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Foam Aptitude of Trepat and Monastrell Red Varieties in Cava Elaboration. 2. Second Fermentation and Aging

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The foam properties of sparkling wines (Cava) made from two red autochthonous grape varieties, Trepat and Monastrell, and coupages, including different percentages of them, were studied during second fermentation and aging. The effect of second fermentation on foam gave the highest decreases when the base wines had the highest foam values, while gave the lowest decreases or even increases for the base wines with the lowest foam characteristics. However, the greater the HM and Σ of the base wine, the greater the foam values of the sparkling wine. Base wine determinations for quality control in cellars could provide information about future sparkling wine foaming. Acidity parameters, ethanol, sulfur, and polysaccharides contents were correlated to foam characteristics in the sparkling wines. In terms of color and foaming, wines made from the red varieties Trepat and Monastrell blended with white variety wines could be appropriate for elaborating "blanc de noirs" sparkling wines.

KEYWORDS: Trepat; Monastrell; foam; sparkling wine; Cava; red varieties; color intensity

INTRODUCTION

Cava, which literally means "cellar", is a quality sparkling wine produced in a specific region (qswpsr), Penedès, using the traditional "méthode champenoise" (*1*). It is aged for a minimum period of nine months in contact with yeast inside a bottle (*2*). The three main grape varieties for Cava production are Macabeo, Xarel.lo, and Parellada. The red varieties Garnacha, Monastrell, Trepat, and, recently, Pinot Noir are used to produce rosé Cava (*2*). The two Penedès autochthonous red varieties, Trepat and Monastrell, are of great interest in terms of maintaining the identity and idiosyncrasy of Cava.

Foam formation and stability are the most important quality parameters of sparkling wines (*3*−*11*). Knowledge about foam capacity and its evolution with the aging of sparkling wines is of interest to winemakers as it provides useful information for improving the final product. This is why wines destined to produce the highest quality sparkling wines should be chosen for their ability, among other properties, to produce foam. The first decisive factors in foaming are the variety (*10*, *12*, *13*), the harvest (*8*, *13*), and the maturity index of grapes (*14*). Juices of white grapes used to produce Cava with a maturation index ranging from 4 to 5.5 have been found to give the wines with the best foam characteristics (*12*). Furthermore, the greater the foam capacity of wine, the better the foam quality of its resultant sparkling wine (*15*). Therefore, the base wine stage, where coupages are done, could be considered as the second decisive point for obtaining the highest quality sparkling wines. However, studies on the relationship between the foam capacity of base wines and their respective sparkling wines have only been carried out on a laboratory scale and have not included wines made from red varieties.

As aging is a very common practice and a characteristic that distinguishes the quality of a Cava (*13*, *16*, *17*), the foam properties during aging have also been studied. Winemakers are aware that aging with yeast seems to improve the quality of the sparkling wine. Several studies on the evolution of foam during aging (*3*, *4*, *10*), using the Mosalux equipment or similar, have shown that aging with lees modifies the foam characteristics. However, no studies on the aging of sparkling wines made from Trepat and Monastrell varieties have been carried out.

The present study had two aims: first, to identify the relationship between the foam parameters of a base wine and the same wine after bottle fermentation; and second, to study the effect of aging on foam and color in sparkling wine made from wines and coupage wines including Trepat and Monastrell.

The foam properties (measured with Mosalux equipment) and enological and chemical parameters of sparkling wines were determined at different points of aging. The sparkling wines were produced on an industrial scale by the same winery and for two consecutive vintages.

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MATERIALS AND METHODS

Samples. Sparkling wines prepared from two red varieties and coupage base wines by secondary fermentation in bottles in contact with yeast were considered. Samples were taken during 21 months of aging in two consecutive harvests. Only in the first harvest were samples followed until 27 months. Duplicates of samples corresponding to two different vinification series and two bottles of each sampling point were analyzed separately to consider any possible variation between them.

Monovarietal sparkling wines were made from Trepat and Monastrell (*Vitis vinifera*) wines. Several sparkling wine blends were also prepared. These blends included a percentage of one of the red varieties and a blend made from the traditional white varieties: Macabeo, Xarel.lo, and Parellada. In the first harvest (1), coupages including 25% Monastrell (CM1a and CM1b) and 50% Trepat (CT1a50 and CT1b50) were assayed. In the second harvest (2), the same blendings were performed, and coupages including 10 and 25% of Trepat (CT2a10, CT2b10, CT2a25, CT2b25) were also made. Due to their intense color, Monastrell wines (M1a, M1b, M2a, M2b) were clarified with 75 g/100 L carbon active immediately prior to blending. All sparkling wines were made in the same winery on an industrial scale so as to avoid interference from technology. The sampling points of aging in contact with the yeast *Saccharomyces bayanus* were as follows: 6 and 9 months [when the wine was considered to be Cava by the Spanish Certified Brand of Origin] and 12, 15, 18, and 21 months. Only for the first harvest were samples also taken at 24 and 27 months of aging.

Samples were centrifuged for 10 min at 2500*g* at 10 °C. They were then kept in the freezer (−18 °C) until analysis, except for the Mosalux analysis, which was carried out with non-frozen and degassed samples.

Analytical Methods. *Foam measurements* were performed using the Mosalux method (*13*). Following Gallart et al. (*18*), the following parameters were chosen: *foamability* (HM), maximum height (mm) reached by the foam after CO_2 injection through the glass frit; *Bikerman coefficient* (Σ) (*19*), average bubble lifetime (s) until all bubbles disappear, after CO_2 injection is stopped, and *foam stability time* (TS), time (s) until all bubbles collapse, when CO_2 injection is interrupted.

Enological parameters such as pH, titratable acidity (g of tartaric acid/L), and volatile acidity (g of acetic acid/L), alcohol content (%, v/v), free, combined, and total sulfur dioxide concentrations (mg of SO_2/L), and absorbances at 280 (in 1-mm cuvette), 420 and 520 nm (in 10-mm cuvette) were measured according to OIV methods (*20*).

Color intensity or density was taken as the sum of the absorbance at 420 and 520 nm (*21*).

Total phenolic content was measured as the absorbance at 280 nm (*21*).

The concentration of *soluble proteins* was determined using the Bradford method (*22*) after decoloring, with polyvinilpolypirrolidone (1 g of PVPP/20 mL Cava), the Cava made from the red varieties.

Total, neutral, and acid polysaccharide contents were determined following the Segarra et al. (*23*) spectrophotometric procedure.

Concentrations of organic acids and glycerol were determined according to the HPLC method of López-Tamames et al., 1996 (*24*).

All analyses were performed in duplicate.

Statistical Procedure. STATGRAPHICS 7.0 (*25*) and SPSS 10.0 (*26*) were used. Using Statgraphics 7.0, stepwise regression analysis was applied to the characteristics of base wines as *independent variables* and to the foam characteristics of the corresponding sparkling wines as *dependent variables*. To show the evolution of HM, Σ, and TS during aging, an error bar (mean ± 2 SE) graphic representation analysis, grouped by months of aging for each foam parameter, was performed using SPSS 10.0. An ANOVA (HSD Tukey) was applied to the color intensity values of the Cavas, sorted by varietal coupage, at each point of aging.

Table 1. Effect of Bottle Fermentation on the Foam Properties of a Wine Made by the Traditional Method[a]

samples $n = 22$		HM (mm)	variation[b] (%)	Σ (s)	variation (%)	TS (s)	variation (%)
CW1	wine	102		15		83	
	cava	61	–40	10	–36	71	–
CW2	wine	170		17		176	
	cava	78	–54	10	–42	277	57
T1a	wine	193		16		23	
	cava	74	–62	14	–	256	1037
T1b	wine	192		18		41	
	cava	70	–64	10	–45	174	324
T2a	wine	225		54		83	
	cava	85	–62	21	–61	402	387
T2b	wine	235		30		45	
	cava	69	–71	19	–38	354	686
T2a10	wine	172		18		28	
	cava	74	–57	10	–45	401	1356
T2b10	wine	157		15		50	
	cava	78	–50	9	–40	297	495
T2a25	wine	205		21		53	
	cava	71	–65	9	–57	273	420
T2b25	wine	187		17		51	
	cava	68	–64	12	–31	354	601
T1a50	wine	186		16		18	
	cava	75	–60	10	–37	163	830
T1b50	wine	175		12		13	
	cava	71	–59	10	–21	61	390
T2a50	wine	220		18		38	
	cava	74	–66	8	–56	245	553
T2b50	wine	210		20		133	
	cava	84	–60	10	–51	292	120
M1a	wine	43		21		53	
	cava	50	–	9	–59	124	136
M1b	wine	50		28		245	
	cava	39	–	9	–68	100	–59
M2a	wine	85		32		1163	
	cava	45	–46	18	–44	436	–62
M2b	wine	77		33		738	
	cava	30	–60	15	–54	375	–49
M1a25	wine	60		14		150	
	cava	79	33	12		133	–
M1b25	wine	55		14	–	142	
	cava	79	45	7	–48	124	–
M2a25	wine	130		19		80	
	cava	46	–64	10	–47	259	225
M2b25	wine	130		19		61	
	cava	51	–61	14	–25	435	618

[a] Wine: base wine, Cava: sparkling wine at 9 months of aging in contact with yeast. 1 and 2: year of harvest. a and b: replicates. –: non statistically significant variation observed. [b] Calculated as (HM Cava – HM base wine)/HM base wine) × 100.

RESULTS AND DISCUSSION

The wines subjected to second fermentation in a bottle and in contact with yeast for 9 months (the minimum time established by Cava regulations) underwent important changes in their foam properties. **Table 1** shows the variation (%) between the foam parameter [foamability (HM), Bikermann coefficient (Σ), and stability time (TS)] values of each base wine and its corresponding Cava. Trepat and coupages of Trepat Cavas always showed a loss of HM (min−max values: 50−71%), as did the blend of whites (min−max values: 40−54%). Cavas made from Monastrell or coupages with Monastrell gave variable results, only some of them showing a loss (min−max values: 46−64%). After the second fermentation and aging to 9 months, either a decrease or no variation in Σ was observed (min−max values: 0−68%). The stability time (TS) increased in Cavas made from Trepat and coupages of Trepat (min−max values: 120−1356%), in contrast to results for Monastrell, coupages of Monastrell, and the white blend Cavas. To test whether the percentage of variation was related to the initial foam values, relationships between the foam parameters of base wine and the variation values were studied. Logarithmic relationships between HM, Σ, and TS of the base wine (x variable) and the variation values (y variable, expressed as a

Table 2. Logarithmical Relationships between the Foam Parameters (HM, Σ, and TS) of the Base Wine (*x*) and the Percent of Variation Due to the Second Fermentation (*y*), and between the Base Wine Foam Values (*x*) and the Foam Parameters of the Sparkling Wine at 9 Months (*y*′)[a]

	HM	Σ	TS
	% Variation (*y*)		
slope	−50,180	−25.932	−253.116
constant	199.767	35.681	1461.926
p	<0.001	<0.01	<0.001
	Cava Foam Parameters (*y*′)		
slope	15.238	7.888	
constant	−8.353	−12.012	
p	<0.01	<0.0001	ns

[a] Logarithmical equation model: y = constant + (slope ln(x)). HM: foamability (mm), Σ: Bikermann coefficient (s), TS: stability time (s), *p*: significance level.

percent), and between the base wine (x) and the sparkling wine at 9 months (y′) foam parameters were indeed found (**Table 2**). The effect of second fermentation was related to the foam parameters of the initial base wine: the highest foam values of the base wine gave the highest decreases, while the lowest foam values of the base wine gave the lowest decreases or even increases in foam. However, as previously described by Maujean et al. (*15*), the greater the foam parameters HM and Σ of the base wine, the greater the foam values of the Cava. No significant relation between the TS of the base wine and the TS of Cava was found. As foam depends on the balance between various chemical compounds (*27*−*29*), determining the chemical parameters of base wine could provide useful information about sparkling wine foaming. Stepwise analysis showed that the foam parameters (HM, Σ, and TS) of a nine-month sparkling wine could be calculated from the physicochemical parameters of the corresponding base wines by applying the following polynomial equations: HM = 349.49 − 28.64[ethanol] + 47.75[total polyphenols] (r^2 adj = 0.7034), TS = −169.84 + 16.21[free SO_2] + 712.03[total polyphenols] (r^2 adj = 0.7291) and Σ = 25.06 − 11.62[lactic acid] − 0.04[combined SO_2] − 0.70[glycerol] (r^2 adj = 0.5557). As the parameters included in these equations were determinations for base wine quality control in wine cellars, they could be used in the future to determine sparkling wine foaming. Similar equations have been previously reported for determining wine foaming from data of grape juice characteristics (*12, 14*).

Figure 1 shows an error bar representation, grouped by months, of the evolution of HM, Σ, and TS during the aging of monovarietal and coupage Cavas. After 9 months, HM and Σ showed two minimums at around 9 and 21 months, the highest values being reached at approximately 15 and 24 months. In contrast, TS had its highest values at approximately 9 and 21 months of aging and its minimums at months 15 and 24 (**Figure 1a**,**c**). During the special aging in contact with lees, Cava wines undergo chemical and biochemical changes (*30*−*32*) that may affect the foam parameter values. **Table 3** shows the relationship between foaming and physicochemical characteristics of Cavas. Acidity parameters, ethanol, sulfur, and polysaccharides contents were correlated to the foam parameters. This is consistent with what has been previously cited for wines (*3*, *12*, *13*, *27*). Moreno-Arribas et al. (*32*) also described the correlation between foam parameters and total polysaccharides and protein contents for sparkling wines. However, in our study, the relation between foam and proteins was surprisingly not found. This is in line with the study of Marchal et al. (*33*), where differences in the concentration of these compounds, could not explain the

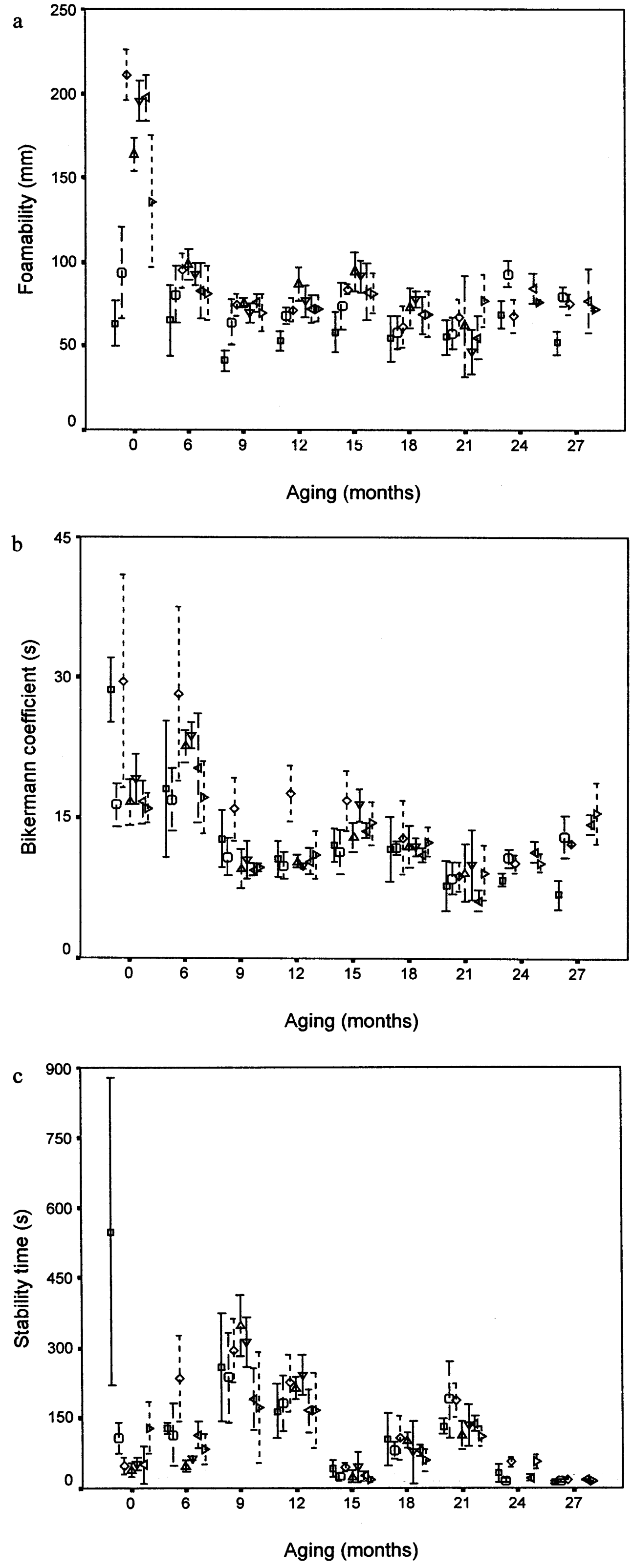

Figure 1. Evolution of HM (a), Σ (b), and TS (c) during aging (months) of varietal and coupage sparkling wines: □: Monastrell, ◇: Trepat, (triangle, right facing): Macabeo, Xarel.lo and Parellada blend, ○: blending which includes 25% Monastrell (1M:3CW), △: blending which includes 10% Trepat (1T:9CW), ▽: blending which includes 25% Trepat (1T:3CW), (triangle, downward facing: blending which includes 50% Trepat (1T:1CW).

differences observed in the foaming properties of sparkling wines. Thus, we believe that not only quantitative, but also

Table 3. Simple Lineal Relationships between Physicochemical Characteristics (95% Confidence Interval for mean) and Foamability (HM), Bikermann Coefficient (Σ), and Stability Time (TS) of Cavas ($n = 128$)

	HM	Σ	TS
positive relationship	tartaric acid (2.99–3.07 g/L)	tartaric acid (2.99–3.07 g/L) total polysaccharides (262–298 mg/L)	
negative relationship	ethanol (11.87–12.02%,v/v) pH (3.11–3.14) volatile acidity (0.33–0.37 g/L) total SO_2 (64–78 mg/L)	total SO_2 (64–78 mg/L)	total and acid polysaccharides (262–298, 33–40 mg/L) volatile acidity (0.33–0.37 g/L) total SO_2 (64–78 mg/L) lactic acid (0.65–0.77 g/L)

Table 4. Means of Color Intensity (CI) of Cavas Grouped by Varietal Coupage[a]

months of aging	0	9	12	15	18	21
			First Vintage			
CW	0.100[a]	0.080[a]	0.080[a]	0.090[a]	0.080[a]	0.090[a]
CT50	0.160[b]	0.110[a,b]	0.115[a,b]	0.120[a,b]	0.115[a,b]	0.123[a,b]
CM25	0.152[b]	0.108[a,b]	0.105[a,b]	0.118[a,b]	0.105[a,b]	0.118[a,b]
T	0.185[c]	0.140[b]	0.135[b,c]	0.150[b]	0.143[b,c]	0.150[b,c]
M	0.275[d]	0.175[c]	0.160[c]	0.173[b,c]	0.170[c]	0.175[c]
p	0.0001	0.0001	0.001	0.001	0.0001	0.0001
			Second Vintage			
CW	0.080[a]	0.080[a]	0.085[a]	0.105[a]	0.090[a]	0.090[a]
CT10	0.120[b]	0.100[a]	0.103[a,b]	0.110[a]	0.125[a,b]	0.123[a,b]
CT25	0.165[c]	0.123[b]	0.125[b]	0.130[a]	0.130[b,c]	0.130[b]
CM25	0.110[b]	0.105[a,b]	0.110[a,b]	0.120[a]	0.118[a,b]	0.120[a,b]
CT50	0.230[d]	0.163[c]	0.170[c]	0.180[b]	0.160[c]	0.168[c]
T	0.360[e]	0.220[d]	0.240[d]	0.253[c]	0.233[d]	0.228[d]
M	0.190[f]	0.188[e]	0.190[c]	0.190[b]	0.183[c]	0.188[c]
p	0.0001	0.01	0.0001	0.0001	0.0001	0.0001

[a] CW: Macabeo, Xarel.lo, and Parellada blend, T: Trepat, M: Monastrell, CT10: blending 1T:9CW, CT25: blending 1T:3CW, CT50: blending 1T:1CW, CM25: blending 1M:3CW, *p*: significance level. Means with the same letter are not significantly different.

qualitative aspects of proteins (*34*) should be also considered in the future.

The color intensity (CI) decreased when the second fermentation took place, but from 9 months onward non-significant differences were observed (**Table 4**). The color intensity of sparkling wines including 25% Monastrell did not differ significantly from that of sparkling wines made from a blend of white wines, neither during aging nor according to the year of harvest. The color intensity of Cavas including Trepat wine did depend on the year of harvest. As can be seen in **Table 4**, the coupage with 50% Trepat of the first vintage would be appropriate for elaborating "blanc de noirs" sparkling wine as it did not differ from the white blends, whereas in the second harvest the color intensity exceeded the CI range for "blanc de noirs" sparkling wines, namely, 140−160 ua × 1000, according to data supplied by the winery. Thus, the percentage of Trepat wine used in the blending for elaborating white sparkling wine depends on both the harvest and a possible decoloration.

In conclusion, the foam properties (HM, Σ, and TS) of sparkling wines which included a percentage of these red varieties in the coupage did not differ from the foam properties of a white sparkling wine. In terms of foaming and color, these red variety wines could be used for preparing blends along with the traditional white varieties to elaborate white Cava, but other sensory properties, such as aroma or tasting, should also be studied. More data from other vintages and a sensory study of these sparkling wines would provide further useful information.

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