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What makes a good Bordeaux wine? A sensory characterization of Bordeaux and Bordeaux Supérieur red wines based on regression analysis

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Abstract

Purpose *- A descriptive sensory study supported by the Syndicate Bordeaux & Bordeaux Supérieur in cooperation with the marketing agency Sopexa Germany was conducted at the Geisenheim Research Center in Germany to describe selected red wines from Bordeaux.*

Design *- Altogether 171 red wines were tested using a special developed sensory evaluation system. A regression analysis was applied to investigate which of the sensory characters of these wines were related to the quality scores given by the panelists. Quality score could be satisfactorily explained by least-square model so that positive and negative sensory attributes could be defined for Bordeaux and Bordeaux Supérieur red wines.*

Findings *- Body had the strongest impact on quality scores but also attributes such as coffee, toasted oak had a significant influence. Additionally a cluster analysis showed that the test wines can be arranged in 3 groups according to their sensory properties.*

Practical implication *- This analysis gives Bordeaux winemakers valuable information about the diversity of wine styles and helps them to find their wines in the different wine groups.*

Key words: Sensory descriptive analysis, Bordeaux wine, Supérieur, Regression analysis

1. INTRODUCTION

Wine consumption has mainly a hedonic aspect, its quality is highly related to its sensory characteristics, which determinate the amount of pleasure (Jover, Montes and Fuentes, 2004). Therefore wine quality should be related to the presence and intensity of odor and flavour nuances which are perceived during its consumption (Lukic et al., 208). Sensory descriptive analysis is a scientific discipline and has been widely used for characterisation of wines (Varela and Gambaro, 2006; Ferreira et al., 2009). In this study sensory descriptive analysis and regression analysis (Saenz-Navajas et al., 2010) were combined to investigate the relationship between sensory properties and quality scores for AOC Bordeaux and Bordeaux Supérieur wines.

Bordeaux wine industry is associated with the well known 1er grand cru wines but the major part of the production is sold in a lower priced segment. In the heart of the prestigious Bordeaux wine region, the Bordeaux and Bordeaux Supérieur Appellations of Controlled Origin represent more than half of the vineyards in Gironde and with its more than 62,000 hectare, 3.3 million hl production and 6300 wine growers as well as 42 cooperatives constitute the world's largest fine wines region. The Bordeaux and Bordeaux Supérieur wines have gradually gained the Bordeaux Wine market leadership, representing nowadays 55% of all the Bordeaux wines consumed in the world (Syndicate AOC Bordeaux and Bordeaux Supérieur, 2011).

A number of studies deal with wine related regression analyses under the title ´hedonic pricing´ (Oczkowski, 1994; Nerlove, 1995; Landon and Smith 1997; Schamel and Anderson, 2003; Ling and Lockshin, 2003; Costanigro et al., 2007; Mueller and Szolnoki, 2010). However these studies only use extrinsic factors to describe the price. Combris et al. 2000 analyzed Bordeaux wines integrating also intrinsic factors in their model and showed that quality is determined by sensory characteristics but not by market price. The studies of Escudero et al., 2002 and Ferreira et al. 2009 also dealt with regression analysis and confirmed the importance of sensory characters in defining wine quality.

In this study the aroma profiles of 171 red wines were used to investigate the relationship between aroma and flavour components, colour as well as other basic characteristics and the quality evaluation[1]. This study aims the following research questions: which sensory factors of red wine have an impact on quality perception by experts and in which main groups can we separate these Bordeaux wines according to their sensory properties?

2. MATERIAL AND METHODS

2.1. Wines

This study included 171 red wines of AOC Bordeaux (40%) and Bordeaux Supérieur (60%). These wines of the vintages 2003(2), 2004(1), 2005(10), 2006(74), 2007(40), 2008(40) and 2009(3) were selected by the Syndicate AOC Bordeaux and Bordeaux Supérieur. The retail price was mainly between 8 and 20 €/bottle.

[1] Profiles of the tested wines can be found under http://www.bordeaux-bordeaux-superieur.com/weinsuche/

2.2 Panel of Judges

The panel consisted of 10 trained wine experts, half of them oenology students at the University of Applied Science, Geisenheim and half of them staff members of the Geisenheim Research Institute. The students were trained in the applied evaluation system during one semester while the staff members had participated in different projects where this method was used. Furthermore all participants were involved in training with aroma references (Jackson, 2009).

2.3 Sensory analysis

A special sensory descriptive analysis based on the Quantitative Descriptive Analysis (QDP) (Stone et. al, 1974; Stone and Sidel, 2004) was applied to describe the profiles of the red wines. First, the panelists were required to describe 10 randomly selected wines from the list without any limitation. The 15 most mentioned aroma attributes were selected and aroma references for a trained in a separate session were prepared. These aroma references were for the participants during the whole tasting available.

Beside these 15 aroma attributes the evaluation sheet of the wine tasting was extended by another 17 aroma attributes. In total the sheet included the following aroma attributes: raspberry, strawberry, red currant, black currant, blackberry, sour cherry, cherry, jam, dried fruits, violet, rose, bell pepper, eucalyptus, black tea, black pepper, liquorice, vanilla, clove, cinnamon, tobacco, caramel, coffee/mocha, chocolate, nutty, leather, toasted oak, cedar wood, bacon, butter, animal, mushroom, damp forest soil (Noble et. al 1987). Beyond that the evaluation sheets contained the following basic characteristics: colour, aroma intensity, body, sweetness, acidity, tannin, aging (Blankehorn, 1998; Jackson, 2009). Unlike QDP, the magnitude of each attribute was scored on an 8-point scale (Otremba et al., 2000), except for quality scores where experts panelists udes the official German quality point system (DLG, 2011) and scored the wines on a 5-point scale.

Before the tasting panelists evaluated collective an extra wine (standard wine) in order to have a standard for further comparison. Each panelist had during the whole tasting a glass of standard wine which they could compare with the test wines.

Six tasting sessions took place in August 2009 and also in July 2010 in sensory room under daylight. Panelists got 30 ml wine presented at 18 °C in covered standard tasting glasses marked with a three-digit code. The huge number of test wines allows only a single tasting of each wine.

A multiple linear regression analysis of 1710 cases (10 panelists x 171 wines) was carried out, searching for certain links between the quality scores and the sensory data. The software package used was STATA 11 (StataCorp LP, Texas, USA).

Cluster analysis is a statistical tool to distinguish different wines styles (Jackson 2009). A clustering including all 171 red wines was arranged with the software package SPSS 18.0 (IBM, Somers, USA). For the analysis the means of basic and aroma characters of each wine were calculated. In case of the aroma characteristic we used the following rule: only the aroma attributes which were evaluated by at least 50% of the panelist were accepted; less than five mentions meant this aroma component is not present in the certain wine.

3. RESULTS AND DISCUSSION

The correlation test showed that the different aroma components are not highly correlated, thus they are not redundant. The highest correlation coefficient was 0.384 which occurred between raspberry and strawberry. Appendix contains the descriptive statistic of all variables.

Table 1 gives an overview of the regression model. Because of suspicion of heteroscedasticity we used robust standard errors (Stock and Watson, 2008). Ramsey's RESET Test showed that there is no regression specification error in this model.

Table 1
Regression evaluation of quality score

Attribute	Coef.	z-Value	P > z	Attribute	Coef.	z-Value	P > z
colour	0.02	1.22	0.222	black tea	0.05 ***	4.01	0.000
aromatic	0.07 ***	3.64	0.000	black pepper	0.02 *	1.93	0.054
body	0.31 ***	14.57	0.000	liquorice	0.00	0.19	0.846
sweetness	0.08 ***	3.71	0.000	vanilla	0.04 ***	3.13	0.002
acidity	-0.05 *	-2.35	0.019	clove	0.00	0.29	0.770
tannin	-0.03	-1.53	0.127	cinnamon	0.04	1.68	0.094
aging	-0.04 *	-2.48	0.013	tobacco	0.02	1.52	0.128
raspberry	0.01	0.65	0.516	caramel	0.03	1.50	0.135
strawberry	0.04 **	3.21	0.001	coffee/mocha	0.06 ***	4.98	0.000
red currant	0.00	0.15	0.885	chocolate	0.03 **	2.84	0.005
black currant	0.01	1.35	0.176	nutty	0.01	0.41	0.680
blackberry	0.02	1.62	0.105	leather	-0.02	-1.27	0.203
sour cherry	0.01	0.44	0.660	toasted oak	0.08 ***	7.41	0.000
cherry	0.02 **	2.69	0.007	cedar wood	0.09 ***	6.75	0.000
jam	0.04 ***	3.56	0.000	bacon	-0.05 *	-2.55	0.011
dried fruits	0.02	1.80	0.072	butter	-0.04 **	-2.75	0.006
violet	-0.01	-0.66	0.506	animal	-0.06 ***	-4.30	0.000
rose	0.05 *	2.21	0.028	mushroom	-0.08 ***	-3.52	0.000
bell pepper	0.02	1.77	0.077	damp forest soil	0.00	0.15	0.884
eucalyptus	0.01	0.97	0.332	number of attrib.	0.02 *	2.55	0.011
				_cons	0.64	4.99	0.000

Numbers of obs.: 1710 Adj. R^2=0.501 RMSE=0.799

* Significance: P < 0.05; ** Significance: P < 0.01; *** Significance: P < 0.001.

Twenty one of overall forty variables turned out to be significant. Except for colour and tannin, all other basic characteristic had a significant influence on the quality scores. Body had by far the highest contribution with a coefficient of 0.31. Other significant basic characteristics move between 0.04 and 0.08. Acidity and age were negative in the regression, which means the higher acidity and the higher oxidative notes the lower the quality stores.

Among the aroma attributes coffee (0.06), toasted oak (0.08) and cedar wood (0.09) were the main attributes that improved the perception of red wine quality. The major part of the wines had been vinificated or aged in barrique barrels, so that this aromatic appeared very often. Coffee and cedar wood are special aromas which –when they are good integrated and not over proportional in the wine– can lead to a complex and individual character. Black tea (0.05),

rose (0.05), jam (0.04), vanilla (0.4) and strawberry (0.04) are additional positive attributes, which have a higher contribution to the quality scores.

Microbiological lactic character (butter), brettanomyces, mushrooms and bacon had a negative influence on the perceived quality.

For the regression analysis an extra variable (number of aroma attributes) was defined. This variable shows with how many characters a panelist described the certain wine. Concerning the results of the multiple test it is clear that also the complexity of red wine character an important role plays (table 1).

Finally a cluster analysis (k-means clustering) with the product profiles of the 171 red Bordeaux wines was undertaken to describe different stylistics. Results of the cluster analysis including the Anova test are listed in Table 2.

Table 2
Descriptive overview of wine groups

Attribute	1	2	3	Attribute	1	2	3
colour	5.47^{a}	4.87^{b}	5.02^{b}	eucalyptus	0.82^{a}	0.93^{a}	0.29^{b}
aromatic	4.31^{a}	3.98^{b}	4.24^{a}	black tea	1.32^{a}	0.85^{b}	0.29^{c}
body	4.19^{a}	3.82^{b}	3.50^{c}	black pepper	1.95^{a}	0.85^{b}	1.17^{b}
sweetness	1.46	1.40	1.41	liquorice	1.26^{a}	1.16^{a}	0.23^{b}
acidity	2.44^{b}	2.54^{a}	2.41^{b}	vanilla	0.59^{b}	0.27^{b}	1.12^{a}
tannin	3.98^{a}	3.81^{a}	3.27^{b}	clove	0.64^{b}	0.24^{b}	1.14^{a}
aging	2.21^{a}	1.7^{b}	2.08^{a}	tobacco	1.27^{a}	0.95^{a}	0.25^{b}
raspberry	0.60^{a}	2.03^{b}	0.37^{a}	coffee/mocha	1.93^{a}	0.4^{c}	1.06^{b}
strawberry	0.75^{b}	2.11^{a}	0.12^{c}	chocolate	0.75^{a}	0.22^{b}	0.58^{ab}
red currant	0.88^{b}	2.49^{a}	0.42^{c}	leather	1.54^{a}	0.27^{c}	0.97^{b}
black currant	3.23^{a}	2.35^{b}	2.89^{a}	toasted oak	2.64^{a}	2.06^{b}	2.42^{a}
blackberry	3.14^{a}	2.43^{b}	2.86^{a}	cedar wood	0.26	0.13	0.12
sour cherry	0.00^{a}	0.38^{a}	0.28^{ab}	bacon	0.23	0.00	0.13
cherry	3.36^{a}	2.97^{b}	3.04^{ab}	butter	0.34	0.21	0.20
jam	3.04^{a}	2.32^{b}	0.76^{c}	animal	1.24^{a}	0.13^{b}	0.78^{a}
dried fruits	2.54^{a}	1.03^{b}	0.85^{b}	mushroom	0.14	0.13	0.21
rose	0.34	0.21	0.12	number of attrib.	13.17^{a}	11.25^{b}	9.06^{c}
bell pepper	2.69	2.41	2.75	number of obs.	46	55	70

ANOVA: Tukey post hoc test, classes with different superscript are different at P = 0.05.

According to the cluster analysis three different wine styles could be defined:

Group 1 [full body wines] includes colour-intensive wines, rich in body with distinctive aromas of black currants, blackberries, dark cherries, jam, dry fruits, black pepper and tea. Other aroma components like tobacco, coffee, chocolate and toasted oak dominate in this segment, too. These wines have more aroma characters (number of attributes approx. 13) than the other two groups.

Wines in Group 2 [fresh wines] have lower colour intensity and weaker body, they can be characterised by fresh fruits such as raspberry, strawberry and red currant while all other

aroma components were neither extremely low nor extremely high. The wines of this group had less number of aroma attributes than Group 1.

Group 3 [perfumed wines] can be described with weaker body and tannin structure; they had a higher intensity of black currant, blackberry and cherry than the Group 2, however in these wines vanilla and clove dominate. This group was evaluated with the lowest number of aroma attributes.

Summarising the results of the regression analysis we can say that body was the highest quality driver in these AOC Bordeaux and Bordeaux Supérieur wines, while aroma complexity - combination of different aroma components such as coffee, black tea and oak or simply the number of aroma attributes found in the wine – was of big importance too. Aroma attributes like mushrooms or butter had a negative effect on quality scores.

The cluster analysis showed the diversity of Bordeaux red wines and confirmed the fact that wines from the same region, produced from the same varieties still have differences in their aroma characteristics. The test wines could be divided into three groups: full body wines, fresh wines and perfumed wines which differ also in their quality evaluation significantly.

This approach could be useful for Bordeaux winemakers to identify their product compared to other Bordeaux wines and gives them valuable information about the diversity of wine styles.

This approach has potential limitations because only experts tasted the wines. Therefore there is no market implication for producer. An extended study with consumers could improve the results and gives more information about the market relevance of these wines.

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Appendix

Descriptive statistics of variables

	Frequency (% of 1710 cases)	**Mean**	**S.D.**	**minimum**	**maximum**
colour	100	5.08	0.80	2.0	7.0
aromatic	100	4.17	0.89	1.0	7.0
body	100	3.72	0.88	0.0	7.0
sweetness	100	1.42	0.67	0.0	5.0
acidity	100	2.45	0.71	0.0	5.0
tannin	100	3.54	0.92	1.0	7.0
aging	100	2.01	0.81	0.0	6.0
raspberry	32.6	0.78	1.27	0.0	7.0
strawberry	29.2	0.75	1.27	0.0	7.0
red currant	31.3	0.88	1.42	0.0	7.0
black currant	55.9	1.74	1.72	0.0	7.0
blackberry	57.2	1.78	1.73	0.0	7.0
sour cherry	19.4	0.55	1.21	0.0	7.0
cherry	63.5	2.08	1.78	0.0	7.0
jam	45.7	1.32	1.64	0.0	7.0
dried fruit	37.2	1.00	1.48	0.0	7.0
violet	11.3	0.31	0.99	0.0	7.0
rose	6.6	0.13	0.53	0.0	5.0
bell pepper	55.3	1.59	1.66	0.0	7.0
eucalyptus	27.6	0.63	1.15	0.0	6.0
black tea	26.2	0.66	1.21	0.0	6.0
black pepper	37.5	0.90	1.29	0.0	6.0
liquorice	29.7	0.66	1.15	0.0	5.0
vanilla	30.7	0.69	1.15	0.0	6.0
clove	30.7	0.66	1.10	0.0	6.0
cinnamon	11.0	0.21	0.68	0.0	6.0
tobacco	28.1	0.61	1.08	0.0	6.0
caramel	13.3	0.29	0.82	0.0	5.0
coffee/mocha	33.4	0.83	1.29	0.0	6.0
chocolate	25.0	0.64	1.22	0.0	6.0
nutty	7.1	0.16	0.62	0.0	5.0
leather	31.6	0.72	1.20	0.0	6.0
toasted oak	63.6	1.60	1.43	0.0	7.0
cedar wood	22.0	0.53	1.09	0.0	6.0
bacon	12.9	0.28	0.81	0.0	5.0
butter	16.1	0.37	0.91	0.0	6.0
animal	25.5	0.63	1.24	0.0	7.0
mushroom	7.7	0.20	0.76	0.0	7.0
damp forest soil	14.2	0.33	0.93	0.0	6.0