (S1, control must not treated with MWE; S4, 100%ST; S10,100%ST with MWE; more details in the results section) were evaluated by TDS.[18] The evaluation was done in duplicate over the two sessions.

At the beginning of the session, panelists were introduced to the idea of temporality of sensations and trained on the concept of dominance, defined as: "the attribute that draws your attention at each moment of the tasting, not necessarily the most intense". The list of attributes was based on the results obtained in the CATA session: viscous, sour, spicy, aggressive, astringent, bitter, dryness and corduroy. Panelists were instructed to put all the sample (10 mL) in the mouth and evaluate it with no time limit. Wines were swallowed during the TDS sessions.

Data analysis

All physicochemical analysis were carried out in triplicate. Statistical analysis was assessed with Infostat software. The results of the chemical parameters were tested for homogeneity of variance using Levene's test. A two-way analysis of variance (ANOVA) was applied considering the factors "maceration strategies (F1, factor one)" and "stem-contact conditions (F2, factor two)". Tukey's Honestly Significant Difference (HSD) test (p<0.05) was used as a post hoc comparison of means.

Data from the Sorting task was assessed by Multi-Dimensional Scaling (MDS) and a Hierarchical Cluster Analysis (HCA) using the Ward criteria.

CATA data was evaluated by Cochran test, differences of p<0.05 were significant. Correspondence Analysis (CA) was performed on the contingency table containing the average frequency citation of terms.

Sequentially of dominant attributes in TDS data were represented on TDS curves.

All representations and analysis of the sensory data was done using the TimeSens software (INRA, Dijon, France).

Results and Discussion

Chemical analytical parameters of Bonarda wines

Table 1 presents ANOVA results of the

Table 1. ANOVA results of the chemical parameters evaluated in Bonarda wines resulting from different treatments.

Treatments	Ethanol* (% v/v)	pH*	Titratable acidity* (g/L)	Volatile acidity* (g/L)	Total phenols* (mg/L)	Total tannins* (mg/L)
S1	13.70±0.10	3.90±0.06 bc	4.60±0.10	0.63±0.03	1022.72±120.45	184.95±34.08
S2	12.97±0.68	3.83±0.04 abc	4.50±0.10	0.61±0.06	1192.85±124.15	271.41±68.62
S3	13.47±0.49	3.85±0.08 bc	4.60±0.20	0.59±0.11	990.15±91.65	226.04±43.89
S4	13.53±0.25	3.97±0.04 c	4.47±0.15	0.62±0.18	1387.57±30.76	357.76±23.40
S5	13.43±0.12	3.91±0.09 bc	4.50±0.10	0.67±0.13	1332.59±172.43	338.22±47.34
S6	13.77±0.40	3.65±0.04 a	4.93±0.32	0.53±0.13	1117.67±149.76	275.04±67.72
S7	13.80±0.10	3.85±0.07 bc	4.43±0.06	0.58±0.04	1361.07±78.47	307.13±16.79
S8	13.87±0.12	3.78±0.06 ab	4.50±0.10	0.52±0.03	1329.67±112.21	348.90±20.60
S9	13.70±0.10	3.84±0.07 bc	4.47±0.06	0.58±0.08	1524.75±3.75	359.38±24.16
S10	13.80±0.10	3.89±0.09 bc	4.47±0.15	0.61±0.09	1427.03±167.78	358.80±30.54
C	13.42±0.42 α	**3.89±0.07**	4.53±0.13	0.62±0.10	**1185.18±192.64**	**275.68±78.04**
MWE	13.79±0.18 β	**3.80±0.10**	4.56±0.24	0.56±0.08	**1352.04±171.46**	**329.85±46.60**
ST	13.73±0.27	3.77±0.14 A	4.77±0.28 B	0.58±0.10	1070.20±132.21 A	230.00±68.80 A
ST50	13.38±0.63	3.84±0.05 AB	4.47±0.08 A	0.59±0.05	1276.96±130.84 BC	289.27±48.78 AB
ST100	13.62±0.19	3.90±0.08 B	4.47±0.10 A	0.60±0.12	1456.16±77.65 C	358.57±21.29 C
ST50MWE	13.67±0.39	3.81±0.07 AB	4.55±0.15 AB	0.56±0.08	1159.91±207.31 AB	287.47±73.95 AB
ST100MWE	13.62±0.22	3.90±0.08 B	4.48±0.12 A	0.64±0.11	1379.81±160.71 C	348.51±37.37 C
Two-way ANOVA (p-values)						
Maceration strategies (F1)	**0.0048**	**0.0009**	0.6401	**0.0970**	**0.0009**	**0.0020**
Stem-contact conditions (F2)	0.4090	**0.0086**	**0.0134**	0.7016	**0.0001**	**0.0002**
Interaction (F1 x F2)	0.3008	**0.0196**	0.1412	0.9653	0.3774	0.1049

*Mean ± SD (n=3). Different Roman lowercase letters in the same column indicate significant differences among treatments (Tukey HSD test, p<0.05). Different Roman uppercase letters indicate statistical differences (p<0.05) between wines with stems additions. Different Greek letters indicate statistical differences (p<0.05) between wines from maceration strategies. Significant p-values are shown in bold. Maceration strategies: C, control (traditional maceration, S1 to S5); MWE, microwaved-assisted extraction after grape crushing (S6 to S10). Stem-contact conditions: ST, control without stems (S1 and S6); ST50, 50% stems addition (S2 and S7); ST100, 100% stems addition (S4 and S9); ST50MWE, 50% stems addition + MWE of the stems (S3 and S8); ST100MWE, 100% stems addition + MWE (S5 and S10).

chemical parameters evaluated in Bonarda wines resulting from the 10 treatments. According to two-way ANOVA (more details in Table 1, section two-way *p*-values) the ethanol content of wines was only modified by the application of microwaves to the grapes (F1 Maceration strategies, *p*=0.0048). The average of ethanol value for all wines elaborated with must without MWE was lower (13.42 ± 0.42 % *v/v*) than wines elaborated with must treated with MWE (13.79 ± 0.18 % *v/v*). These findings may indicate, as reported by other authors, a higher nitrogen content (yeast assimilable nitrogen) in microwave-treated musts, which would favor yeast metabolism and alcohol yield.[28] They could also be due to an inhibitory effect of microwaves on native yeasts and bacteria, allowing a more efficient and controlled fermentation process by the inoculated strains.[29]

For wine pH the two-way ANOVA *p*-values showed a significant F1 x F2 interaction (*p*=0.0196, more details in Table 1, section two-way *p*-values). The S6 treatment (must treated with MWE and without ST addition) showed the lowest levels of this parameter, while the application of a higher proportion of fresh stems (S4, must not treated with MWE and 100% ST) in control musts showed the highest value. This behavior was also observed by other authors on Cabernet Sauvignon musts[15] and during Pinot noir winemaking using various materials (fresh, dried, or in the whole bunch).[30-32] Since potassium represents the main mineral element in the stems,[33] the pH increase can be ascribed to the extraction of potassium from the stems and, consequently, a decrease in titratable acidity by combining with tartaric acid and enhancing the precipitation of tartrates.

Regarding phenolic composition, two-way ANOVA indicated that both factors [microwave-assisted extraction (F1) and stems addition (F2)] had a statistically significant impact ($p<0.05$) on the levels of total phenols and total tannins in wines (Table 1), with no interaction between them. Wines elaborated with must treated by MWE (S6 through S10) had higher total phenols (14.1%) and tannins (19.6%) concentrations than wines made with must without MWE (S1 through S5). These results confirm efficient phenolic extraction with this technology, as indicated by previous reports on Pinot noir,[30-32,34] Merlot,[10] and Dornfelder,[35] grapevine varieties. Likewise, the addition of a higher proportion of fresh stems (ST100, S4 and S9 treatments) showed 36% and 56% more phenols and tannins than wines without ST (S1 and S6), respectively. These results are in agreement with other experiments on different red grapevine varieties reviewed by Blackford *et al.*, (2021).[33] However, even though chemical concentrations of phenolic compounds are significantly different according to the two-way ANOVA analysis, they might not be enough to exhibit differential sensory characteristics among wines.[36]

Sorting task

The first step in the study was to evaluate differences among the 10 treatments (Figure 1). The sorting task methodology was selected to reduce the number of sessions and the sensory fatigue.[37] Data was analyzed according to Multidimensional Scaling (MDS) and Hierarchical Cluster Analysis (HCA). HCA makes it possible to check the spatial arrangement of MDS data and identify the wines that belong to a same cluster.

Results for the HCA are presented in Figure 2. It can be observed that samples were divided into four different clusters. This showed that the winemaking methods had a minimal and subtle impact on mouthfeel sensation. Goldner & Zamora (2010)[36] investigated the effect of two levels of polyphenol concentrations on astringency perception in non-commercial red wines and reported that a great increase in polyphenol concentration was necessary to perceive a difference in astringency sensation.

Given the similarities, the number of samples to be further investigated was reduced choosing one treatment from each cluster: i) S2. Must with 50 % (*w/w*) ST; ii) S4. Must with 100 % (*w/w*) ST; iii) S8. Must treated with MWE + 50 % (*w/w*) ST previously treated with MWE; iv) S10. Must treated with MWE + 100 % (*w/w*) ST previously treated with MWE

Moreover, sample S1 was also kept for the following sensory analysis given that it

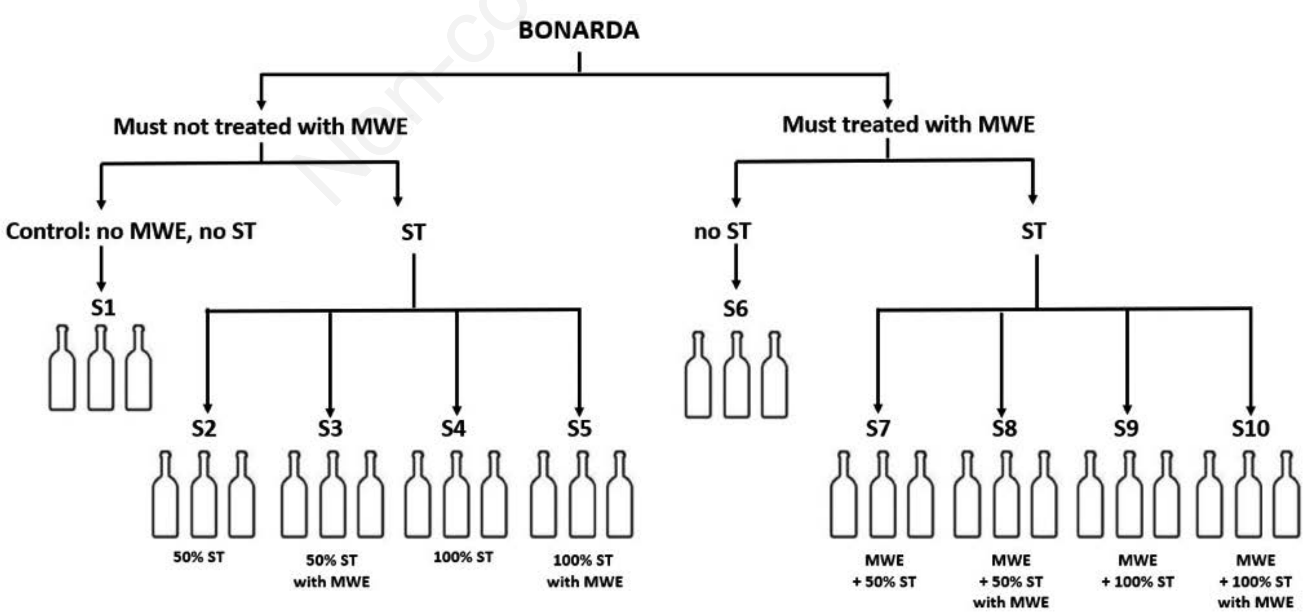

Figure 1. Experimental design with different combinations of microwave-assisted extraction (MWE) and stems (ST) during Bonarda winemaking.

was the Control treatment (no MWE, no ST). For the purpose of clarity the chosen samples are marked with an (*) in Figure 2.

Check All That Applies (CATA)

Figure 3 presents the results of the Correspondence Analysis (CA) done on the CATA data: the first two dimensions accounted for 71% of the variance within treatments; samples were grouped in three clusters.

Samples chosen for CATA description were found to be different in the Sorting Task. However, it can be observed in Figure 3 that samples S2, S4 and S8 were grouped together. The aim of performing this test on the samples, was to obtain the descriptors best suited to characterize them and their differences. However, one of the limitations of CATA method is the loss of quantitative information.[38] Evidently, samples presented small differences that could not be exposed by the presented terms. Moreover, even though the used attribute list was made by the panelists (highly trained in wine evaluation and *sommelier* students) based on the previous sessions with the samples, characteristics responsible for the differences could have been missing. This complies with the literature, where loss of quantitative information has been mentioned as one of the main limitations of CATA compared to Descriptive Analysis, especially when highly similar products are profiled.[38]

Nonetheless, it can be observed that samples S1 and S10 remained the most different. S1 was mainly described as spicy, soft, and corduroy. S10 was described as puckering, sweet, fresh, and woody. The terms silky, adhesive, and viscous were used more frequently for S2 treatment, while S8 and S4 had the most terms in common (mainly vegetal and astringent).

As mentioned before, the CATA analysis was coupled with the use of touch standards to better train on mouthfeel sensations and, hopefully, increase the sensibility related to tactile sensations.[21] However, descriptors related to aroma and flavor (e.g., fruity, vegetal, woody and others) were also presented and considered during the evaluations (Figure 3).

So far, results indicate that the differences observed on the chemical parameters of the different treatments of Bonarda wines, did not highly influence the mouthfeel sensations evaluated by the panelists in the static sensory analysis.

Given that no significant differences were found among these three samples (S2, S4 and S8) with a static descriptive method such as CATA, describing them by TDS (following step) would have been confusing for the evaluators (resulting in noisy data).

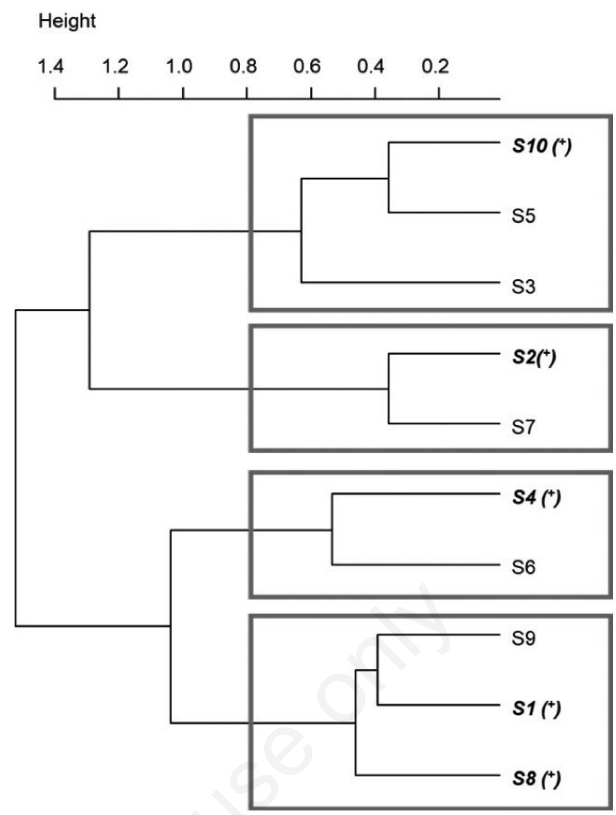

Figure 2. Cluster dendrogram. Samples marked as (+) were chosen for the following steps of the evaluation.

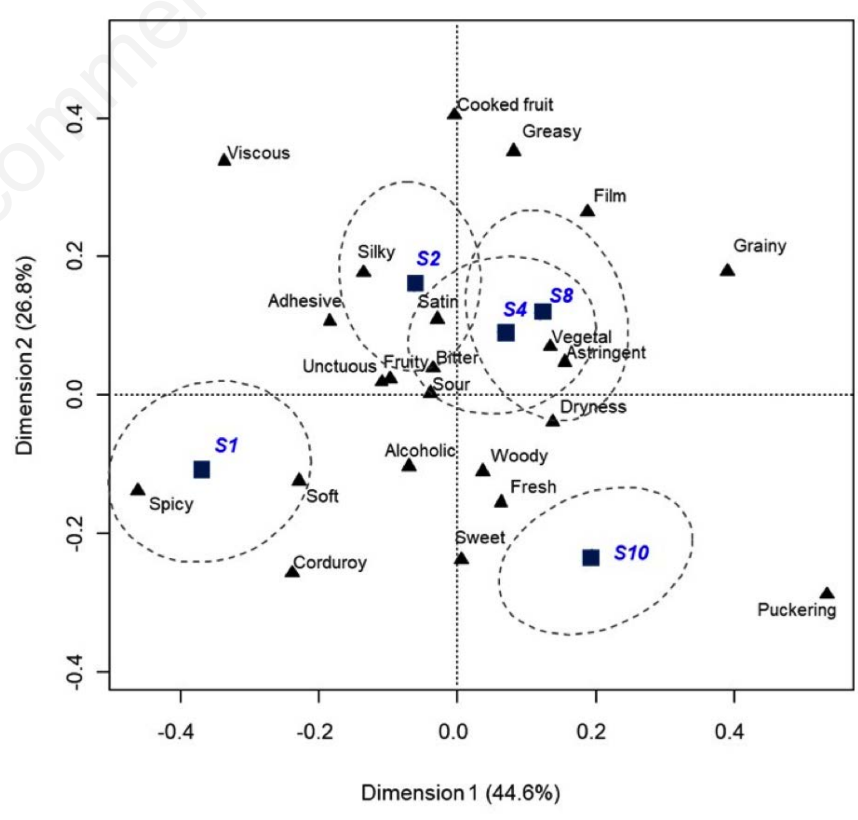

Figure 3. Correspondence Analysis (CA) on CATA data for the 5 selected wine samples.

Therefore, from this cluster, only S4 was selected for the dynamic evaluation. This choice was based on the fact that, of the three of them, it was the one with the highest addition of ST and without MWE, contrasting it with the remaining two other samples (S1 and S10).

Temporal Dominance of Sensations (TDS)

Figure 4 shows the TDS curves for the three evaluated samples selected according to the results obtained in Sorting Task and CATA analysis. As Figure 4a shows, in S1 the first dominant attribute was sour together with spicy, followed by bitter and dryness at the end of the evaluation. Also, in S4 (Figure 4b), sour was dominant for the first half of the evaluation, followed by spicy ending in a peak of high agreement on dryness and then bitter. Even though agreement on dryness as dominant was higher in S4, the sensation was dominant for a longer period in S1. Finally, in S10 (Figure 4c) the dominant attributes were spicy and sour in the beginning, then sour continued to be dominant for more than half of the tasting while the evaluation ended with a small rate of dryness and bitter as dominant. A common characteristic was that the three samples (S1, S4 and S10) showed bitter taste as a dominant descriptor at the end of the evaluation. But the dominance rate was different among them, being bitter more dominant in S1. There was a decrease in bitter and dryness as dominant at the end of the evaluation in the S4 and S10 and, interestingly, both treatments promoted higher concentration of phenolic compounds than S1. However, different maceration strategies were used for each treatment, and it could be the reason why bitter and dryness sensation decreased as dominant at the end of evaluation in the S4 and S10 treatment. Soares *et al.* (2013)[39] published that bitterness is a common sensory attribute related to phenolic compounds, and they could be responsible of it in food products even if they are present in very low concentrations. Furthermore, it is important to bear in mind that TDS does not measure intensities. Previous studies reported by Frost *et al.* (2017)[19] evaluated the effect of tannins, acid, and ethanol concentration on the temporal perception of taste and mouthfeel in Merlot wines and reported that between two tannin concentrations, sourness was significantly higher at the higher tannin concentration. Since TDS is based on the concept of dominance and not intensity, according with the panelist's evaluation we can say that the winemaking method slightly changed the sequentiality of attributes that called the panelists attention.

Medel-Maraboli *et al.* (2017)[40] studied the effect of different concentrations of Commercial Enological Tannin (COT) on the timing of the perception of astringency in red wines using TDS. They reported that an increase in the tannin concentration in a model wine solution generated an increase in the dominance and duration of astringency. In addition, the type of astringency is closely related to the tannin concentration, since according to the responses in the dominance curves, the dominant descriptors changed as a function of the tannin concentration. At the lowest concentration, the dominant descriptors were soft, mouth filling and adhesive, while at the highest concentration, the dominant descriptors were aggressive and drying. In the present work, dryness was more present in S1 even though it was the sample with the lower tannin content. This would mean that this mouthfeel sensation depends on multiples variables and is probably not only a direct function of tannin content.

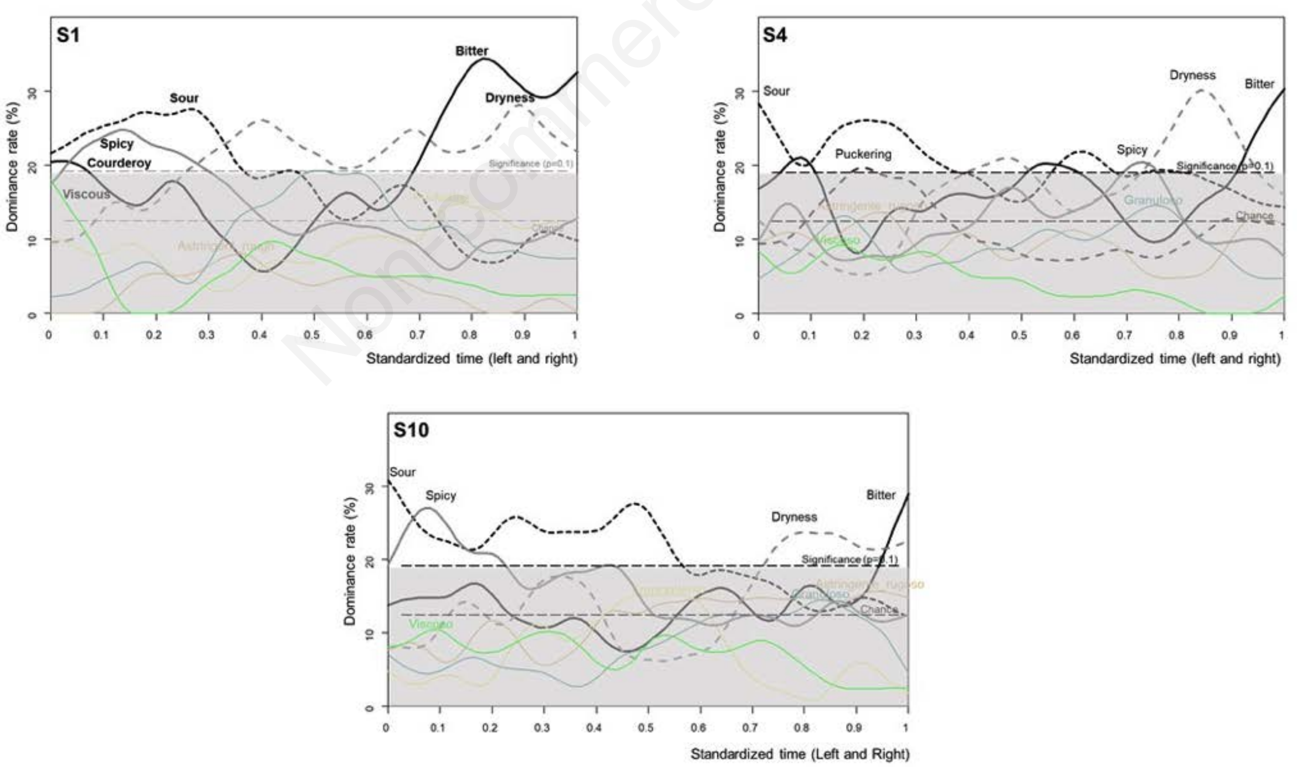

Figure 4. TDS curves for three wine samples: S1, Control treatment (no MWE, no ST); S4 must with 100 % ST; S10 must treated with MWE and added with 100 % ST previously treated with MWE. The x-axis indicates the moment of the tasting (beginning, middle and end). The y-axis indicates the dominance rate.

Conclusions

The addition of stems and the application of MWE technology to stems and must prior to fermentation of Bonarda wines did not greatly affect the perceived mouthfeel sensations. The dynamic sensory method showed slight differences in the sequentiality of dominant sensations among extreme treatments. The evaluation of mouthfeel sensations with touch standards coupled with descriptive sensory methods can provide an interesting way to reveal small differences of the mouthfeel sensations.

In summary, even though the physicochemical characteristics were modified, mouthfeel sensations of Bonarda wines did not change dramatically when ST and MWE technologies were used during winemaking as maceration strategies. This is an interesting finding because the studied technologies, under the experimental conditions described, did not affect the sensory profile of wine. Further studies are needed to determinate the best condition of combination of Microwave-Assisted Extraction (MWE) technology with Stems (ST) during vinification with greatest sensory impact in mouthfeel sensations.

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