Influence of Variety and Aging on Foaming Properties of Sparkling Wine (Cava). 1

Cristina Andrés-Lacueva, Magda Gallart, Elvira López-Tamames, and Rosa M. Lamuela-Raventós*

Nutrició i Bromatologia, Facultat de Farmàcia, Universitat de Barcelona, Avinguda Joan XXIII s/n, 08028-Barcelona, Spain

Forty-eight cavas produced by the same winery during the same harvest were studied to evaluate the effect of variety and aging on their foaming properties, measured with the Mosalux method. Foamability and stability time were inversely correlated ($r = -0.7782$). Variety and blending were decisive for the foaming properties of the sparkling wines. Aging improved the stability time of the foam collar; however, it decreased foamability.

Keywords: *Sparkling wine; cava; foam; aging; variety*

INTRODUCTION

Cava is the final product after two fermentations during a minimum period of aging of 9 months with yeast inside a bottle. According to the European Union (CEE 2043/89), it is a *v.e.c.p.r.d* (quality sparkling wine produced in determinate regions). Its effervescence leads to a foam collar in the champagne glass that is easily perceived by the consumer, who expects it to be stable. For this reason, the cava companies are interested in studying this property.

Few papers discuss the foam phenomenon in sparkling wines (Bidan and Salgues 1982; Maujean et al., 1990; Machet et al., 1993; Viaux et al., 1994; Pueyo et al., 1995). Foam formation and stability have been described as the two characteristic properties that define it (Maujean et al., 1990; Brissonnet and Maujean, 1991, 1993; Marchal et al., 1993; Robillard et al., 1993; Malvy et al., 1994; Viaux et al., 1994; Andrés-Lacueva et al., 1996). However, only one study of base wines and champagnes (Maujean et al., 1990) attempts to establish a relationship between foam formation and stability. However, these authors, using the Mosalux method, did not find any correlation between them.

Sparkling wine foam depends on the foam capacity of the base wines (Maujean et al., 1990), which depends, in turn, on the grape variety (Andrés-Lacueva et al., 1996). Empirically, winemakers consider the Chardonnay variety gives rise to sparkling wines with better foaming properties than the three autochthonous grapes from Penedès area varieties (Macabeo, Xarel.lo, and Parellada). However, the direct effect of variety on the foam of sparkling wines has not been reported previously, mainly because of the difficulty of obtaining varietal sparkling wines at industrial scale. It is important for the winemakers to determine the foam capacity of each variety and the effect of blending them to produce sparkling wines with better foam. Winemakers have perceived that aging with yeast seems to improve the quality of the foam. However, at a certain time of aging, arround 21 months, they observe a decrease in foaming. Moreover, the stock of cava in the celler represents a large investment for the producers. For these reasons it is important to optimize the length of this aging and to study the effect of aging on sparkling wine for a minimum period of 2 years at industrial scale.

Maujean et al. (1990), studying three points of aging (2, 5, and 15 months after the addition of the "tirage" liqueur) of six champagnes and their foaming parameters, noticed that the maximum height reached by the foam (HM) decreased with the time of aging, although the time for all bubbles to collapse (TS) increased. Stability height during CO_2 injection (HS) increased until the fourth month; however, it decreased thereafter. Pueyo et al. (1995) consider the effect of aging on foam of one cava made from a base wine obtained by the blending of three varietal wines: Macabeo, Xarel.lo, and Parellada. They observed that the foamability decreases with time, while foam stability increases only during the first 3 months after the tirage.

In this paper, the influence of variety and the effect of blending have been evaluated in 96 cavas. Furthermore, we have followed the evolution of the foam during aging. All cavas were produced in parallel from the same harvest by the same winery to avoid the effects of technological and climatic variations.

MATERIALS AND METHODS

Samples. Six kinds of wine vinified in bottles in contact with yeast for sparkling wine were considered. Samples were taken 8 times in duplicate along 26 months of aging, following a factorial design ($6 \times 8 \times 2$) (Table 1). The two bottles of each sampling point were analyzed separately to consider the variation between them. The coefficient of variation between these two bottles considered for the foaming parameters (HM, HS, and TS) was 4%.

Sparkling wines were made from three white varietal autochthonous *Vitis vinifera* from Penedès region (Macabeo, Xarel.lo, and Parellada), another one from Chardonnay, and two coupages: one of them with the three autochthonous varieties (1:1:1) and the other plus Chardonnay (3:3:3:1). All sparkling wines were made in the same winery at industrial scale from one harvest (1993) to avoid the interference of technology and crush. The eight sampling points of aging in contact with the yeast *Saccharomyces bayanus* were as follows: 3, 6, and 9 months [when the wine is considered cava by the Spanish *Denominación de Origen Controlada* (DOC)—Certified Brand of Origin)] and 12, 15, 18, 23, and 26 months of aging. Sparkling wines (filtered and degassed) were analyzed according to the Mosalux method immediately after disgorging with nonfrozen samples to minimize the changes in the structures of the compounds responsible for the foam.

Analytical Methods. Measurement of Foaming Properties. All foam measurements were carried out using the

* Author to whom correspondence should be addressed (telephone 34-3-4024508; fax 34-3-4021896; e-mail lamuela@farmacia.far.ub.es).

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Table 1. Number of Bottles Analyzed at Each Point of the Sampling

sparkling wines	3 months	6 months	9 months	12 months	15 months	18 months	23 months	26 months	total
Macabeo	2	2	2	2	2	2	2	2	16
Xarel.lo	2	2	2	2	2	2	2	2	16
Parellada	2	2	2	2	2	2	2	2	16
Chardonnay	2	2	2	2	2	2	2	2	16
blending CP[a]	2	2	2	2	2	2	2	2	16
blending CPC[b]	2	2	2	2	2	2	2	2	16
total	12	12	12	12	12	12	12	12	96

[a] CP, blending with Macabeo, Xarel.lo, and Parellada (1:1:1). [b] CPC, blending with Macabeo, Xarel.lo, Parellada, and Chardonnay (3:3:3:1).

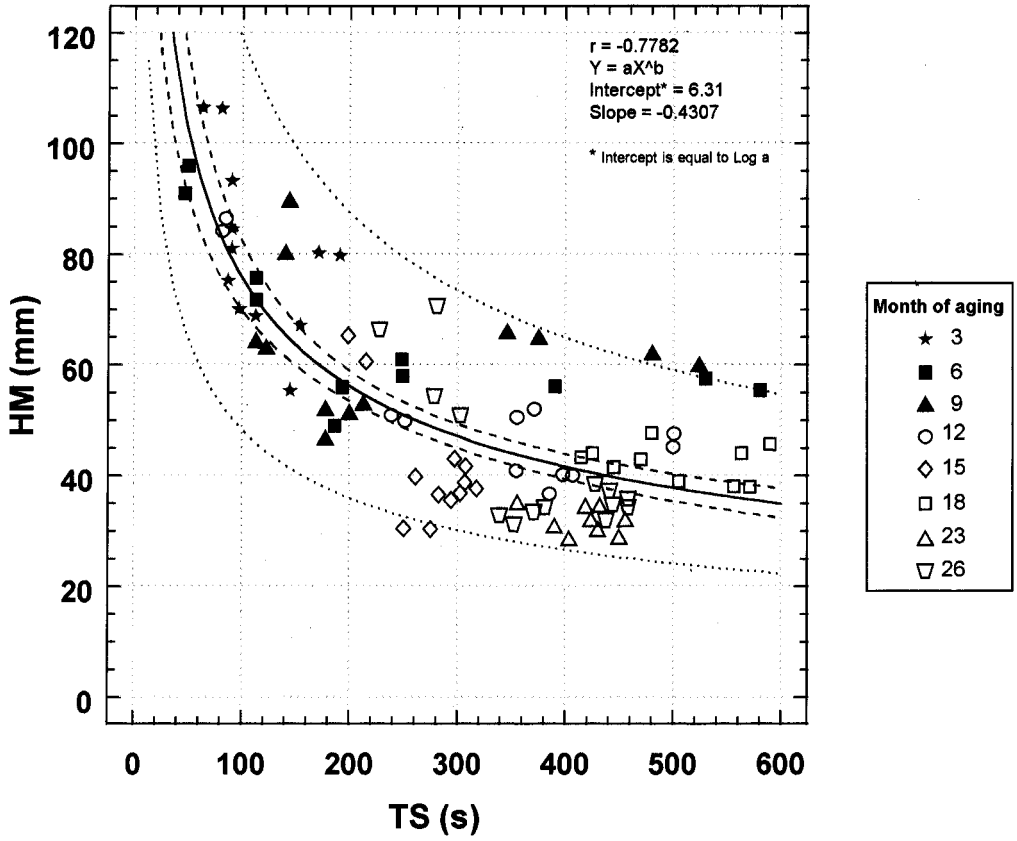

Figure 1. Inverse multiplicative relation ($r = -0.7782$) between the foamability of sparkling wines (HM) and its stability time (TS) ($n = 96$).

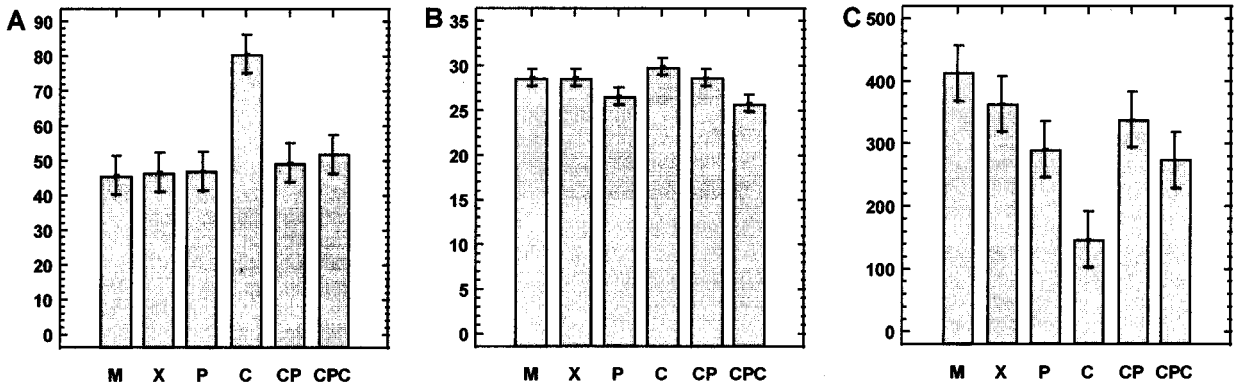

Figure 2. Mean values of HM (foamability, mm) (A), HS (permanence of the foam, mm) (B), and TS (stability time, s) (C) represented with their 95% confidence intervals for four varietal cavas, M (Macabeo), X (Xarel.lo), P (Parellada), and C (Chardonnay), two *coupages*, CP (M:X:P) (1:1:1), and *coupage* plus Chardonnay, CPC (M:X:P:C) (3:3:3:1). Six kinds of sparkling wines were used, $n = 16$.

Mosalux procedure (Maujean et al., 1990), used by the industry, with the clean procedure described by Poinsaut (1991). A glass cylinder placed on a glass frit was filled with 100 mL of sparkling wine to be analyzed, previously filtered and degassed. Carbon dioxide was injected into the glass cylinder throuh the glass frit with a constant rate of gas flow (7 L/h) under a constant pressure (100 kPa). Foam height, mesured in millimeters, was measured by photoelectric cells (infrared beams).

Three parameters were measured: (1) HM (foam height), the maximum height reached by the foam after carbon dioxide injection through the glass frit, expressed in millimeters, which

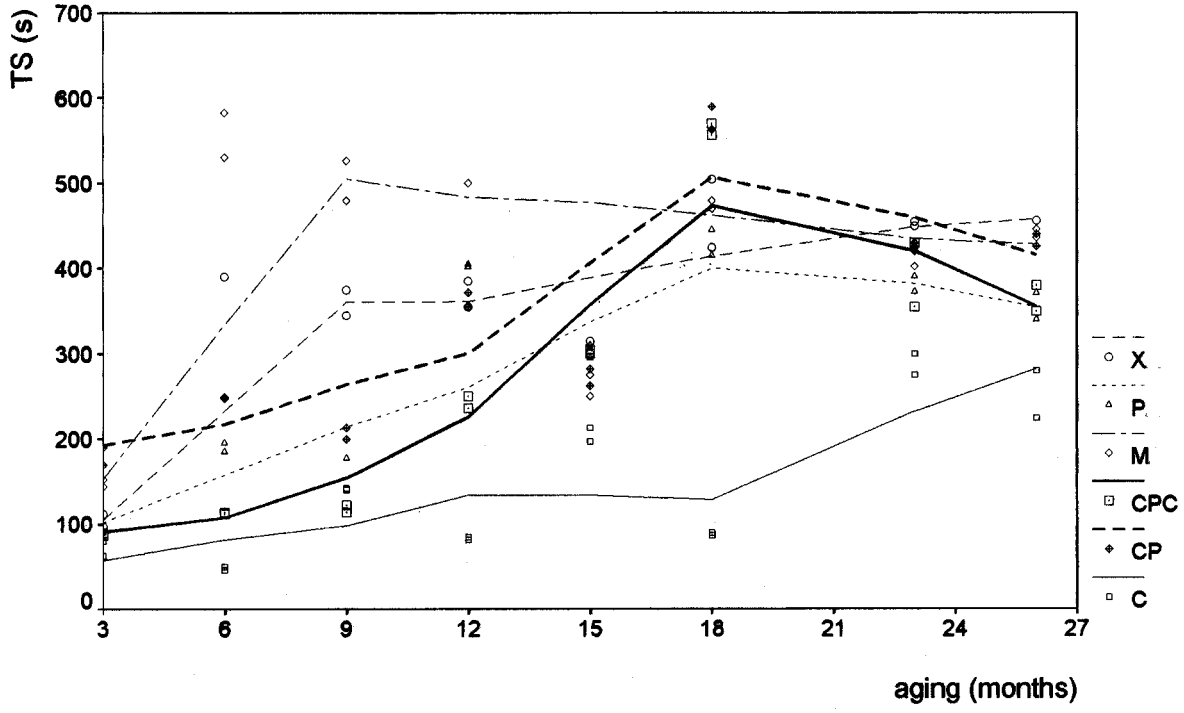

Figure 3. Evolution of TS (stability time) during aging within varietal and blending cavas: M (Macabeo), X (Xarel.lo), P (Parellada), C (Chardonnay), blending CP (M:X:P) (1:1:1), and blending plus Chardonnay CPC (M:X:P:C) (3:3:3:1).

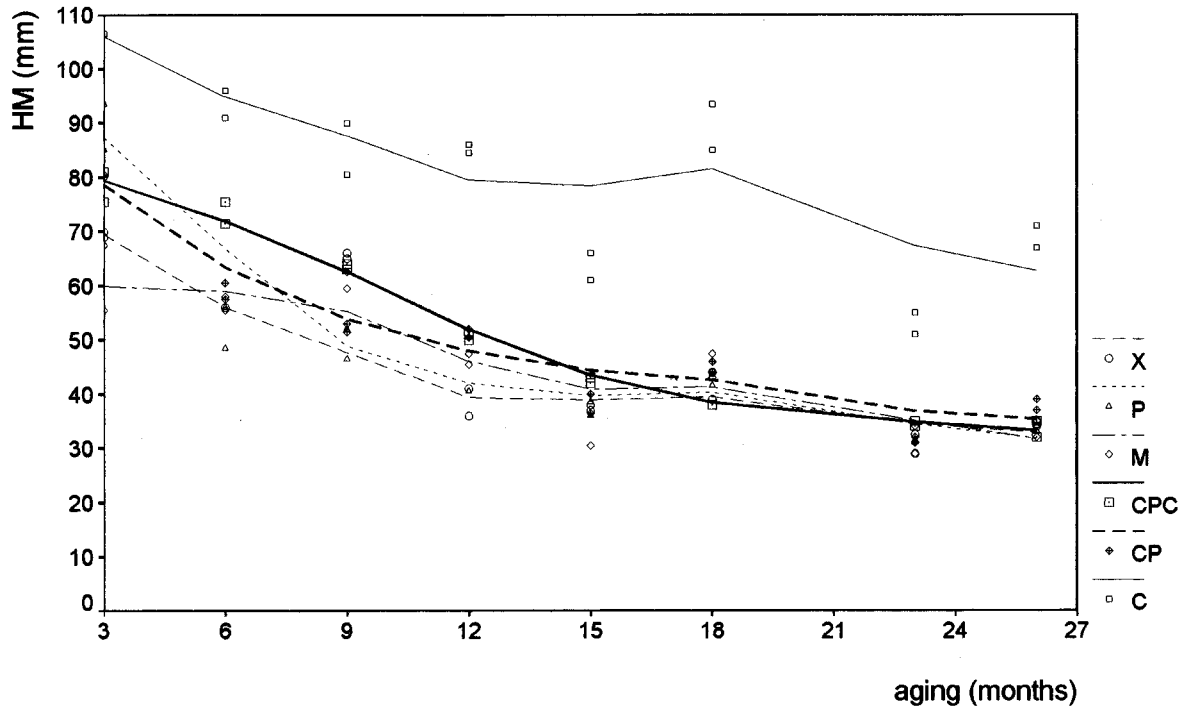

Figure 4. Evolution of HM (foamability) during the aging within varietal and blending cavas: M (Macabeo), X (Xarel.lo), P (Parellada), C (Chardonnay), blending CP (M:X:P) (1:1:1), and blending plus Chardonnay CPC (M:X:P:C) (3:3:3:1).

represents foamability; (2) HS, foam stability height during carbon dioxide injection, expressed in millimeters, which represents the persistence of the foam collar or the wine's ability to produce stable foam; (3) TS, foam stability time until all bubbles collapse, expressed in seconds, which represents the foam stability time once effervescence has decreased. The Mosalux parameters (HM, HS, and TS), which were determined in quadruplicate for each bottle, had an average of coefficients of variation of <8%.

Statistical Analysis. STATGRAPHICS 7.0 program was used to study the model that gave the best fit between the variables HM, HS, and TS and also to carry out MANOVA, considering variety and time of aging as independent variables. The models considered were simple regression: [lineal ($y = a + bx$), multiplicative ($y = ax^b$), exponential ($y = e^{(a+bx)}$), and reciprocal ($1/y = a + bx$)]. To evaluate the interactions, SPSS 6.01 was used: interpolation type of calculation used was according to the lowess model. This produces the locally weighted regression scatter plot smoothing method (Cleveland, 1979). Lowess uses an iterative weighted least-squares method to fit a line to a set of points on a scatter plot. The percentage of data points to use for local weighted regression is 50%.

RESULTS AND DISCUSSION

An inverse multiplicative relation ($r = -0.7782$, $p < 0.0001$) was found for the foaming slope obtained from HM and TS (Figure 1). From 3 to 9 months of aging with yeast, HM decreased considerably. However, after 9 months, there was only a slight decrease. Inversely, TS increased during aging, reaching the highest levels at 18 months. A positive relationship between HM and HS ($p < 0.01$) was found when a multiplicative regression was carried out; however, its coefficient was lower than 0.5. This last result was reported by Andrés-Lacueva et al. (1996) when they studied the foam capacity of 44 base wines, although they did not establish a significant relation between HM and TS. However, Maujean at al. (1990) noted that the three foaming properties (HM, HS, and TS) are not correlated. The wineries prefer a sparkling wine with a visible, stable collar of foam, which could be associated with HS and TS, respectively, rather than a high foamability when the cava is poured into the glass, which may be associated with HM. The minimum time established by the cava regulation for aging with yeast is 9 months. In this study, optimum foaming properties were obtained only after 9 months (Figure 1).

The variety of grape selected to make cava is a decisive variable in the study of the foamability (HM). Chardonnay variety had the highest foamability ($p < 0.0001$); even the blends elaborated with this variety maintained higher HM than blends without this variety ($p < 0.001$). The three autochthonous varieties had the same HM, although blending them slighly improves this property due to a synergic effect (Figure 2A).

Despite its relation with HM, the Chardonnay variety had the highest HS, although Parellada sparkling wines and the blend with Chardonnay had significantly lower values of HS ($p < 0.0001$) (Figure 2B).

Sparkling wines made from Chardonnay had the lowest TS ($p < 0.0001$) followed by the blending with Chardonnay and Parellada ($p < 0.0001$). In contrast, Macabeo and Xarel.lo cavas and blending with autochthonous varieties had the highest TS (Figure 2C).

Considering the interaction between variety and aging with yeast, TS values, in general, increased with it (Figure 3), as reported by Maujean et al. (1990). Moreover, there is a maximum at 18 months for Parellada, blending (CP), and blending plus Chardonnay (CPC). In Chardonnay cava alone, however, the increase in TS was observed only after 18 months. Macabeo sparkling wines reached the maximum value at 9 months.

The foamability, HM, decreased throughout aging, although an increase was observed at 18 months followed by a decrease from 21 months (Figure 4). The same evolution was observed at 15 months by Maujean et al. (1990), who correlated it with the autolysis of the yeast as described by Feuillat and Charpentier (1982). After about 2 years of aging, foaming properties of cava are unlikely to improve, as winemakers are already aware.

CONCLUSIONS

HM and TS were inversely correlated; in contrast, HM and HS were directly related. Variety was decisive for the foam of sparkling wines. Chardonnay cavas had high foamability and the lowest stability time. Blending of different varietal wines improved the foaming properties with respect to each varietal wine separately, owing to a synergic effect among components. Taking into account the aging in the bottle, TS increased during the aging with yeast and HM decreased throughout the aging. The study of chemical composition to identify the components of these sparkling wines responsible for the foaming properties is currently under investigation.

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