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Sensory characters of Cabernet Sauvignon dry red wine from Changli County (China)

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ABSTRACT

The aromas of Cabernet Sauvignon red wines from eight vintages in Changli County (China) were evaluated by sensory analysis. A panel was trained to assess wine aroma by a "Le Nez du Vin" aroma kit. Measurements of the olfactory threshold and aroma discrimination ability of panelists were taken before and after the training. Student *t* tests showed that training reduced the olfactory threshold and improved the aroma discrimination ability of the panelists. Sample wines were analyzed in duplicate by trained panelists over five sessions using a balanced, complete block design. Aroma description of wine was expressed by "modified frequency (*MF*)". Principal component analysis (PCA) performed on "*MF*" data showed that Cabernet Sauvignon wines from Changli County were characterized by blackcurrant, green pepper, smoke, redcurrant, cut hay, vanilla, bilberry, and cinnamon aromas.

1. Introduction

Geographical indication of wine is a new concept in China but has a longer history in Europe, where it is a central part of agricultural policy (Li, 2001). The unique chemical and sensory characteristics of a product from a specific geographical area give the product *typicité*, meaning that the product is representative of its *terroir*. Currently, China has four districts used for denomination of wine origins, one of which is Changli County. Winemaking is the principal economic activity of the County, and the main red grape variety used is Cabernet Sauvignon. In Changli County, the growing area of Cabernet Sauvignon is 2400 ha, which is 72% of the total grape planted areas. With so much Cabernet Sauvignon wine produced in Changli County, there is a need to define the characteristics of the red wine made there.

The *Vitis vinifera* grapevine is capable of expressing distinctive flavor characteristics as a function of its physical and cultural environment. Wine aroma is an important aspect of wine quality, and the flavor of wine is one of the most important attributes to consumers when buying wine. Several authors have studied the aromatic profiles of wines of many varieties, using descriptive analysis (Cliff & Dever, 1996; Parr, Green, White, & Sherlock, 2007). A study of the sensory profile of 56 Champagne wines started with 64 attributes, which were subsequently reduced to 19: five olfactory, three gustatory, five fruity, and six miscellaneous (Vannier, Brun, & Feinberg, 1999). Sensory characteristics of Canadian ice wines showed that wines from Ontario had apricot, raisin, honey, and oak aromas, while wines from British Columbia had higher intensities of pineapple and oxidized aromas (Nurgel, Pickering, & Inglis, 2004).

Aroma analysis was applied to Cabernet Sauvignon wines very early. The aroma of Merlot and Cabernet Sauvignon wines from the Bordeaux region of France is often described as fruity or floral with roasted, woodsmoke, and cooked meat nuances; it is also often described as herbaceous, especially for the Cabernet Sauvignon wines (Allen, Lacey, & Boyd, 1994; Allen, Lacey, Brown, & Harris, 1990; Peynaud, 1980). A study of commercial Merlot and Cabernet Sauvignon wines in Australia and California showed that both wines were characterized by highly fruity, caramel, green, and earthy aromas. Merlot wines from both areas contained 4–5 times more ethyl octanoate than Cabernet Sauvignon wines from the same sources (Gurbuz, Rouseff, & Rouseff, 2006). In another study, differentiation of the wines of these two varieties was significant only for the caramel descriptor, which was rated higher in the Merlot wines (Kotseridis, Razungles, Bertrand, & Baumes, 2000). The aromas of Cabernet Sauvignon wine from Brazil feature "bell pepper" for wines from higher altitudes, while wines from lower altitudes have "red fruits" and "jam" aromas. Altitude and other local climate factors can exert an important effect on grape maturation and thus the composition of wine (Falcao et al., 2007).

With the rapid development of wine production in China, the typicality and characters of Chinese wine began to attract people's attention. However, sensory data of Chinese wine are scarce, especially for wines with a denomination of origin. The aim of this work was to define the typical aromas of Cabernet Sauvignon

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wines produced in Changli County (China) and to determine the effect of training on a panel of assessors.

2. Materials and methods

2.1. Wine samples

Cabernet Sauvigion wine from the 1998–2005 vintages (supplied by Huaxia winemaking company and Yueqiannian winemaking company, both in Changli County) was used to carry out sensory analysis.

Wine making: Sound grapes of Cabernet Sauvignon were obtained from the vineyard, destemmed and crushed on a commercial grape destemmer-crusher, and pumped to stainless steel tanks. The must was treated with sulfur dioxide (45 mg/L) in the tank and soaked about 24 h. The fermentation temperature was 25–30 °C. After fermentation, the wines were racked and experienced malo-lactic fermentation. When malic acid conversion was complete, the wines were then racked, and more sulfur dioxide (75 mg/L) was added. They were stored at 15 °C in stainless steel tanks, and normal racking and stabilizing processes were carried out. Wines used in the analysis did not undergo any ageing in oak barrels.

Reducing sugars, density, ethanol, extract, titratable acidity, pH, volatile acidity, and total and free SO_2 of the sample wines were analyzed with the methods of the Office International de la Vigne et du Vin (O.I.V., 1990). Results are shown in Table 1.

2.2. Panel training

Thirty members of the panel were students of the College of Enology, Northwest A & F University, China. They were selected on the basis of their interest and availability, and ages ranged between 21 and 24 years old (18 males/12 females). Panelists were trained over a period of 70 days to assess wine aroma using a "Le Nez du Vin" aroma kit (supplied by Ease Scent Company, Beijing, China). The "Le Nez du Vin" aroma kit is composed of 54 vials, where each vial contains one typical aroma character in wine, such as Blackcurrant, Green pepper, Smoke, Prune, Cut hay, Mint, Violet, etc. The training was carried out three times each week for 60–90 min. There was an aroma identification test every weekend.

2.3. Evaluation of training

Measurements of olfactory threshold and aroma discrimination ability of panelists were taken before and after the training. Four reference compounds with different aromas were dissolved in synthetic wines. The synthetic wine contained 11% (v/v) alcohol, 6 g/L of tartaric acid, and a pH of 3.3–3.4 adjusted with 1 M NaOH. Each chemical solution had five continuously declining concentrations, which were designed according to the olfactory threshold (GB/T15549-1995,). A triangular test method was used; that is, there were one or two controls in three glasses. The panelist was required to detect the glass containing the reference chemical. The lowest concentration perceived by the panelist was the olfactory threshold of that reference chemical. After training, if the olfactory threshold of one reference was reduced, the panelist could get one score.

To determine aroma discrimination ability, Cabernet Sauvignon wine of 2006 was selected as the reference wine. Three other wine samples were created by adding isopentyl alcohol (300 mg/L, bitter almond note), ethyl acetate (100 mg/L, pineapple flavor) and isopentyl acetate (3 mg/L, banana flavor), respectively, to the reference wine. These four wine samples could comprise 10 groups via couple partnership. A comparison test was used in which the taster needed to detect whether two wine samples in one group were similar. When one group was correctly detected, the panelist received one score.

Table 1
General composition of Cabernet Sauvignon must and wine

Composition	Ranges
Must composition	
Titratable acidity[a](g/L)	9.3–9.7
pH	3.2–3.4
Reducing sugars (g/L)	191–200
Wine composition	
Density (20°C)	0.991–0.994
Ethanol (%, v/v)	10.4–12.1
Reducing sugars (g/L)	0.78–1.82
Extract (g/L)	21–25
Titratable acidity[a] (g/L)	3.6–4.5
pH	3.3–3.6
Volatile acidity[b] (g/L)	0.46–0.71
Free SO_2 (mg/L)	11–19
Total SO_2 (mg/L)	90–121

[a] As tartaric acid.
[b] As acetic acid.

2.4. Sensory analysis

Cabernet Sauvignon red wines from eight vintages were analyzed in duplicate by trained panelists over five sessions using a balanced, complete block design. Each test session consisted of two flights, and each flight contained four wine samples coded with random three-digit numbers, with the order of samples randomized in each flight. Wine samples were stored at 10 °C and presented at 15 °C (20 mL) for the detection of odor and aroma. The panelists were encouraged to use the aroma terms of "Le Nez du Vin" and were asked to choose the five or six most significant terms to describe the wine aroma. Panelists also needed to score the intensity of each term using a 5-point scale: (0) not detected; (1) weak, hardly recognizable note; (2) clear, but weak; (3) clear but not an intense note; (4) intense note. The data processed were a mixture of intensity and frequency of detection ("modified frequency", *MF*), which was calculated with the formula proposed by Dravnieks (1985) and GB/T15549-1995,:

$$MF = \sqrt{F(\%)I(\%)}$$

where $F(\%)$ is the detection frequency of an aromatic attribute expressed as a percentage and $I(\%)$ is the average intensity expressed as a percentage of the maximum intensity.

The aroma training and analysis was conducted in the wine sensory laboratory from March to July in 2006. The environment for tasting was controlled as advised for sensory laboratories (ASTM, 1986) and international wine competitions (O.I.V., 1994). There was a uniform source of lighting, absence of noise and distracting stimuli, and ambient temperature was between 19 and 22 °C throughout the day. Participants were then seated in separate booths. In all cases, solutions or wines (20 mL) were presented in coded, tulip-shaped wine glasses covered by glass petri dishes. samples were presented in a random order.

2.5. Data analysis

All statistical analyses were performed using the SPSS version 13.0 for Windows statistical package (SPSS Inc, Chicago, IL, USA). Student *t* tests were used to evaluate improvements in the olfactory threshold and aroma discrimination ability of panelists. Correlation analysis was performed to detect the correlation of the olfactory threshold and aroma discrimination ability of panelists.

Principal component analysis (PCA) was performed on *MF* data of aroma descriptions to find the dominant aroma terms of the wines.

3. Results and discussion

3.1. Evaluation of training

In the test of olfactory threshold, chemical solutions were presented to tasters. The chemicals were isopentyl acetate, isobutyl alcohol, acetaldehyde, and ethyl acetate. More details are shown in Table 2. The olfactory threshold and aroma discrimination ability of panelists were detected before and after the training.

In many previous wine sensory analyses, panelists were free to generate and define their own vocabulary. In a reliable sensory panel, the sensory analysis score of each taster is required to not be significantly different from the average score. Therefore, training of the panelists was conducted not only to improve the sensory analysis ability of the panelists but also to exclude unsatisfactory panelists and to select typical sensory descriptions in sample wines (Aznar, Lopez, Cacho, & Ferreira, 2003; Tsakiris et al., 2006). In our work, the panelists were asked to describe wine aromas with the aroma terms in the "Le Nez du Vin" training tool. It was necessary to make sure that the olfactory threshold and aroma discrimination ability of the panelists were improved by the training tool. Table 3 shows the result of data processing of the panelists' olfactory thresholds and aroma discrimination abilities. The variances of the two data sets of olfactory threshold before and after the training were equal. However, training improved the mean score of panelists by 1.733, and training reduced the panelists' olfactory thresholds significantly. Furthermore, after training, the standard error of score data decreased from 0.487 to 0.419. The variances of the two data sets of panelists' aroma discrimination abilities before and after the training were also equal. However, training improved the mean score of panelists by 1.100, and training increased the panelists' aroma discrimination abilities significantly. Furthermore, after training, the standard error of score data decreased from 0.279 to 0.265.

Correlation analysis showed there was no correlation between the olfactory threshold and aroma discrimination abilities of the panelists. The cure of the relationship between these two indexes is shown in Fig. 1.

Table 2
The concentration of reference compounds used to determine olfactory threshold

Compounds	Concentration (mg/L)				
	1	2	3	4	5
Isopentyl acetate	0.016	0.032	0.063	0.125	0.25
Isobutyl alcohol	3.75	7.5	15.0	30.0	60.0
Acetaldehyde	0.32	0.63	1.25	2.5	5.0
Ethyl acetate	3.2	6.3	12.5	25.0	50.0

Table 3
Results of the data processing of panelists' olfactory thresholds and aroma discrimination abilities

Item	Test of olfactory threshold		Test of aroma discrimination	
	Before training	After training	Before training	After training
Number	30	30	30	30
Mean	12.167	13.900	4.267	5.367
Standard deviation	2.666	2.295	1.530	1.450
Standard error	0.487	0.419	0.279	0.265
95% confidence intervals	11.171–13.162	13.043–14.757	3.695–4.838	4.825–5.908
Homogeneity of variance test	$F = 1.350$, $p = 0.424$		$F = 1.1132$, $p = 0.7748$	
Test of mean difference	$t = 2.699$, df = 58, $p = 0.009$		$t = 2.859$, df=58, $p = 0.006$	

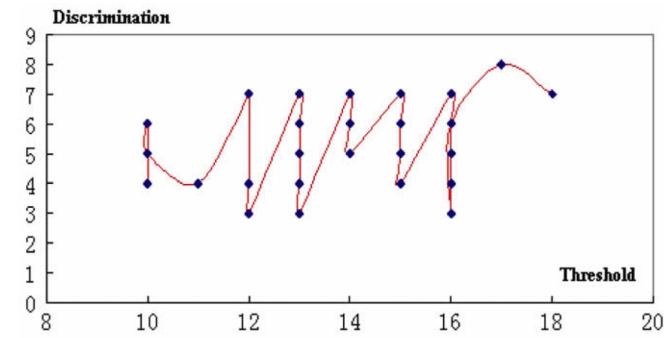

Fig. 1. The cure of the relationship of olfactory threshold and aroma discrimination ability.

3.2. Aroma description analysis

Gillette suggested that aroma description analysis in olfactometry could detect differences between food products (Gillette, 1984). In most of wine sensory studies reported recently, the using frequency was used to select some impact aroma characters of sample wines, and then the intensities of those selected characters were analyzed (Kontkanen, Reynolds, Cliff, & King, 2005; Koussissi, Paterson, & Piggott, 2003; Nurgel et al., 2004; Vannier et al., 1999). However, in these studies, panelists were asked to describe wine aroma with their own vocabulary, which increased subjective factors.

In fact, in the process of aroma description analysis, panelists subjectively describe aroma characters and allocate intensities to those aroma terms. It is therefore necessary to train them by exposure to adaptive aroma characters before having them perform their analysis. Description terms in food olfactometry are not discretional. Therefore, description terms for food analysis are often selected by statistical methods (Danzart & Sieffermann, 2001). In our research, aroma terms in the "Le Nez du Vin" kit were used to train panelists, and panelists were asked to define the aroma of sample wines with these training terms. These terms have exact meanings and cover almost all of the aroma characters of wine. Furthermore, in order to synthesize information on frequency and intensity of aroma terms, the aroma description analysis of sample wines was expressed by modified frequency (*MF*). During processing of the sensory analysis data, some aroma terms with relatively low *MF* values (<0.05) were omitted. Therefore, 32 aroma terms remained. The *MF* of these 32 aroma terms are shown in Table 4. Principle component analysis (PCA) was applied to all aroma term data to obtain a more simplified view of the total aroma characters of the sample wines. The first six PCs represented 96.89% of total variance, so those PCs after PC7 made very little contribution to the total variance. However, several terms had much heavier loadings for those PCs after PC7. In order to get more convictive results, these aroma terms were deleted, including soil, mulberry, coffee, prune, cherry, leather, green grass, cedar, strawberry, mushroom, and violet. PCA was then applied to the remaining data.

The second PCA yielded four principal components explaining >80% of the total variance in the data (Table 5). Loading values (i.e., correlation coefficients) >0.700 were marked throughout

Table 4
The modified frequency (*MF*) of aroma of Cabernet Sauvignon dry red wines from eight vintages in Changli County.

	Aroma terms	Vintages							
		1998	1999	2000	2001	2002	2003	2004	2005
1	Blackcurrant	0.535	0.576	0.654	0.432	0.348	0.627	0.468	0.654
2	Green pepper	0.495	0.575	0.243	0.310	0.581	0.611	0.566	0.479
3	Smoke	0.343	0.391	0.327	0.282	0.333	0.411	0.561	0.512
4	Prune	0.355	0.333	0.433	0.305	0.220	0.404	0.467	0.482
5	Pepper	0.287	0.265	0.333	0.203	0.299	0.237	0.386	0.299
6	Raspberry	0.321	0.327	0.186	0.240	0.253	0.272	0.231	0.350
7	Black coffee	0.271	0.321	0.341	0.158	0.196	0.287	0.282	0.310
8	Redcurrant	0.237	0.254	0.287	0.203	0.260	0.258	0.237	0.287
9	Cut hay	0.311	0.321	0.184	0.124	0.265	0.192	0.271	0.287
10	Blackberry	0.247	0.248	0.181	0.152	0.230	0.420	0.146	0.287
11	Mint	0.214	0.146	0.350	0.247	0.220	0.192	0.136	0.305
12	Truffle	0.293	0.361	0.209	0.271	0.173	0.220	0.134	0.146
13	Vanilla	0.203	0.244	0.260	0.225	0.208	0.134	0.186	0.343
14	Toast	0.288	0.311	0.085	0.181	0.214	0.394	0.181	0.111
15	Cherry	0.192	0.280	0.141	0.197	0.277	0.198	0.241	0.208
16	Mulberry	0.310	0.288	0.156	0.146	0.130	0.260	0.129	0.308
17	Violet	0.028	0.051	0.168	0.032	0.045	0.356	0.515	0.523
18	Coffee	0.197	0.161	0.237	0.197	0.136	0.197	0.237	0.243
19	Bilberry	0.152	0.173	0.164	0.207	0.107	0.265	0.192	0.277
20	Cinnamon	0.248	0.181	0.237	0.124	0.152	0.107	0.096	0.181
21	Leather	0.136	0.186	0.101	0.173	0.124	0.231	0.174	0.169
22	Liquorice	0.364	0.311	0.085	0.096	0.240	0.087	0.000	0.023
23	Eucalypt	0.000	0.000	0.124	0.175	0.124	0.184	0.248	0.163
24	Cedar	0.159	0.181	0.248	0.085	0.090	0.078	0.055	0.062
25	Coco	0.141	0.078	0.062	0.073	0.117	0.124	0.085	0.138
26	Strawberry	0.039	0.048	0.124	0.062	0.062	0.175	0.192	0.087
27	Oak	0.090	0.045	0.101	0.106	0.090	0.096	0.068	0.113
28	Mushroom	0.085	0.101	0.039	0.152	0.048	0.107	0.078	0.073
29	Caramel	0.101	0.051	0.071	0.078	0.169	0.083	0.045	0.078
30	Green grass	0.000	0.036	0.023	0.000	0.000	0.124	0.158	0.271
31	Toast almond	0.060	0.068	0.000	0.032	0.000	0.164	0.101	0.130
32	Soil	0.000	0.000	0.032	0.068	0.000	0.000	0.240	0.068

Table 5
Unrotated principal component loadings for aroma terms.

Aroma terms	Component					
	1	2	3	4	5	6
Blackcurrant	0.113	0.725	0.264	0.203	−0.436	0.208
Green pepper	0.853	0.103	−0.303	−0.283	0.325	0.077
Smoke	0.489	0.789	−0.161	−0.467	0.123	−0.179
Pepper	−0.168	0.346	0.132	−0.210	0.310	0.192
Raspberry	0.324	0.137	0.361	0.204	0.124	−0.518
Black coffee	0.222	0.241	0.599	−0.317	−0.297	0.330
Redcurrant	−0.035	0.526	0.727	−0.056	0.254	0.398
Cut hay	0.757	0.028	0.428	−0.494	0.322	−0.192
Blackberry	0.335	0.343	0.054	0.571	0.067	0.358
Mint	−0.299	0.202	0.537	0.405	0.119	0.065
Truffle	0.379	−0.422	0.277	0.158	−0.597	−0.103
Vanilla	−0.329	0.294	0.755	−0.026	0.088	−0.540
Toast	0.231	−0.238	−0.378	0.351	−0.186	0.277
Bilberry	0.232	0.797	−0.143	0.443	−0.290	−0.217
Cinnamon	−0.288	−0.246	0.926	0.122	0.029	0.068
Liquorice	0.501	−0.264	0.396	0.008	0.069	0.021
Eucalypt	−0.425	0.377	−0.186	−0.022	0.116	0.034
Coco	0.543	0.317	0.135	0.397	0.630	−0.099
Oak	−0.541	0.275	0.058	0.294	0.322	−0.039
Caramel	−0.029	−0.445	−0.003	0.311	0.604	0.190
Toast almond	0.482	0.326	−0.240	0.205	−0.131	−0.066
% of variance explained by PCs	24.172	23.231	18.938	13.771	11.253	6.224
Cumulative% of variance	24.172	47.403	66.341	80.112	91.365	97.589

Table 5 in boldface type. According to these loading values, blackcurrant, green pepper, smoke, redcurrant, cut hay, vanilla, bilberry, and cinnamon were considered the typical aroma characters of sample wines.

4. Conclusion

This work performed a sensory analysis of Cabernet Sauvignon red wines from Changli County (China). Thirty students of enology were selected to compose a sensory panel for evaluating wine aroma. They were trained with the "Le Nez du Vin" training kit before sensory analysis. In the evaluation of the training, measurements of olfactory threshold and aroma discrimination ability of the panelists were taken before and after the training. Student *t* ests showed that training reduced the olfactory threshold and improved the aroma discrimination ability of the panelists. Sample wines were analyzed in duplicate by trained panelists over five sessions using a balanced, complete block design. Panelists were asked to use the aroma terms contained in the "Le Nez du Vin" kit to define the wine aroma, and they also scored the intensity of each term using a 5-point scale. Aroma description of the wine was expressed by "modified frequency (*MF*)" in order to synthesize the information on the frequency and intensity of aroma terms. Principal component analysis (PCA) performed on "*MF*" data showed that Cabernet Sauvignon wines from Changli County were characterized by blackcurrant, green pepper, smoke, redcurrant, cut hay, vanilla, bilberry, and cinnamon aromas. Instrument analysis of aroma compounds in sample wines will be designed to find the active odorants in the wine in our next study. A correlation between sensory characters and active odorants could be built.

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