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SENSORY CHARACTERISATION OF WINE VINEGARS

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ABSTRACT

Ninety-six samples of vinegars of different sources were subjected to sensory analysis. For white vinegars, Linear Discriminant Analysis showed that sensory analysis could be used to distinguish between the different sources of vinegar, and especially to discriminate between alcohol and apple vinegars from wine vinegars on the basis of only seven sensory parameters. Principal Component Regression showed that the quality level of vinegars could be determined by taste, smell and clarity. Only 'quality' red vinegars were appreciated for their vinous character. Copyright © 1996 Elsevier Science Ltd

Keywords: Wine vinegars; sensory analysis; multivariate statistical analysis; Linear Discriminant Analysis.

INTRODUCTION

Over five million hectoliters of fermented vinegar are currently produced in Europe. These vinegars are both directly consumed and used as an ingredient by the food industry. Italy and Spain together produce over 20% of Europe's vinegar but this production is mediated almost entirely by the acetic bioxidation of wine. It is obvious that producing countries have an intrinsic interest in enhancing the value of wine vinegar, which is produced by two fermentations of a complex raw material of considerable commercial value.

As European prospects pave the way towards an easier and further reaching circulation of food products between different countries, the time has come to characterise not only wine vinegars but also alcohol and apple vinegars. The aim of this work is to establish indicators of quality that go beyond current legal requirements and chemical-analytical literature (Ministero dell'Agricoltura e delle Foreste, 1986; Mecca & Vicario, 1971; Sakata *et al.*, 1991).

Although it is possible to defend typical Mediterranean products by enhancing their quality, there is often a lack of appropriate parameters for characterising them. On the basis of available literature on product characterisation, it is not currently possible to establish composition variability since it is mediated by the origin, production technology and commercial nature of the product.

There has been much less published about wine vinegar than about other food products and most research in the field has concentrated on studying analytical methods to reveal adulteration.

In Europe, most contributions have been made by the Spanish school at Llugano and its collaborators. With the exception of research on balsamic vinegars, most of the Italian work in the field has been carried out by the Mecca group which was in charge of the Vinegar Control Office in Milan for many years (Carnacini & Gerbi, 1992).

Sensory analysis is an indispensable pre-requisite to chemical analysis, in the definition of the characteristics and value of food products. However, sensory analysis for vinegar is particularly arduous because of the aggressive taste and smell of the product.

For balsamic vinegars, sensory testing by the Board of Master Tasters (Costanzini, 1989) has been an irreplaceable tool for quality evaluation and for the concession of manufacturers' seals of guarantee.

MATERIALS AND METHODS

Ninety-six samples of vinegar of various sources (wine, apple, alcohol, etc.) were subdivided into white (63 samples) and red (33 samples) and subjected to sensory analysis (Table 1).

The testing panel was made up of 20 trained wine assessors (Gerbi *et al.*, 1990). Preliminary tests were used to devise methods of treating the samples to limit the taste and smell aggressiveness (e.g. dilution with cold or hot water, neutralisation with alkalines), in keeping with the recommendations of Nieto *et al.* (1993). However, it was found that such procedures tended to distort aroma or attenuate differences between samples.

In order not to excessively tire the assessors, therefore, only six vinegars were examined at each tasting session.

Sensory analysis was carried out twice a week, for four consecutive weeks. Each day 12 vinegars were tasted.

Samples were served in normal tasting glasses and the taste was evaluated using a glass rod or stainless steel teaspoon to limit the quantity of vinegar ingested.

Sensory attributes in these tests were described previously (Gerbi *et al.*, *loc cit.*) (Table 2).

Two 'wheel' cards with unstructured scales were used, one for white and the other for red vinegars (Figs 1 and 2).

After sensory evaluation, the panel expressed a degree of liking for the vinegars with a score between 0 and 100.

TABLE 1. White and Red Vinegars Subjected to Sensory Analysis, with an Indication of Their Acidity and/or Origin and Their Identification Codes

White vinegars	**Samples**	**Identification code**
Italian - Wine - 6% of acidity	21	IVB6
Italian - Wine - 7% of acidity	14	IVB7
Italian - Wine - Decoloured	3	IVDE
French - Wine	2	FVB
Swiss - Wine	1	CHVB
Alcohol	3	AL
Apples	13	AP
Malt	1	MA
Honey	2	HO
Wine and alcohol mixture	3	AV
Red vinegars	**Samples**	**Identification code**
Italian - Wine - 6% of acidity	13	IVR6
Italian - Wine - 7% of acidity	13	IVR7
French - Wine	3	FVR
Spanish - Wine	2	EVR
Swiss - Wine	2	CHVR

TABLE 2. Sensory Attributes Used to Describe Vinegars and Their Meanings in English

Limpidezza	Clarity
Intensità del colore	Colour intensity
Componente giallo paglierina	Straw yellow
Componente giallo dorata	Gold yellow
Componente ambrata	Amber yellow, amber
Componente rossa	Red
Componente gialla	Yellow
Componente mattone	Brick red
Intensità olfattiva	Odour intensity
Aggressività olfattiva	Odour pungency
Franchezza olfattiva	No odour defects
Aromi florali	Floral, floral note
Aromi fruttati	Fruity
Aromi vegetali	Vegetative odour
Vinosità	Vinous character
Armonia dei profumi	Balance of odour
Armonia del gusto	Balance of taste
Sapidità	Sapidity, salty
Persistenza del gusto	Taste persistence
Valutazione complessiva	Overall impression, degree of liking

During tasting sessions, the assessors were only told the acidity of the product, without being given any information on the manufacturer's name or the source (wine, apple, etc.) of the vinegars.

The cards were read and the evaluations of the panel were then transformed into numeric data using a graphic digitizer and special software (Zeppa & Gerbi, 1995). The data were processed using SPSS for Windows (SPSS, 1993). The values obtained from the cards were normalised to the maximum score for each assessor.

RESULTS AND DISCUSSION

Of the 15 descriptors, 5 concerned visual attributes, 7 smell and 3 taste. The majority of the descriptors (12) referred to product characteristics (such as *Aromi fruttati, Intensità olfattiva)* for which higher intensity did not necessarily imply higher quality.

In contrast two parameters (*Armonia dei profumi* and *Armonia del gusto*) referred to a hedonic judgment of the product, and higher values for these parameters indicated higher quality.

White vinegars

Only certain coefficients were higher than 0.8 in absolute values, as it was revealed by the correlation matrix. There were linear positive correlations between *Valutazione complessiva* and the parameters *Franchezza olfattiva, Armonia dei profumi* and *Armonia del gusto.*

Further information on correlations between sensory descriptors can be obtained from the scatterplot of all parameters (Fig. 3).

Limpidezza was constant and was not related to other sensory parameters. Only *Valutazione complessiva* showed a linear relation with the panel's preference for clear products. Similar or related concepts of colour (e.g. *Intensità del colore, Componente giallo paglierina*) showed high degrees of both positive and inverse correlation.

Asymptotic trends between the descriptor *Intensita' del colore* and the decriptors *Componente giallo dorata* and *Componente ambrata* underlined the difficulty assessors had in evaluating colour intensity in strongly oxidised samples which are intensely amber in colour. The correlation between descriptors of smell and taste were nonsignificant. Correlations between sensory parameters adversely affected Principal Component Analysis (PCA) causing five factors to show eigenvalues greater than 1 and the first two factors explain only 53% of the total variance. Cumulatively five factors account for 79% of the total variance. Table 3 presents loading values greater than 0.5 for these five factors.

Using the principal components as variables in a multiple linear regression with *Valutazione complessiva* as a dependent variable, a linear equation with an R^2 of 0.87 can be formulated ($F = 81.49$, $p < 0.01$) (Table 4).

The sensory descriptors that have a more direct effect on *Valutazione complessiva* are: *Franchezza olfattiva, Armonia del gusto, Armonia dei profumi, Sapidità, Limpidezza* and *Persistenza del gusto*. There was however a negative correlation between *Valutazione complessiva* and the descriptors *Aggressività olfattiva* and *Intensità olfattiva*.

Characterisation of white vinegars by Linear Discriminant Analysis of the sensory parameters (see, e.g. Morrison, 1978; Powers & Ware, 1986) was successful if *Valutazione complessiva* was excluded.

Malt vinegar (of which only one sample was available) as well as decoloured and honey vinegars were also

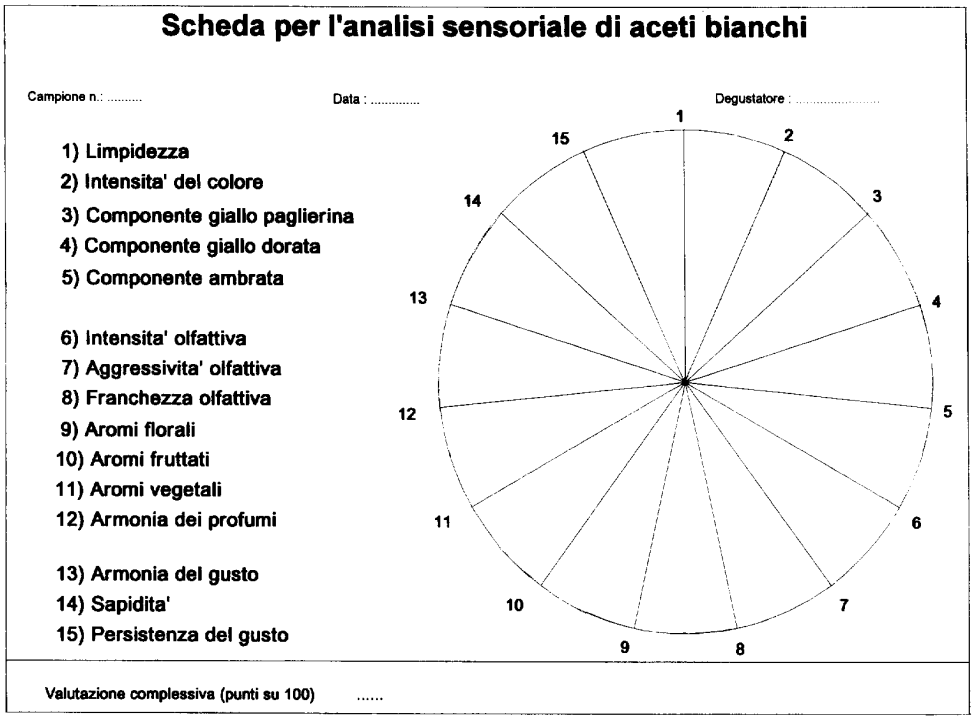

FIG. 1. Unstructured card used for the sensory analysis of white vinegars.

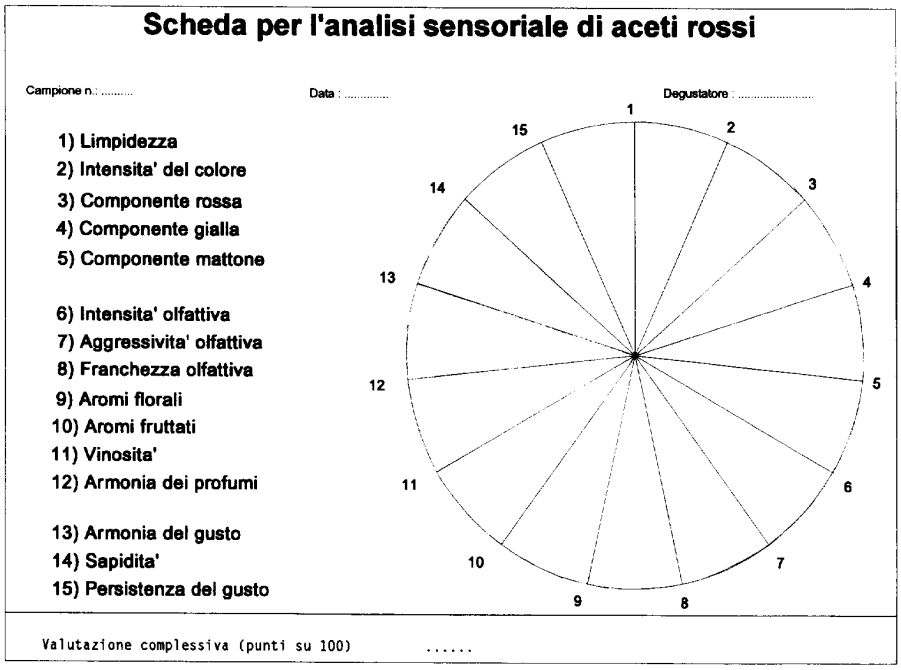

FIG. 2. Unstructured card used for the sensory analysis of red vinegars.

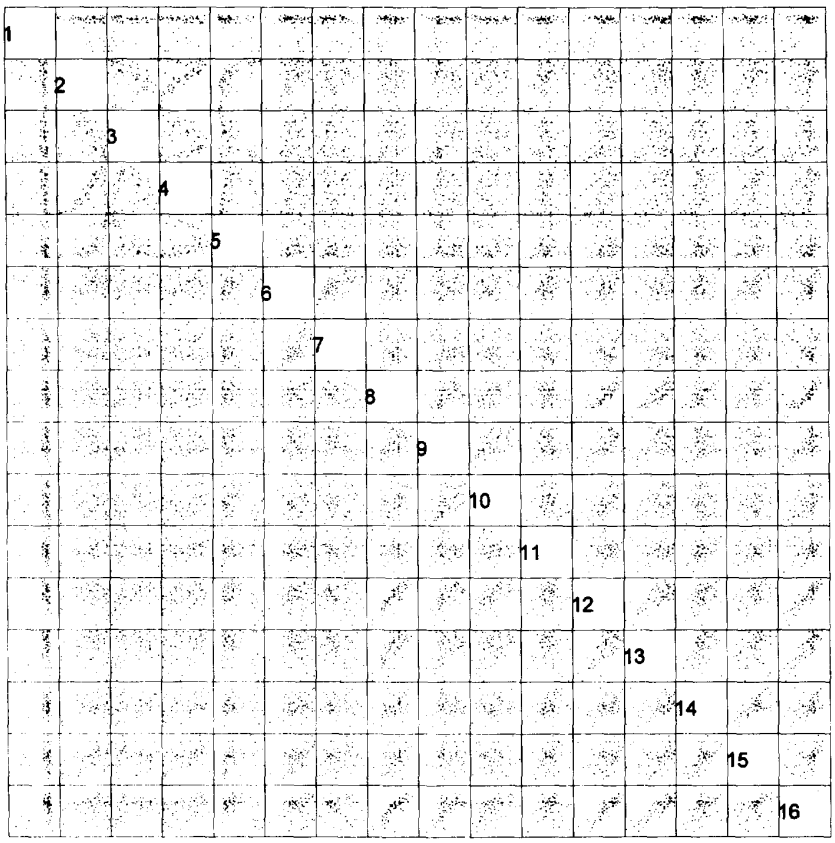

FIG. 3. Scatterplot of all sensory parameters for white vinegars.

TABLE 3. Loading Values for the First Five Principal Components of Sensory Descriptors with the Exception of *Valutazione complessiva*. The Table Shows Coefficients with the Highest Absolute Value for Each Parameter

	Factor 1	**Factor 2**	**Factor 3**	**Factor 4**	**Factor 5**
Franchezza olfattiva	0.822				
Armonia del gusto	0.794				
Armonia dei profumi	0.735				
Sapidità	0.661				
Limpidezza	0.615				
Persistenza del gusto	0.567				
Intensità del colore		0.897			
Componente giallo dorata		0.736			
Aromi vegetali		0.712			
Componente ambrata		0.608			
Aromi fruttati			0.887		
Aromi florali			0.683		
Aggressività olfattiva				0.923	
Intensità olfattiva				0.797	
Componente giallo paglierina					0.878

TABLE 4. Statistical Presentation of the Coefficients of the Regression of Principal Components on *Valutazione complessiva* for White Vinegars

	B	**SE B**	**Beta**	**T**	**Sig T**
Factor 1	0.132	0.008	0.761	5.623	**
Factor 2	0.034	0.008	0.194	–0.778	ns
Factor 3	0.076	0.008	0.436	9.399	**
Factor 4	–0.006	0.008	–0.036	4.182	**
Factor 5	0.045	0.008	0.261	16.414	**
(Constant)	0.578	0.008		72.186	**

excluded, since decoloured vinegars are produced from wine vinegars subjected to unusual treatment while malt and honey vinegars are of little commercial interest. French wine vinegars with 7% acidity were included in the batch of Italian vinegars at 7% and Swiss vinegars with 6% acidity were included in the batch of 6% Italian vinegars.

Data was split into two parts, a training set and a test set, chosen at random. Vinegars obtained by a mixture of alcohol and wine vinegar were included in the test set. Discriminant functions (Table 5) showed a total apparently correct classification of 100% for the training set (Table 6) and 73% for the test set (Table 7). There was an overlap between wine, apple and alcohol vinegars and the classification error reflected this incomplete separation.

Two of the vinegars obtained by a mixture of alcohol and wine vinegars were correctly classified in the alcohol category whereas one was reclassified in the apple category. 'Quality commercial vinegars' or wine vinegars with 7% acidity were overlapped with wine vinegars at 6% or with apple vinegars but never with alcohol vinegars.

Figure 4 presents the use of standardised canonical discriminant function coefficients to distinguish between vinegars with 7% acidity and other vinegars on the basis of colour intensity and aroma. Vinegars with 7% acidity tend to be characterised with prevalent fruity tones and especially, a very harmonious and persistent taste.

Discrimination between wine and alcohol vinegars is of considerable practical interest since alcohol vinegars are very pungent, imbalanced and have a typical smell. Alcohol vinegars can also be distinguished from other vinegars on the basis of sapidity and a lack of persistence and balance in taste.

Apple vinegars were also discriminated satisfactorily. They were characterised by higher values for golden and yellow components as well as taste balance. Overall balance was also good but lower than that of wine vinegars, with characteristic fruity tones.

TABLE 5. Standardised Discriminant Function Coefficients

	Function 1	**Function 2**	**Function 3**
Aggressività olfattiva	0.421	1.384	0.482
Componente ambrata	0.177	−1.855	0.627
Armonia del gusto	−0.96	−0.911	1.205
Armonia dei profumi	−1.945	−0.788	0.526
Componente giallo dorata	0.654	−2.788	0.362
Aromi florali	−1.097	−0.372	−0.252
Franchezza olfattiva	2.269	1.721	0.232
Aromi fruttati	0.233	1.856	−0.093
Intensità del colore	0.252	3.737	0.007
Intensità olfattiva	1.202	−0.189	0.353
Limpidezza	0.481	0.936	−0.672
Componente giallo paglierina	−0.355	−0.061	0.401
Persistenza del gusto	−1.699	−1.489	−0.681
Sapidità	1.581	1.305	−0.217
Vegetale	−0.336	−0.019	0.764

TABLE 6. Classification Results of the Training Set

		Predicted group membership			
Actual group	**Samples**	**Wine 6%**	**Wine 7%**	**Alcohol**	**Apples**
Wine 6%	11	11	0	0	0
Wine 7%	7	0	7	0	0
Alcohol	2	0	0	2	0
Apples	7	0	0	0	7

TABLE 7. Classification Results of the Test Set

		Predicted group membership			
Actual group	**Samples**	**Wine 6%**	**Wine 7%**	**Alcohol**	**Apples**
Wine 6%	10	7	2	0	1
Wine 7%	9	0	7	0	2
Alcohol	1	1	0	0	0
Apples	6	1	1	0	4
Wine-Alcohol	3	1	0	2	0

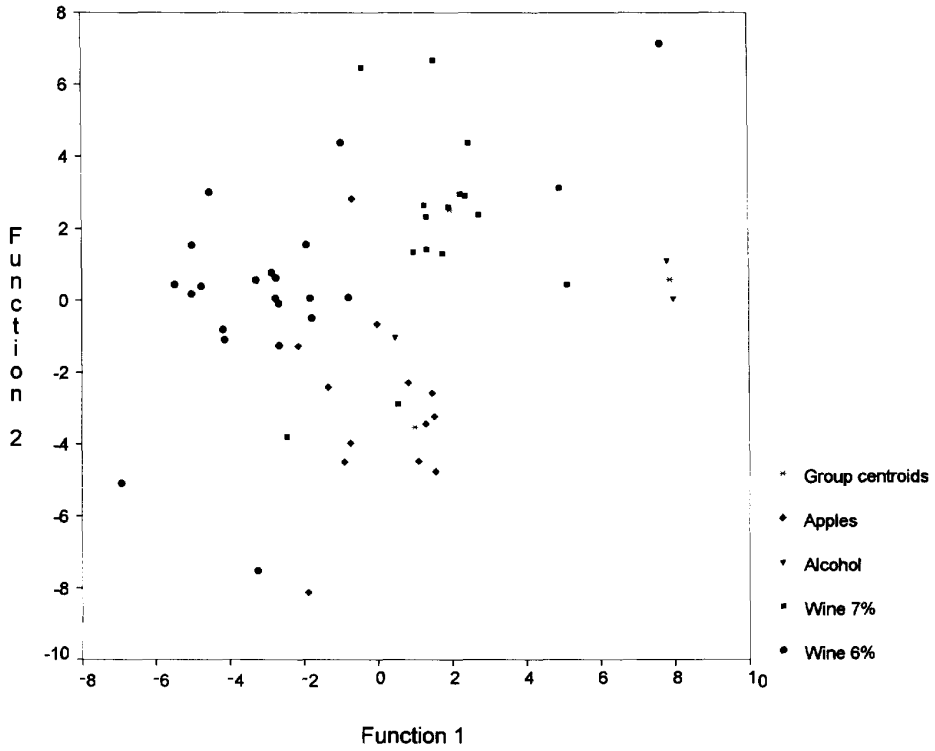

FIG. 4. Graphical presentation of white vinegar groups on a discriminant plane.

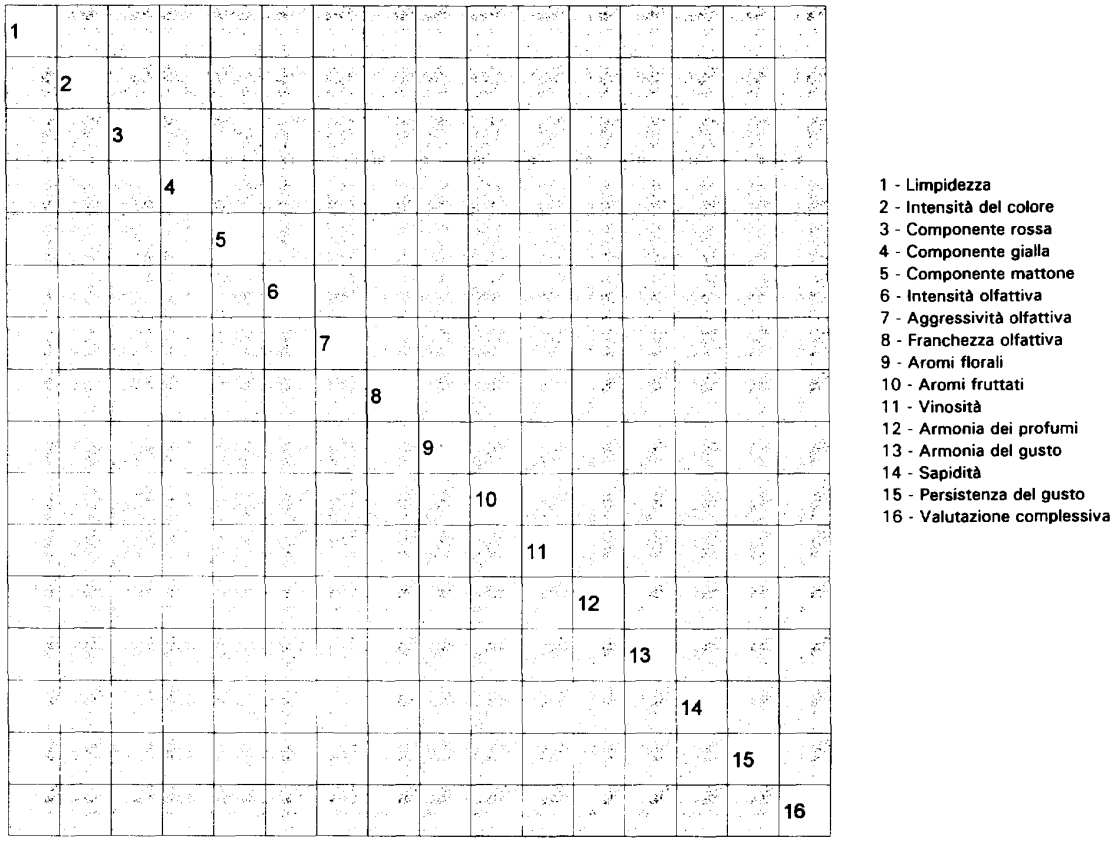

FIG. 5. Scatterplot of all sensory parameters for red vinegars.

Red vinegars

Red wine vinegars presented a correlation matrix with many significant coefficients but only a few where $r > 0.8$.

As Fig. 5 underlines, *Limpidezza* in red vinegars was independent of the other sensory descriptors. Only *Valutazione complessiva* showed a linear response with *Limpidezza* ($r = 0.642$, $p < 0.01$).

Both positive (between *Valutazione complessiva* and *Componente rossa*, between *Intensità del colore* and *Componente rossa*) and negative (between *Intensità del colore* and *Componente gialla*) linear relations between colour descriptors were numerous. There were a greater number of linear positive relationships between smell descriptors.

Valutazione complessiva was correlated with all parameters except *Intensità olfattiva* and *Aggressività olfattiva*. *Vinosità* was correlated with *Aromi fruttati, Aromi florali, Franchezza olfattiva* and above all *Valutazione complessiva*.

Numerous taste descriptors showed positive linear relationships. For example, *Sapidità* was correlated with *Valutazione complessiva* and *Persistenza del gusto*.

PCA applied to the complete data-set revealed three factors with an eigenvalue higher than 1 (Table 8), accounting for 74% of the variance (47, 18.9 and 8.4% respectively).

For red vinegars, the R^2 calculated for the linear regression of two principal components with *Valutazione complessiva* was 0.89 ($F = 79.54$, $p < 0.01$). The descriptors that had the most influence on *Valutazione complessiva* were *Armonia del gusto, Armonia dei profumi, Limpidezza, Aromi florali, Franchezza olfattiva, Aromi fruttati, Componente rossa, Componente mattone* and *Vinosità* (Table 9).

Both *Componente mattone* and *Componente gialla* had negative coefficients. This indicates that the assessors did not appreciate vinegars with yellow–orange colour. Finally, the preference of assessors for clear white vinegars was re-confirmed while the high coefficient of *Vinosità* for the first principal component confirmed its influence on *Valutazione complessiva*.

CONCLUSIONS

It was possible to come to a sensory characterisation of a number of vinegars with the application of multivariate methods using models that are easy to interpret and that lend themselves to reclassification. The accuracy of the models underlined the suitability of most of the sensory parameters selected for the sensory card, since they were used to discriminate between the characteristics of various categories of vinegars.

Although the analysis of a large number of foreign samples will be helpful in obtaining a broader range of responses, the number of wine, apple and alcohol vinegars examined was sufficient for the sensory characterisation of both white and red products.

Using multivariate statistical analysis it was possible to characterise the relationships between *Valutazione complessiva* and sensory parameters, in the form of two linear equations, for white and red vinegars, which always

TABLE 8. Loading Values of Sensory Descriptors of Red Vinegars, with the Exception of *Valutazione complessiva*. The Table Shows Coefficients with the Highest Absolute Value for Each Parameter

	Factor 1	Factor 2	Factor 3
Armonia del gusto	0.836		
Armonia dei profumi	0.828		
Limpidezza	0.807		
Aromi florali	0.785		
Franchezza olfattiva	0.761		
Aromi fruttati	0.707		
Componente rossa	0.666		
Componente mattone	−0.601		
Vinosità	0.594		
Aggressività olfattiva		0.892	
Intensità olfattiva		0.867	
Persistenza del gusto		0.821	
Sapidità		0.632	
Componente gialla			−0.848
Intensità del colore			0.602

TABLE 9. Statistical Presentation of the Coefficients of the Regression of Principal Components on *Valutazione complessiva* for Red Vinegars

	B	SE B	Beta	T	Sig T
Factor 1	0.128	0.009	0.795	12.992	**
Factor 2	0.034	0.009	0.213	3.485	**
Factor 3	0.075	0.009	0.465	7.594	**
(Constant)	0.535	0.009		55.156	**

included *Limpidezza, Armonia dei profumi, Armonia del gusto* and *Franchezza olfattiva*. Although chemical-physical analysis imposed for the legal evaluation of products remains an important factor, sensory analysis has proven to be a simple and reliable tool for assessing the quality of vinegars, on condition that it is carried out with trained assessors, using methodological criteria that provide for the statistical processing of results.

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