Qualitative data analysis for an exploratory sensory study of *grechetto* wine

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ABSTRACT

Grechetto is a traditional white-grape vine, widespread in Umbria and Lazio regions in central Italy. Despite the wine commercial diffusion, little literature on its sensory characteristics is available. The present study is an exploratory research conducted with the aim of identifying the sensory markers of *Grechetto* wine and of evaluating the effect of clone, geographical area, vintage and producer on sensory attributes.

A qualitative sensory study was conducted on 16 wines, differing for vintage, Typical Geographic Indication, and clone, collected from 7 wineries, using a trained panel in isolation who referred to a glossary of 133 white wine descriptors. Sixty-five attributes identified by a minimum of 50% of the respondents were submitted to a correspondence analysis to link wine samples to the sensory attributes. Seventeen terms identified as common to all samples are considered as characteristics of *Grechetto* wine, 10 of which olfactory: fruity, apple, acacia flower, pineapple, banana, floral, herbaceous, honey, apricot and peach.

In order to interpret the relationship between design variables and sensory attributes data on 2005 and 2006 wines, the 28 most discriminating descriptors were projected in a principal component analysis. The first principal component was best described by olfactory terms and the second by gustative attributes. Good reproducibility of results was obtained for the two vintages.

For one winery, vintage effect (2002–2006) was described in a new principal component analysis model applied on 39 most discriminating descriptors, which globally explained about 84% of the variance. In the young wines the notes of sulphur, yeast, dried fruit, butter, combined with herbaceous fresh and tropical fruity notes (melon, grapefruit) were dominant. During wine aging, sweeter notes, like honey, caramel, jam, become more dominant as well as some mineral notes, such as tuff and flint.

1. Introduction

Sensory descriptive analysis has been widely used for characterization and discrimination across wines. Quantitative techniques have been since long applied to show the wine's distinctiveness on basis of cultivar [1–3], geographical area of origin [4–6], or vintage [2]. However, quantitative sensory methods require a long-lasting training of the panellists to obtain reliable results, particularly for complex food matrices, such as wine. Sensory studies have been recently conducted by using qualitative evaluation approaches such as a descriptive analysis with a free vocabulary technique [7,8] or sorting [9–12]. Correspondence Analysis (CA) [13,14] for the former, and Multidimensional Scaling (MDS) [15], or DISTATIS [16] for the second, are the common methods used for data reduction and analysis.

Grechetto is a traditional white-grape vine, widespread in Umbria and Lazio regions in central Italy. It is the primary white-grape of Controlled Denomination of Origin (CDO) Orvieto and it is also used in the production of CDO Torgiano (Umbria). *Grechetto* wine has a distinctive dry fruit character, which allows it to make a typical very sweet Italian wine (Vin Santo – holy wine). It is often blended with the more widespread but less valuable Trebbiano Toscano and Malvasia grapes.

Despite the wine commercial diffusion, no scientific literature on its sensory characteristics is available. To contribute filling this gap, a qualitative sensory study was undertaken addressing the following aims: identifying the main sensory markers of *Grechetto* wine and evaluating differences in terms of clone, geographical area, vintage and winery.

2. Materials and methods

2.1. Wine samples

Seventeen commercial wines, all in 750 mL glass bottle with cork, were collected (5 bottles for vintage) from 7 wineries of the *Grechetto* production area. The wines were stored at $10 \pm 1\,^\circ$C in the dark until analyses.

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Table 1
Grechetto wine sample origin.

Wine sample	Winery	Vintage	Ethanol (% v/v)	Cultivation area	*Grechetto* grapevine clone	Soil texture	Typical Geographical Indication (TGI)
Bi05	Bigi	2005	12.5	Ponte Giulio	G109[c]+G5[d]	VIT[a]	White Umbria
Bi06		2006	12.5				
Ba05	Barberani	2005	13.5	Orvieto	G5[d]		
Ba06		2006	13.5				
Ca05	Cardeto	2005	12.5	Baschi	G109[c]+G5[d]	VIT2[b]	
Ca06		2006	12,5				
Pa05	Palazzone	2005	14	Rocca Ripesena	G5[d]	VIT[a]	
Pa06		2006	14				
Le05	Leonardi	2005	13	Montefiascone	G109[c]+G5[d]		Lazio
Le06		2006	13				
Pz05	Pazzaglia	2005	12.5	Bagnoregio	G109[c]+G5[d]		
Pz06		2006	12.5				
Mo02	Mottura	2002	13.5	Civitella d'Agliano	GPC+G[e]		Civitella d'Agliano
Mo03		2003	13.5				
Mo04		2004	14				
Mo05		2005	14				
Mo06		2006	14				

[a] VIT, volcanic-ignimbritic-tuffaceous, from Bolsena volcanic lake. Igneous rocks eroded by river and gravitative morphogenetic process.

[b] VIT2, volcanic-ignimbritic-tuffaceous, from Bolsena volcanic lake. Igneous rocks eroded by river and gravitative morphogenetic process, presence of fluvial-lacustrine sediments. Marl-arenaceous relief.

[c] G109, biotype *Grechetto* di Orvieto

[d] G5, biotype *Grechetto di Todi*; respect to G109 it has a smaller bunch and best qualitative characteristics, suitable for in purity winemaking, greater resistance to the drought and a best adaptability to the short pruning.

[e] GPC + G is a blend of a private clone *Poggio della Costa* (80%) + other local clones (20%).

The standard production procedure of wines consisted in destemming and crashing of *Grechetto* grapes before their skin maceration and softly pressing of pomaces. After the must settling down, the alcoholic fermentation is induced using selected yeast and controlled temperature (18–20 °C). At the end of fermentation, the wine is racked and the SO_2 level is adjusted to prevent oxidation and malolactic fermentation. It is then stored in stainless steel tank for the stabilization process. Finally, the wine is filtered and bottled.

Wine sampling differed for vintage, Typical Geographic Indication (TGI), cultivation area, grapevine clone and soil texture (Table 1). From a preliminary screening of the wines, Palazzone samples from vintage 2006 (Pa06) resulted in outlying olfactory profile for the dominance of oxidation notes. For this reason, this wine was not considered in the main sensory sessions, which were indeed conducted on 16 wine samples.

2.2. Sensory evaluation

Ten wine-tasting panellists (5 women and 5 men; mean age 45) participated to a qualitative study of wine description referring to a list of a hierarchically structured vocabulary of white wine descriptors (Table 2). These panellists, who are part of a trained panel with a long experience (12–20 years) in sensory evaluation, were already specifically trained in the recognition of odour attributes of wines by using the Olfactorium® Wine Aromas Kit of 144 aromas specific to wine (Cinquième sens, Paris, France). The panellists were also skilled to recognise common wine defects (oxidation, cork, volatile acidity) since a previous EU project (ProfiSens SMT-4-CL98–2227). Panellists were provided with a total list of 133 attributes of visual, olfactory and gustatory characteristics and were asked to select the terms that best described the wines' sensory properties. Aroma attributes were selected from the standardized wine aroma terminology proposed by Guinard and Nobel [17], whereas colour and gustatory attributes corresponded to classes of different intensities of the same sensory characteristic (categorical variables). Panellists individually selected from the list the attributes fitting each wine and a matrix of the elicitation frequency of each attribute from this list was constructed. Sixty-five attributes were retained for analyses excluding the descriptors elicited by less than 50% of the respondents and only once or twice for the sample (Table 3).

Previous to serving, the wine samples were tasted for defects of oxidation or cork by the panel leader who was qualified to do this.

Evaluations were conducted in a sensory laboratory equipped with facilities for individual work. The environment for tasting was controlled as required by the international standard (ISO 8589)

Table 2
Original list of 133 white wine descriptors.[*]

Visual descriptors

White (paper), yellow-white, greenish-yellow, straw colour, golden-yellow, amber, amber brown

Olfactory descriptors

Floral—linalool, orange blossom, acacia flower, rose, violet, geranium
Spicy—cinnamon, cloves, black pepper, liquorice, anise
Fruity—citrus fruit (grapefruit, lemon)
      berries (blackberry, raspberry, strawberry, blackcurrant)
      stone fruit (cherry, apricot, peach)
      pomacee (pear, apple)
      grape (Muscat grapes)
      tropical fruit (pineapple, melon, banana)
      dehydrated fruit (fig, prune, raisin)
Candy caramel, caramel, chocolate, coffee, golden syrup, jam/jelly, honey, milk and honey candies
Toasted/smoked—smoke, toast
Yeast—dough, bread crust, malt, beer, butter
Dry fruit (nutty)—almond, walnut, hazelnut
Vegetal—fresh herbaceous (grape stalk, fresh cut grass, pepper)
      canned (olive, artichoke, asparagus, green beans)
      dried (hay,/straw, tobacco, tea)
      herbs (basil, sage, rosemary, fig leaf)
Boisè—phenolic (phenol, vanilla)
      resinous (pine, cedar, eucalyptus, meant, oak, cork)
Mineral—tuff, flint/silica, sulphur

Gustatory descriptors

Sapid—unsalty, salty/sapid
Alcoholic—low alcohol, quite alcoholic, alcoholic, very alcoholic
Acidity—slightly sour, quite sour, sour, very sour, tart
Bitterness—no bitter, slightly bitter, bitterish, bitter
Sweetness—dry, lightly dry
Astringency—soft, numbing, parching, dry, harsh
Body—light, supple, mouth-coating, rich
Persistence—low, medium, high, very high

[*] Modified from Guinard and Noble [17].

Table 3
List of descriptors (65) selected for *Grechetto* wine.

Visual descriptors
Yellow-white, greenish-yellow, straw colour, golden-yellow
Olfactory descriptors
Floral, orange blossom, acacia flower, rose, geranium
Spicy, black pepper
Fruity, citrus fruit (grapefruit, lemon)
stone fruit (apricot, peach)
pomacee (pear, apple)
grape
tropical fruit (pineapple, melon, banana)
dehydrated fruit
Caramel, jam/jelly, honey
Yeast, butter
Dry fruit (nutty), almond
Vegetal, Fresh herbaceous
dried (hay,/straw)
herbs
Boisè, phenolic (vanilla)
resinous
Mineral, tuff, flint/silica, sulphur
Gustatory descriptors
Sapid—unsalty, salty/sapid
Alcoholic—quite alcoholic, alcoholic
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Body—light, supple
Persistence—low, medium, high

Fig. 1. Plot of attributes derived by Correspondence Analysis (CA) *Internal dashed circle**: Acacia flower, fruity, lemon, pomacee, apple, tropical fruit, pineapple, melon, banana, dried herbaceous, boisè, resinous, salty/sapid, sour, no bitter, soft, numbing, medium persistence and *External continuous circle**: straw colour, floral, geranium, spicy, citrus fruit, grapefruit, stone fruit, apricot, peach, caramel, jam, honey, dry fruit, almond, vegetal, herbs, phenolic, mineral, unsalty, quite alcoholic, alcoholic, slightly sour, quite sour, slightly bitter, dry, supple body, high persistence. * Attributes are listed according to Table 3 hierarchy.

[18]. Panellists seated in separate booths and there was a uniform source of lighting and absence of noise and distracting stimuli. Ambient temperature was between 19 and 23 °C throughout the day. The tests were performed over three days. Each day the assessors participated to two 1-h sessions with 20-min break. During the test sessions, all panellists evaluated the complete set of samples presented twice from different bottles. In each session, the panellists evaluated from 5 to 6 wines, which were allocated at random to the session. Within a session each participant received the wines is a unique order according to a Latin Square Design in order to balance serving order and carryover effects [19]. Wines were served at 22 ± 2 °C temperature (50 mL) in standard wine-tasting glasses (ISO 3591) [20] coded for anonymity purposes. Mineral still water and unsalted crackers were available for palate cleaning.

2.3. Data analysis

Univariate statistical analyses were performed using the SPSS version 14.0 for Windows statistical package (SPSS Inc, Chicago, IL, USA).

In order to study the association between wines and sensory attributes, a Correspondence Analysis (CA) was run (XLSTAT Version 1.02). Principal component analysis (PCA) was then performed on a reduced set of wine descriptors based on percent frequency elicitations to find the main aroma, taste and mouth-feel terms of the wines using the Unscrambler (Windows Version 9.6 software package, CAMO A/S, Trondheim, N). Full cross validation was used as validation criterion.

3. Results and discussion

3.1. Key dominant aroma attributes of Grechetto wine samples

With the aim of establishing the descriptors characteristic of *Grechetto* wine, the total set of samples (16) was considered, and
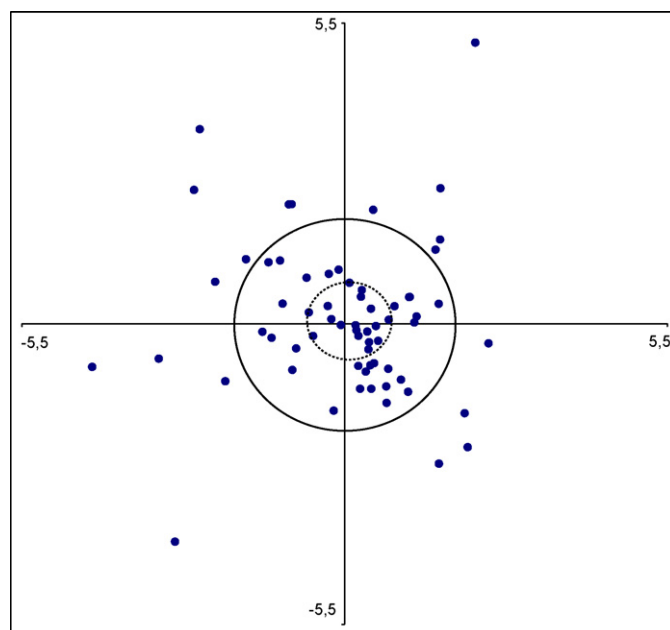
the attributes' elicitation frequency matrix was submitted to a Correspondence Analysis to link the wine samples to sensory attributes (Fig. 1). From the figure, attributes that lie within the external circle (continuous line) were identified in at least 50% of the wine samples, whereas 18 key attributes, which lie close to the axes' origin, within the internal circle (dashed line), were common to more than 80% of the wines. Among these attributes there were 12 odour descriptors, namely acacia flower, fruity, lemon, pomacee, apple, tropical fruit, pineapple, melon, banana, dried herbaceous, boisè, resinous. We consider these attributes the *Grechetto* key odourants of the sample set.

3.2. Grechetto attributes and sampling design

In a second step of analysis, only the wines, from vintages 2005 and 2006 (13 wines), were considered to explore the relationship between *Grechetto* attributes and sampling design variables (vintage, grapevine clone, cultivation area, soil texture, winery).

A Principal Component Analysis was applied on the reduced data set of 65 attributes per 13 samples with the aim of interpreting the sensory descriptor variation among wines. Since only 28 of them contributed to the model in a meaningful way (≥40% explained variance), the analysis was repeated with 28 attributes. A three-dimensional model explained 75% of the variance in the data. The first two principal components are illustrated in Fig. 2A and B. The model did not highlight differences among wines for vintage, winery or soil. Wine samples are grouped on the plane according to the clone of origin. A clear separation of the clones G5 and GPC+G is given along the first dimension (36% of variance) and of the combined clones G109+G5 on the positive semi-axis of the second dimension (27% of variance) by G5 and [GPC+G], on the negative semi-axis. However, Le05 occupies a misleading position.
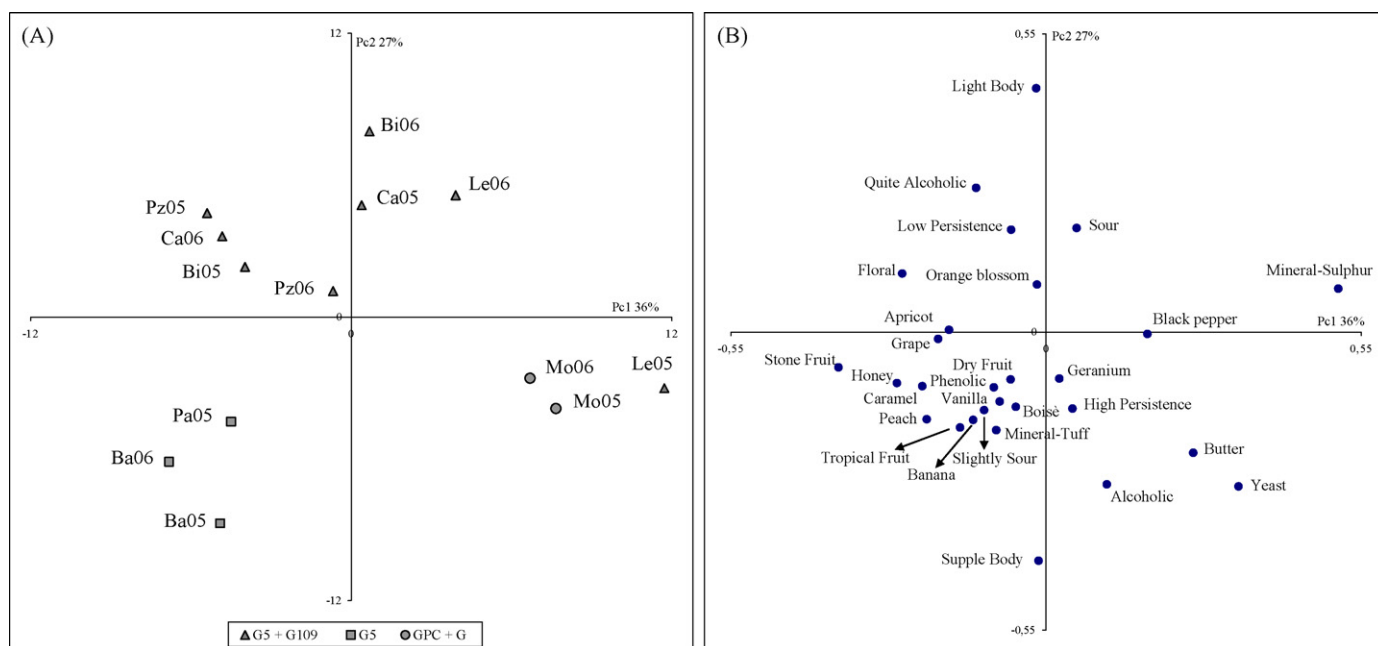
Fig. 2. (A and B) Plot of samples (2005–2006) and attributes on the first two principal components.

The first principal component (PC1) was best described by odourants. The attributes stone fruit (77% of variance), honey (66%), caramel (55%), grape (54%), floral (49%) and apricot (31%), were best explained. There were more occurrences of these descriptors in the wines derived by the clones G5 and G109+G5 (negative semi-axis). In the wine GPC+G (positive semi-axis) mineral (88%), butter (50%) and yeast (48%) descriptors were detected.

The second dimension (PC2) related better to the mouth-feel attributes: quite alcoholic (50%), sour (30%), light body (80%) and low persistence (51%) (positive loadings), alcoholic (50%), slightly sour (25%), supple body (85%), high persistence (34%) (negative loadings). Wines derived by the clones G5+G109 were distinguished by those derived from G5 and GPC+G along this dimension for their higher sour taste and lower alcoholic, body and persistence. Some odour notes have a portion of variance explained by PC2, like orange blossom (47%), mineral-tuff (36%), boisè (35%) and geranium (28%). Moreover, the odour notes of vanilla (60%), banana (4%), tropical fruit (39%) and dry fruit (26%), were perceived in the wines derived by the clones G5 and GPC+G.

A third significant dimension provided an additional 12% of variance explained by the odours of black pepper and peach that distinguished between two TGI (Lazio and Civitella d'Agliano) besides by some gustatory descriptors. Black pepper was a characteristic odourant of Leonardi wines, and peach of Mottura wines.

3.3. Grechetto attributes and vintage

In order to investigate wine differences related to vintage, the five samples (2002–2006) from Mottura winery were described in a new Principal Component Analysis (dataset of 65 attributes per 5 samples). The PCA was then repeated on the most discriminating descriptors (39 terms) selected on basis of their expressed variance (≥40%) on the first two dimensions, which globally explained 84% of the total variance. Scores for each wine and descriptors on the two components are projected in Fig. 3. The first principal component distinguishes vintages 2002 and 2003, located on the negative semi-axis from vintages, 2005 and 2006 on the positive semi-axis. In the young wines, the notes of sulphur (99% of variance), yeast (91%), dehydrated fruit (52%), butter (47%), combined

with fresh herbaceous and tropical fruit (melon, grapefruit) were dominant, whereas with the wine aging (vintage 2002 and 2003) sweeter notes, like honey (97%), caramel (83%), jam (68%), became more dominant as well as some mineral notes, such as tuff and flint. On basis of these results, the wine age olfactory differences seems to became noticeable after 3 years' bottle fining. Particularly, the mineral-sulphur note, which is frequent in the young wines, evolved into tuff and flint mineral nuances, whereas yeast and butter were replaced by sweeter notes of honey and caramel.

The second principal component describes differences among 2002 and 2003 wines. Best explained descriptors were floral (79%), acacia flower (64%), spicy (54%), lemon (65%), apricot (70%),
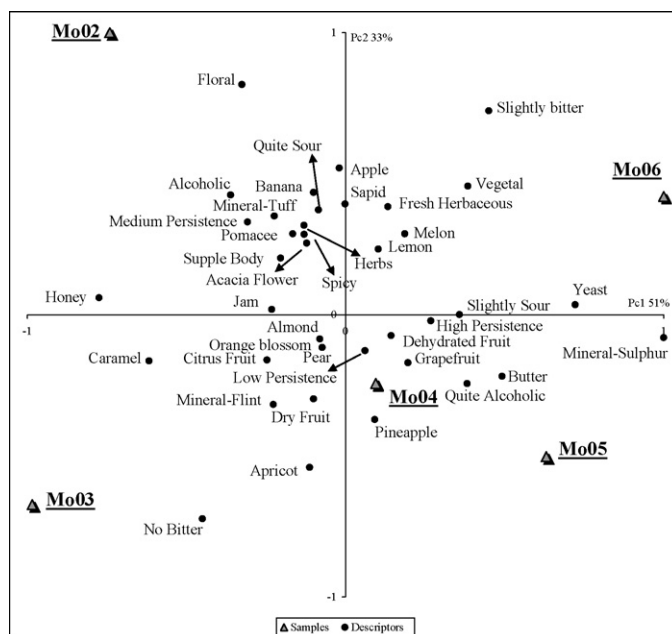

Fig. 3. Bi-plot of a principal components analysis for studying the vintage effect over years (2002–2006).

pomacee (51%), apple (93%), pineapple (84%), banana (89%), dry fruit (59%), herbaceous fresh (68%), and the gustatory attributes of sapid (73%) and quite sour (65%).

4. Conclusions

Although its exploratory nature, the study highlights new interesting findings about the sensory characteristics of *Grechetto* wines.

Correspondence Analysis applied on elicitation frequencies of wine descriptors resulted to be a preliminary but useful tool for identifying and selecting *Grechetto* wine attributes. Key odourants extracted from the elicitation frequency data matrix were: acacia flower, fruity, lemon, pomacee, apple, tropical fruit, pineapple, melon, banana, dried herbaceous, boisè, and resinous.

Grapevine clone seemed to be the design variable having a major effect on the sensory asset of one or two-year *Grechetto* wines, whereas vintage, winery, cultivation area and soil were not relevant to distinguish the wines.

The vintage effect, explored for 1 winery over 5 years, highlighted noticeable sensory differences after three years' bottle fining.

Further research on an extensive set of *Grechetto* wine is needed to confirm these results in view of its identity improvement and promotion.

Acknowledgement

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