SENSORY DESCRIPTIVE ANALYSIS OF URUGUAYAN TANNAT WINE: CORRELATION TO QUALITY ASSESSMENT

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ABSTRACT

*Tannat (*Vitis vinifera *L. cv. Tannat) was the main grape variety to be established in Uruguay, being the only country in the Americas where this grape is commonly found. Because of its small cultivation in the world, this variety has not been thoroughly studied, hence, considerable research and development on this variety is still needed. The aims of this study were to obtain the aroma and taste profiles of Tannat red wine by means of descriptive analysis and to correlate the quantitative sensory data to the quality assessment obtained through a small panel of fine wine consumers. The correlations obtained resulted in a useful tool in Uruguayan Tannat wine development. Results showed that an increment in* yeasty, burned *and* earthy *aromas resulted in lower quality scores, while high intensities of* dried fruit, phenolic *and* berry *aromas are desirable in this fine wine variety. As far as taste is concerned,* astringency *positively influences quality evaluation of* flavor *(*attack, evolution *and* persistence*),* body *and* overall quality.

INTRODUCTION

Quantitative descriptive analysis techniques in order to obtain an objective characterization and discrimination of products have been applied to wines during the last decades and have become standard practice in sensory evaluation (Noble *et al.* 1984; Vannier *et al.* 1999; Gámbaro *et al.* 2003). Among other applications, this technique is used as an adjunct to quality

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control and as a diagnostic tool to characterize product differences. The use of correctly trained assessors is a key factor in producing meaningful profiles. Even with training, judges may vary in their perceptions; thus, examination of assessor performance should be a routine part of data analysis (King *et al.* 2001). Because univariate techniques do not give a global estimate of the panel performance (Vannier *et al.* 1999), multivariate statistics has been widely used to examine judge performance, using a composite of sensory terms. Principal component analysis (PCA), Procrustes, correspondence analysis and cluster analysis are some of the most used multivariate methods for studying panel performance (Powers and Ware 1986; King *et al.* 2001).

In the evaluation of wines, the judgment of quality has traditionally been carried out by winemakers or depended on the scoring of a few expert judges. However, these tastings do not necessarily reflect the opinion of the consuming public. For this reason, hedonic scaling methods were developed. Lawless *et al.* (1997) showed that a method using a small panel of fine wine consumers was suitable for generating quality scores for consumer guidance. This kind of method generally uses a structured hedonic scale, with variations in the number and definitions of the points (Goldwin and Lawless 1991; Lawless *et al.* 1997).

Tannat (*Vitis vinifera* L. cv. Tannat) was the main grape variety first established in Uruguay, being introduced in 1870. Although it originated from the south of France, it is almost unknown in Europe today. This French red variety acclimatized very well to the cool and humid conditions of Uruguay and today, high quality wines are starting to be produced. This grape is a tough, blackberried vine variety and as its name suggests, is exceptionally tannic and also high in anthocyanins. Because of its small cultivation in the world, this variety has not been thoroughly studied, even in France, as a profound characterization is necessary (Carrau *et al.* 2001; Zoecklein 2002). For this reason, the Uruguayan wine-making industry has established a strategy to produce Tannat wine using state-of-the-art viticultural technology (Carrau 1997). Finding out the main differences in the chemical aroma composition and the sensory description of Tannat wines were the first approach to the characterization of this variety (Carrau *et al.* 2001; Gámbaro *et al.* 2001). Considerable research and development on the viticulture and enology of this variety is still needed; therefore, of great interest are the determination of the sensory characteristics and quality parameters of Uruguayan Tannat wines.

The aims of this study were (1) to obtain the aroma and taste profiles of Uruguayan Tannat wine by means of descriptive analysis and (2) to correlate the quantitative sensory data to the quality assessment obtained with the use of a consumer panel.

MATERIALS AND METHODS

Wine Samples

Thirteen samples of Tannat red wine confirmed to be 100% varietal were taken directly from the wineries of southern vineyards of Uruguay. They were aliquots of their annual production, and each wine was produced according to its manufacturer procedures (different yeasts, timings, etc.). In order to assure as much homogeneity as possible, the samples were all taken at the same point of the elaboration process, after undergoing malolactic fermentation and being subsequently stabilized by cold; none of them was stored in wood. The samples were bottled in 750-mL bottles and kept refrigerated until the analysis (10C, a maximum of 5 weeks). The group of samples in study constituted a homogeneous category of high quality wines (MERCOSUR 1996).

Sensory Descriptive Analysis

Panel Training. A panel of 22 members was trained in three stages of 2 months each, with 2 weekly sessions. The aim of the first stage was to recognize the typical attributes of aroma and taste, the second to discriminate among the attributes and the third the evaluation of aroma and taste intensity using a 9-point structured scale (1 = threshold, 9 = very intense). For this last purpose, a hydroalcoholic 12% solution was used in the beginning and then a neutral red wine with different concentrations of added standards (for aroma, "La Nez du Vin," Editions Jean Lenoir, Cave du Cep d'Or, Dessous Bellegarde, 74250 Fillinges, France). The aroma standard solutions were prepared as described by Gámbaro *et al.* (2003). Thirty aroma attributes were selected from the Wine Aroma Wheel of Noble *et al.* (1987). The wheel is divided into groups of terms that describe similar aroma characters. The main groups (primary tier terms) were further divided into specific aroma characters (secondary and tertiary tier terms) (Gámbaro *et al.* 2003) (Table 1). The taste attributes chosen and their standards used for the training were: *sweet* (sucrose), *alcoholic* (ethanol), *acid* (citric acid), *bitter* (caffeine) and *astringent* (tannins). The standard solutions were prepared as in Peynaud (1996).

Formal Assessment. Testing was carried out in a sensory laboratory equipped with individual booths, designed in accordance with ISO 8589 (1988). Sixty-milliliter samples were served at 18 ± 1C, in 250-mL clear tulip-shaped wine glasses (ISO 3591 1977) identified with random three-digit codes and covered with petri dishes. A balanced complete block

TABLE 1.
AROMA DESCRIPTORS

Primary	Secondary	Tertiary
Fruity	Berry	Raspberry
		Black currant
	Tree fruit	Cherry
		Apricot
		Quince
	Dried fruit	Prune
		Fig
Nutty	Nutty	Walnut
		Hazelnut
		Almond
Vegetative	Fresh	Mint
		Cut grass, green
		Green pepper
	Dried	Tea
		Tobacco
Caramelized	Caramelized	Honey
		Butter
Spice	Spice	Licorice
		Black pepper
		Cinnamon
		Cloves
Floral	Floral	Rose
		Violet
Woody	Phenolic	Vanilla
	Burned	Coffee
		Smoky
	Resinous	Oak
Earthy	Earthy	Truffle
Animal	Animal	Musk
Microbiological	Yeasty	Yeasty

experimental design was used by the 22 trained assessors for evaluating the 13 samples, in duplicate. Three samples were evaluated for aroma and taste characteristics in the first eight sessions, and two samples in the last session.

For aroma characteristics, the panelists were required to rate secondary and tertiary aroma tier terms using a 9-point structured scale (1 = threshold, 9 = very intense) (Gámbaro *et al.* 2001). The panelists always rated the secondary tier term equal to or higher than the more specific tertiary tier term. Any terms not rated were assigned a value of zero (no intensity) in the analysis. Only secondary tier terms were statistically analyzed in this work.

Taste characteristics were also evaluated using a conventional 9-point intensity structured scale (1 = threshold, 9 = very intense).

Quality Evaluation

The panel for quality evaluation consisted of 30 fine wine consumers recruited from a local amateur tasting group such as "Les amis du vin," also called "Enotria." They drank cork-finished wines on a regular basis and were knowledgeable about wines but otherwise inexperienced in any formal judging procedure. The panel tasted the 13 wine samples using a 9-point structured quality scale (1 = very bad, 9 = excellent). The attributes evaluated were: *appearance*, *color*, *aroma*, *flavor* (separated into *attack*, *evolution* and *persistence*), *body* and *overall appreciation*. *Attack* was defined as the first impression of the wine within the first 1–2 s of tasting, as it first hits the tongue, and evaluating principally the sweet substances (alcohol, sugars and glycerol). *Evolution* was evaluated immediately after the attack, lasting 4–12 s, comprising the observation of acidity and saltiness as well as retronasal aromas. *Persistence*, also known as "finish," was evaluated after swallowing the sample, and is the last impression that the wine leaves in the mouth, when bitterness and astringency are detected (Sancho *et al.* 1999).

Approximately 50 mL of each sample was served at 18 ± 1C, in 250-mL clear tulip-shaped wine glasses (ISO 3591 1977) identified with random three-digit codes, and the evaluation was performed in a clean, odor-free room under fluorescent lighting with the consumers facing away from one another to minimize distractions (Attributes used in the aroma and taste descriptive analyses as well as those used in the quality evaluation are shown in italics throughout the text).

Statistical Analysis

Panel performance was evaluated using PCA and cluster analysis. Analysis of variance (ANOVA) was performed on the trained sensory panel and on the quality data. In order to study the differences among samples, least significant differences were calculated by Fisher's test. PCA of the correlation matrix of mean ratings for each sensory term, which differed significantly across the samples, was used to illustrate the relationship among sensory terms and the relative taste and aroma of the individual wines. Correlation matrices (Pearson's) of the sensory and quality data were performed in order to identify correlations between sensory parameters and quality. All statistical analyses were done using the Statistica 5.1 software (StatSoft Inc., Tulsa, OK).

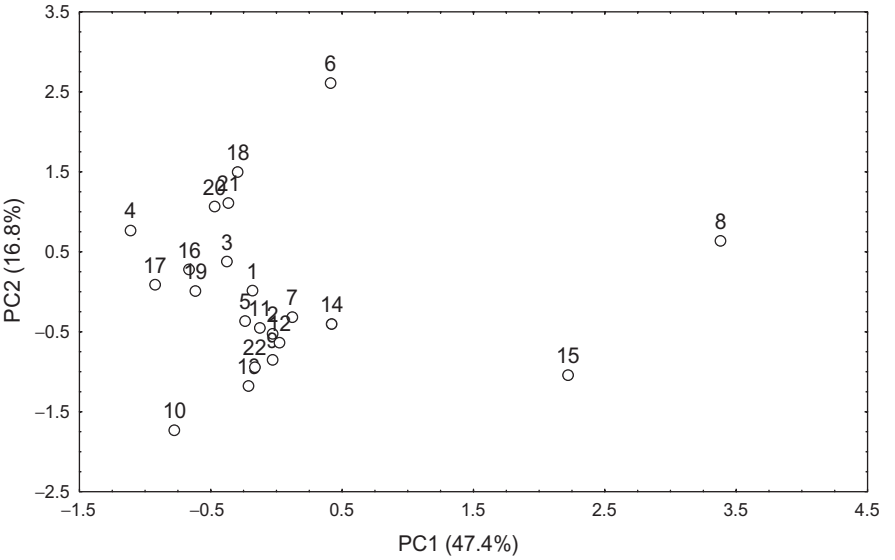


FIG. 1. PCA LOADING PLOT OF THE ASSESSORS ON THE FIRST TWO PRINCIPAL COMPONENTS
Numbers correspond to assessors 1 through 22.
PCA, principal component analysis; PC, principal component.

RESULTS AND DISCUSSION

Assessor Performance Evaluation

In this study, both PCA and cluster analysis were performed and compared to evaluate the panel, as these methods were more effective when used in conjunction with each other (King *et al.* 2001).

PCA was conducted for all assessors across all samples on the mean judge scores for each secondary aroma attribute, using the correlation matrix. The total amount of variance explained by the first three components was 73.6%. Factor 1 accounted for 47.4% of the variation and was highly loaded in the positive direction with *dried fruit*, *caramelized*, *spice*, *phenolic* and *burned*. Factor 2 accounted for an additional 16.8% of the variation in the data set and was loaded in the positive direction with *berry*. The third factor (9.3% of the variation) is positively loaded with the attribute *earth*. The location of the assessors on the PCA plot (Fig. 1) shows the similarities and differences in their attributes used to describe the wines. Assessors that were grouped together were most alike in their attributes used, while those located at a distance from the others were more dissimilar. For example, the location of

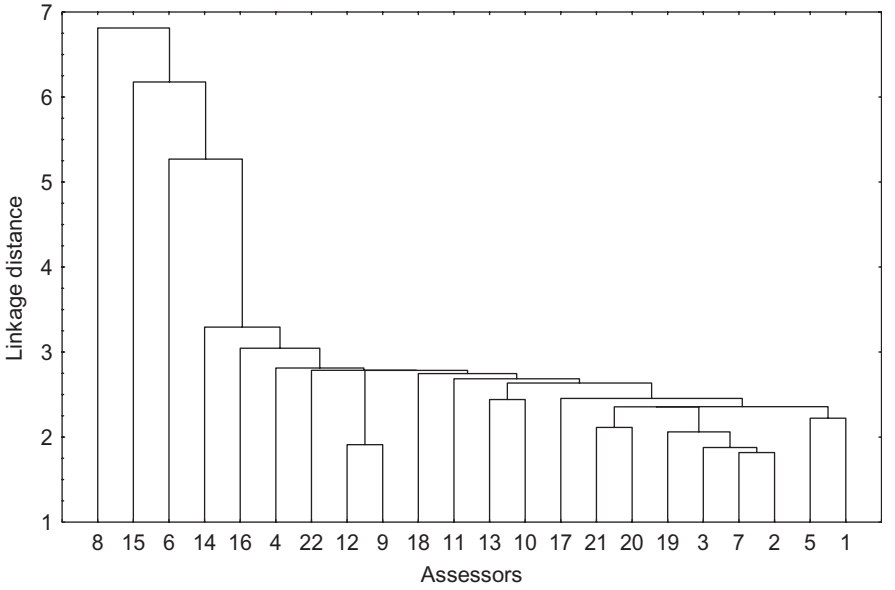


FIG. 2. CLUSTER ANALYSIS OF ASSESSORS

assessors 8 and 15, far to the right on Factor 1, suggested higher scores for *dried fruit*, *caramelized*, *spice*, *phenolic*, *burned* and *yeasty.* Similarly, assessor 6 had higher scores for attributes that loaded positively on Factor 2 (*berry*), conversely to assessor 10.

Cluster analysis was conducted using the average linkage method on the mean sensory secondary aroma scores. The plot of the cluster analysis (Fig. 2) displays assessor similarity across all samples and attributes. Assessors 6, 8 and 15 were added later in the analysis, reflecting their discrepancy with the other judges.

Outliers within a panel could increase or decrease the estimates of treatment differences and reduce the power of the test to conclude a treatment, making the difference significant; false discrimination might result when a panelist erroneously indicates a sensory signal is present. When it is desired to reduce the risk of erroneously concluding a difference exists, it is important to remove the effects of a false discriminator (Arnold and Williams 1986; Lundhal and McDaniel 1991).

Both methods were useful tools for identifying dissimilar judges and their results were in agreement. PCA and cluster analysis identified assessors 6, 8 and 15 as possible outliers, suggesting their evaluations were dissimilar from the group so they were eliminated from further analyses in this study.

Sensory Descriptive Analysis of Aroma

The ANOVA showed that *nutty*, *floral*, *resinous* and *animal* aromas did not present significant differences, so they were not used in the rest of the analysis; all the other secondary aroma attributes were highly significant in discriminating among samples ($P \leq 0.05$).

PCA revealed that the amount of variance among samples explained by the first, second and third dimensions were 33.6, 24.1 and 18.4%, respectively. Figure 3a,b shows the consensus plots of the samples on these dimensions, including the attributes that were most cited. The first dimension was positively loaded with *yeasty*, while in the negative direction it was loaded with *berry*, *caramelized* and *dried fruit*. The second dimension was negatively loaded with *fresh*, *tree fruit* and *spice*.

Thus, a clear differentiation is observed among groups of samples with distinct characteristics. In the upper-left quadrant, samples are characterized by the *caramelized* and *dried fruit* aromas. Similarly, M3, M4 and M8 are defined by *fresh*, *tree fruit* and *spice*, respectively; samples in the upper-right quadrant are characterized by the descriptor *yeasty*, in particular M12.

Sensory Descriptive Analysis of Taste

ANOVA revealed no significant differences among samples in *sweet* and *bitter* tastes ($P > 0.05$). *Acidity* showed significant differences ($P \leq 0.001$), the same for *alcoholic* ($P \leq 0.05$) and *astringent* ($P \leq 0.001$).

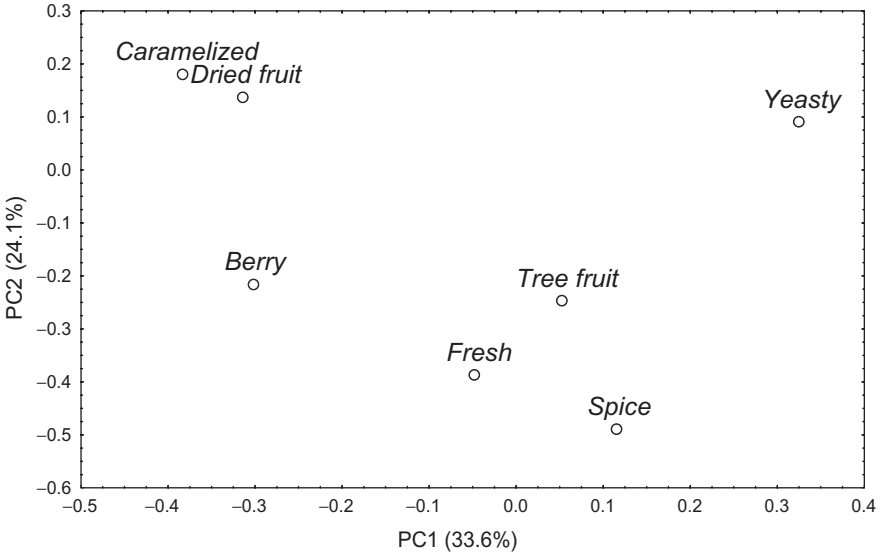
PCA accounted for 61.25% of the variation in the data with only the first factor representing it. This dimension was loaded in the positive direction with *acidity* and in the negative with *alcoholic* and *astringent.* Figure 4 shows the consensus plot on dimension 1. Samples M4 and M9 are plotted as more acidic and less alcoholic and astringent than the rest of the samples, which appear in the diagram as more balanced.

Quality Evaluation

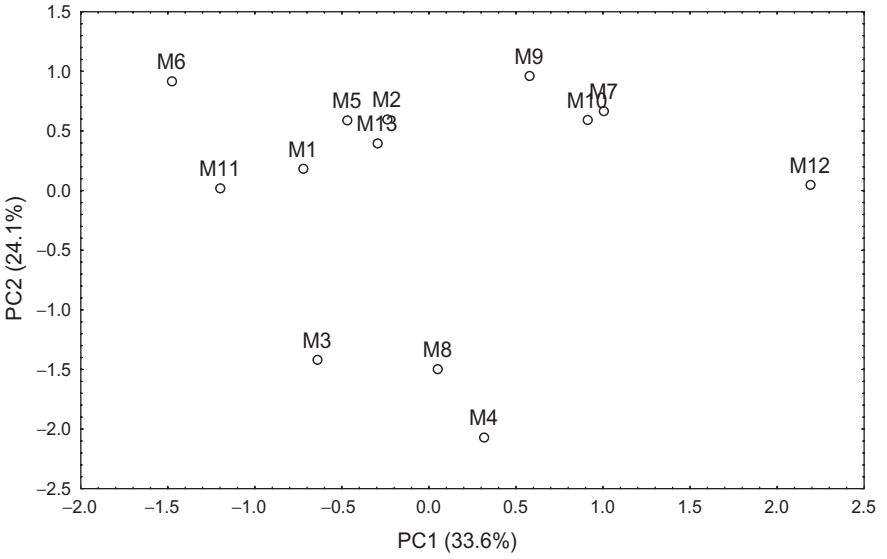
The consumer panel presented no significant differences in all the parameters evaluated, and all consumers rated the samples in the same way, showing their agreement in their concept of wine quality, which was somehow logical, as they were part of the same amateur tasting group.

The ANOVA revealed that the 13 samples of Tannat wine presented significant and highly significant differences in all quality attributes evaluated (data not shown), i.e., the fine wine consumer panel were able to differentiate samples with regard to their quality. Because of that, all quality attributes were used in the correlation analysis with aroma and taste descriptors.

PCA of the quality attributes evaluated by the consumers' panel showed that the total amount of variance explained by the first and second dimensions



(a)



(b)

FIG. 3. (a) PCA LOADING PLOT OF THE AROMA ATTRIBUTES ON THE FIRST TWO PRINCIPAL COMPONENTS. (b) PCA LOADING PLOT OF THE SAMPLES ON THE FIRST TWO PRINCIPAL COMPONENTS (AROMA EVALUATION)
PCA, principal component analysis; PC, principal component.

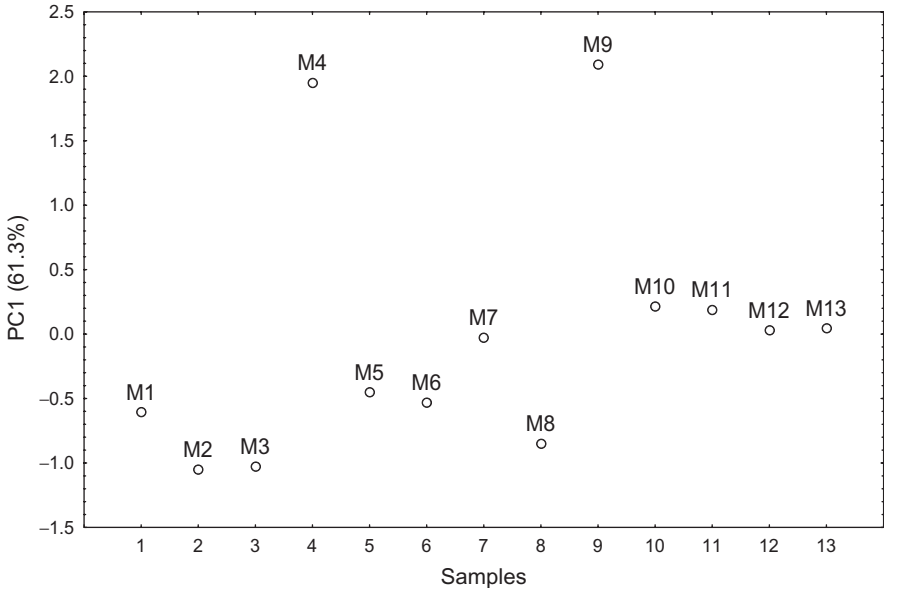


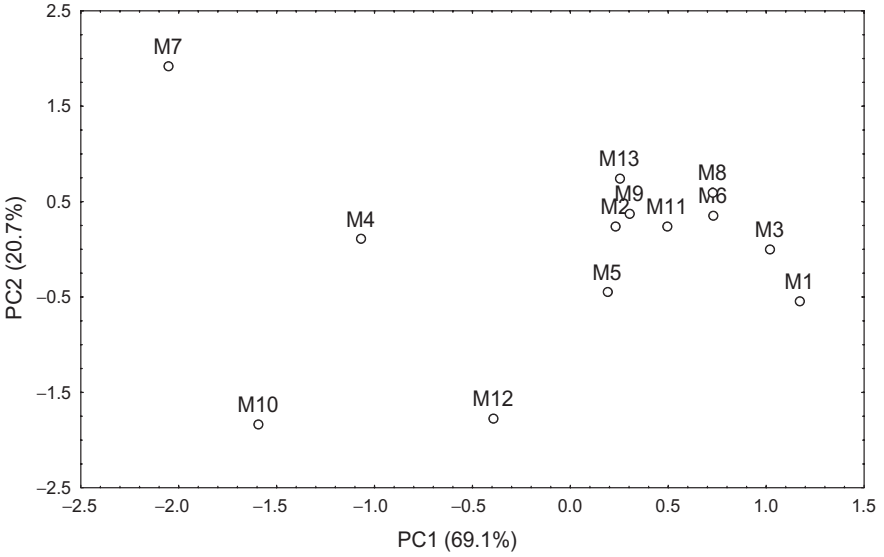
FIG. 4. PCA LOADING PLOT OF THE SAMPLES ON THE FIRST PRINCIPAL COMPONENT (TASTE ATTRIBUTES)
PCA, principal component analysis; PC, principal component.

were 69.1 and 20.7%, respectively. Figure 5a,b presents the consensus plots of the samples and the quality attributes associated with these two dimensions.

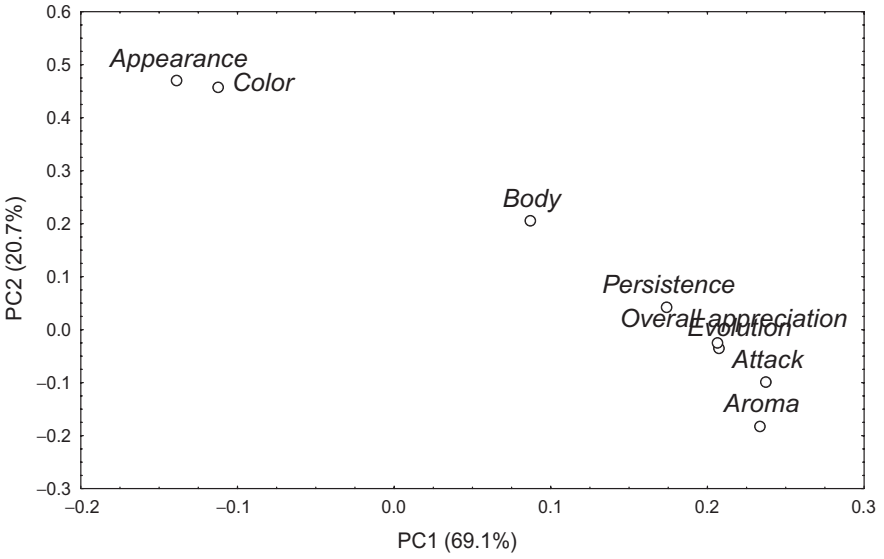
It can be observed that the first dimension is positively loaded with *aroma*, *attack*, *evolution*, *persistence*, *body* and *overall appreciation*, while the second dimension is loaded with *appearance* and *color.*

It is interesting to point out that the second dimension of the PCA is explained only by the visual quality descriptors, while the first one includes nose and mouth perceptions as well as the global quality (*overall appreciation*), suggesting that the relative weight consumers give to taste, mouthfeel, aroma (retronasal perception) and odor in evaluating the overall quality is higher than what they give to visual appreciation.

Then, sample M7 had high visual quality scores, while scoring quite low in the other parameters, and had poor *overall appreciation*. However, samples M13, M11, M9, M8, M6, M5, M3, M2 and M1 had good to intermediate scores on *aroma*, *attack*, *evolution*, *persistence*, *body* and *overall appreciation*, and as well as intermediate hedonic scores in visual attributes. Samples M10 and M4 showed low scores, and M12 showed low to intermediate scores in all quality characteristics evaluated.



(a)



(b)

FIG. 5. (a) PCA LOADING PLOT OF THE QUALITY PARAMETERS ON THE FIRST TWO PRINCIPAL COMPONENTS (QUALITY EVALUATION). (b) PCA LOADING PLOT OF THE SAMPLES ON THE FIRST TWO PRINCIPAL COMPONENTS (QUALITY EVALUATION) PCA, principal component analysis; PC, principal component.

TABLE 2.
CORRELATION MATRIX BETWEEN SENSORY (TASTE AND AROMA) AND QUALITY DATA (CONSUMER PANEL)

	Appearance	Color	Aroma	Attack	Evolution	Persistence	Body	Overall quality
Berry	0.08	0.17	0.55*	0.33	0.36	0.39	0.38	0.58*
Tree fruit	–0.36	–0.04	–0.20	0.04	0.13	0.15	–0.06	0.09
Dried fruit	0.02	0.19	0.48	0.58*	0.59*	0.56*	0.56*	0.54*
Fresh	–0.07	0.21	0.34	–0.06	–0.16	–0.01	0.21	0.02
Dried	0.05	0.16	–0.26	–0.26	–0.23	–0.27	–0.11	–0.35
Caramelized	0.29	0.38	0.41	0.35	0.46	0.38	0.51	0.50
Spice	–0.18	0.33	0.12	0.11	0.05	0.22	0.24	0.07
Phenolic	–0.16	–0.18	0.55*	0.42	0.43	0.35	0.24	0.48
Burned	0.26	0.40	–0.54*	–0.34	–0.21	–0.03	–0.00	–0.19
Earthy	0.10	0.05	–0.37	–0.55*	–0.57*	–0.59*	–0.25	–0.64*
Yeasty	–0.60*	–0.60*	–0.59*	–0.58*	–0.57*	–0.66*	–0.73**	–0.76**
Acidity	0.46	0.40	0.09	–0.23	–0.27	–0.22	0.02	–0.20
Alcoholic	0.05	0.18	–0.17	0.12	0.23	0.27	0.34	0.22
Astringent	0.28	0.39	0.49	0.68**	0.72**	0.62*	0.70**	0.68**

* Significant at $P \leq 0.05$.
** Significant at $P \leq 0.01$.

Correlations

In order to determine the possible correlations, a matrix was constructed between sensory descriptive data (taste and aroma, evaluated by the trained assessors) and the quality scores (assessed by the fine wine consumer panel). Correlations were considered as significant if $P \leq 0.05$ (Table 2).

Aroma Quality

Yeasty aroma showed a negative correlation to all quality attributes evaluated. Thus, as this aroma grows in intensity, wine quality lowers in all aspects. It is not strange that yeasty aroma also had a correlation to visual attributes. The excess of this aroma is usually because of an excess in yeast biomass or their autolysis products, after alcoholic fermentation concludes. This defect, commonly found in lower-priced wines, is often accompanied by turbidity or poor translucence. *Earthy (*associated to *truffle*) and *burned* (*coffee*, *smoky*) aromas were also negatively correlated to the quality evaluation, in particular *earthy* to taste descriptors, and *burned* to the aroma evaluated by the consumers.

The secondary tier descriptor *dried fruit*, associated with *fig* and *prune*, was positively correlated to *attack*, *evolution*, *persistence*, *body* and *overall appreciation*. In the same way that *berry*, whose associated tertiary descriptors

are *raspberry* and *blackcurrant*, showed a positive correlation to *aroma* and *overall quality*. *Phenolic* aroma (associated with the *vanilla* tertiary descriptor) was also positively correlated to aroma-quality evaluation.

Summarizing the aroma-quality correlation analysis: *yeasty*, *earthy* and *burned* aroma lower Uruguayan Tannat wine quality scores, while high intensities of *dried fruit*, *berry* and *phenolic* are desirable in this fine wine variety. *Dried fruit* and *berry* aromas were found to be characteristic of the Tannat variety in previous studies (Gámbaro *et al.* 2003).

Taste Quality

The only taste that presented significant correlation to quality ($P \leq 0.05$) was *astringency*, a mouthfeel perception actually considered to be a joint perception (texture and taste). *Astringency* positively influences quality scores of *attack*, *evolution*, *persistence*, *body* and *overall quality*. Therefore, it can be inferred that frequent fine wine consumers expect a Tannat wine to be highly astringent in order to consider it of superior quality. Although in many wines astringency is regarded as a defect, in this particular case it is one of the distinctive characteristics of the grape and the wine variety (Carrau *et al.* 2001; Zoecklein 2002), so it came not as a surprise that this sensation was associated with high quality. Of course this high astringency might have a limit, a fact that should have to be studied in further researches.

Thus, to exemplify the correlation study, we have the sample M7 aroma that was high in *yeast* and low in *berry* and *dried fruit*, and although its *color* and *appearance* ratings were good, it was rated as very poor in all other quality attributes, including *overall appreciation*. On the other hand, sample M2 had a low *yeasty* aroma but high *berry* and *dried fruit* aromas, as well as having a high *astringency*. Further, this sample had very high quality ratings.

CONCLUSIONS

Correlations obtained between sensory descriptive evaluation performed by a trained panel and wine quality evaluated by frequent fine wine consumers resulted in a useful tool applicable to Uruguayan Tannat wine development. Although the results obtained with a small consumer panel could not be considered as statistically representative of the whole Uruguayan population, this is an important first approach to Tannat preferences and its characteristics. Results obtained for the 13 samples analyzed showed that the increment in *yeasty*, *burned* and *earthy* aromas lowers quality scores, while high intensities of *dried fruit*, *phenolic* and *berry* are desirable in this fine wine variety. As far as taste concerns, astringency positively influences quality evaluation of *flavor* (*attack*, *evolution* and *persistence*), *body* and *overall quality*.

Consumers are the ones who decide when it comes to buying. By knowing the desired characteristics in superior quality wines, and thus, the basis of consumer decision, we could contribute to Uruguayan fine wine improvement. The next step should be further consumer studies with a greater number of consumers in order to identify more precisely consumer preferences.

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