MULTIVARIATE STATISTICAL ANALYSIS OF ROYAL FETEASCA WINE QUALITY FROM DIFFERENT REGIONS OF ROMANIA COUNTRY

Silvia MIRONEASA[1], Georgiana Gabriela CODINĂ[1], Ana LEAHU[1], Costel MIRONEASA[2]

[1]Stefan cel Mare University, Faculty of Food Engineering, 13th University Street, 720229, Suceava – Romania, e-mail : silviam@usv.ro; codina@usv.ro; leahu@usv.ro
[2] Ştefan cel Mare University, Faculty of Mechanical Engineering, Mechatronic and Management, Suceava – Romania 13th University Street, 720229, Suceava – Romania, e-mail: costel@fim.usv.ro

Abstract: *The objective of this study is to establish a relation between the physico-chemical parameters and the sensorial characteristics of the Royal Feteasca wine from eight viticulture regions from Romania. The correlation between the physico-chemical parameters of wine and the sensorial characteristics were analyzed using the Principal Component Analysis (PCA) method. The analysis of variation and the principal component analysis showed that there were significant correlations between the wines from the Hills of Banat viticulture region – the winegrowing center Recas, the Hills of Dobrogea viticulture region – the winegrowing center Murfatlar and the Danube's Terraces viticulture region – the winegrowing center Fetesti. The wines from these viticulture regions were the best renowned (the silver medal) both sensory – using the sensorial analysis of the wines, with denotation in the penalty points, and physico-chemical through parameters – density, alcoholic concentration, total acidity, volatile acidity and total dry extract. The multivariate analysis of the data show significant differences between various variables that were used for the quality assessment of wine. Significant direct correlations were obtained between taste-quality, taste–intensity, odour- intensity and clarity (r = 0.800, r = 0.775, respectively r = 0.800) and reverted correlations between odour–quality and wine density and volatile acidity (r = - 0.712, r = - 0.771), correlation is significant at the 0.05 level.*

Keywords: *Romanian wines, Principal Component Analysis, physico-chemical parameters, sensory evaluation*

Introduction

Royal Feteasca is an assortment of grapes originating from Transylvania, 7-8 decades ago and cultivated in the majority of Romanian vineyards. The wines obtained from this assortment have the following characteristics: moderate alcoholic concentration, light, balanced, restful, but their main characteristic remains the flavour, a very interesting floral flavour [1]. Thanks to its valuable characteristics, the wines are largely spread in plantations, being cultivated in almost all vineyards from the country. The Royal Feteasca wines produced in the vineyard from Tarnave, in general from Transylvania, have a special quality [2]. The quality of the wine is determined both by the physico-chemical parameters and sensorial characteristics. The main physico-chemical parameters which are computed usually for evaluating the quality of wine are: density, alcoholic concentration, total acidity, volatile acidity, content of total sugars, dry irreducible extract etc. Sensory analysis involves a series of techniques designed to study wine attributes, how they are perceived and how they relate to features such as chemical, varietal, regional or stylistic origin. That is, these are the primarily research tools. These procedures include techniques such as discrimination testing, descriptive sensory analysis, time-intensity analysis and charm analysis. As in all tests, specific instructions on how the procedure is to be conducted and clear indications of what is expected are essential if the desired results are to be obtained [3]. In Romania, wine results are usually reported to the consumer in the form of a specific type of medal, i.e. gold, silver or bronze according to SR 13461:2001.

Descriptive analysis transcends quality and differences in measurements by determining sensory attributes and physico-chemical parameters that differ from Royal Feteasca wines were studied. From our knowledge, there have been made few studies using multivariate analysis to characterize the impact of physico-chemical parameters on sensory attributes of wines. Therefore, we conducted a study in which sensory attributes of wines from different eight viticulture regions from Romania were evaluated by the method of grading through penalty points. The obtained data were correlated to the physico-chemical parameters which were computed using the principal component analysis (PCA).

Materials and methods

Wines-study material. Eight commercial Royal Feteasca wines (harvest 2008) were provided by different vineyards, abbreviated as shown in Table 1.

Physico-chemical analysis. The physico-chemical parameters of wines were determined according to Romanian standard methods: density (STAS 6182/8-71), alcoholic concentration (STAS 6182/6-70), total acidity (SR 6182-1:2008), volatile acidity (SR 6182-2:2008), sugars (SR 6182-18:2009) and total dry extract (STAS 6182/9-80). All analytical determinations were performed at least in triplicate. Values of different parameters were expressed as the mean of all measurements.

Table 1.
The source of the studied Royal Feteasca wines

Viticulture Region	Vineyard	Winegrowing center	Abbreviation
Moldovia's Hills	Husi	Husi	A
Transylvania Plateau	Tarnave	Jidvei	B
Banat Hills	-	Recas	C
Moldovia's Hills	Cotnari	Cotnari	D
Dobrogea Hills	Murfatlar	Murfatlar	E
Crisana and Maramures Hills	Silvaniei	Ratesti	F
Muntenia and Oltenia Hills	Dealu Mare	Valea Calugareasca	G
Danube’s Terraces	Ostrov	Fetesti	H

Sensory analysis. Sensory testing has been carried out, in conformity with the method described by SR 13461:2001 which mentions a sensorial analysis of the wines by scoring them with penalty points. In order to use this type of sensorial analysis, a 13 member panel was selected from available students and personnel at “Stefan cel Mare” University, Faculty of Food Engineering, (five men and eight women, aged between 21 and 50 years). The majority of the judges had participated in previous sensory tests, but only a few had extensive wine tasting experience. All wines were presented in coded (according SR ISO 6658:2007) standard, tulip-shaped, clear 250 mL wine glasses and evaluated at 10-12^{o}C in the sensory laboratory of the Food Engineering Faculty from Suceava. A 50 mL sample of wine was poured into each glass and covered with a watch glass at least for 30 min prior to testing. Distilled water was provided for cleaning the palate between wines. The organoleptic properties of wine, measured trough this sensorial method of analysis, are: clearness of wine, intensity and quality of odour, intensity and quality of its taste, colour and harmony of the whole product. The sensorial impression, individually determined for every organoleptic property, is quantified by 4 penalty coefficients as it follows: excellent: 0; very good: $1^2 = 1$; good: $2^2 = 4$; acceptable: $3^2 = 9$; eliminated: –. This penalty coefficients are established by *combining* a *consecutive* logarithmic method with 5 correlated factors of importance: 1. clarity; 2. odour-quality; 3. taste-intensity; 4. taste-quality; 5. harmony-colour. The penalty points are calculated, resulting in the total penalty score. Using the total penalty scores, which were assigned to every wine type by the members of tasting board, a panel score range is determined, representing the only score that can be found at the middle of the individual wine scores, as sorted in ascending order. The connection established between the qualitative graduations, median penalty points and award is represented in Table 2.

Table 2.
Quality scoring ranges used to allocate quality designations (SR 13461:2001)

Qualitative graduations	Median penalty points	Award
Excellent	0...6	Gold medal
Very good	7...8	Silver medal
Good	9...11	Bronze medal
Acceptable	12...48	Honorary degree
Acceptable	49...108	Degree of participation
Eliminated	≥ 109	-

Data analysis. In order to make the correlation analysis between the two variables: one is the effect (the dependent one), the other is the cause (the independent one) the bivariate correlation was used. The selected method to analyze the interdependence between all the variables involved in the wine quality evaluation is the principal component analysis (PCA). PCA is a multivariate analysis technique that is intended to reduce the number of variables by preserving as much as possible the variance of original data, resulting in a smaller set of variables. In this way, new variables (principal components) are determined, expressed as linear combination of original variables that have both no correlation in between and maximum variance. The graphical representations visualize the relations between variables, while allowing the detection of possible groups of variables. PCA is in fact a powerful method for summarizing variations in many variables of wine quality, since it is able to project the principal variation onto a few principal components. Factors extracted are retained if they have an eigenvalue $\lambda > 1$(Kaiser's criterion) because they bring a lot more information than the initial variables. The principal components are pairs of uncorrelated variables: the first principal component has maximum variance while the second component has a variance as high as possible, but less than the value of the first component. Samples and variables were compared and interpreted through two dimensional bi-plots that visually represented the results of the PCA [4]. Bi-plots show the position of explanatory variables and identify how the variables relate to both the principal components and other input. The goal of the principal component analysis is to establish groups of similar samples and significant variables and use those to distinguish among the studied cases. The principal component analysis was performed using SPSS on the covariance matrix of the variables involved, in order to illustrate the relationships between sensory characteristics and physico-chemical parameters of wine.

Results and Discussion

Physico-chemical parameters. Table 3 presents the physico-chemical parameters of Royal Feteasca type of wine from all the eight wine regions of Romania. All the values shown in Table 3 are means of the three determinations. The variation limits of organoleptic characteristics which are used to evaluation wine quality are shown in Table 4. The alcoholic concentration is one of the most important parameters defining wine quality. Considering the analyzed samples, the alcoholic concentration did not have significant variations between 10.92% v/v (sample F) and 12.45% v/v (sample D). Although sample A has a higher alcohol content (12.19% v/v.) it was less appreciated comparing with the other analyzed samples, probably due to the lowest dry extract (25.19 g/l) and sugar content (8.0 g/l).

Table 3
Physico-chemical parameters Royal Feteasca wine samples

Physico-chemical parameters	Abbreviated name	Mean	Range		CV %
			min	max	
Wine density at 20°C, [g/cm^3]	W_D	0.99	0.9937	0.9993	0.19
Alcoholic concentration, [% v/v]	A_C	11.65	10.92	12.28	4.64
Total acidity, [g/l sulphuric acid]	T_A	4.51	4	5.22	9.48
Volatile acidity, [g/l sulphuric acid]	V_A	0.48	0.2	0.88	40.94
Sugar, [g/l]	S	8.89	7.7	10.45	11.11
Total dry extract, [g/l]	T_D_E	31.10	25.19	39.55	16.96

Table 4
Organoleptic characteristics used to assess the Royal Feteasca wine samples

Organoleptic characteristics	Abbreviated name	Range	
		min	max
Clarity	Cl	0	1
Odour - intensity	O_I	0	4
Odour - quality	O_Q	0	8
Taste - intensity	T_I	2	18
Taste - quality	T_Q	0	12
Harmony - Colour	H_C	3	12

The density of wine depends on the content of extractive substances and alcohol, but also on temperature. The highest value of density was found at the sample H – the wine originating from Danube's Terraces region.

The amount of remaining unfermented sugars is in small and variable quantities and has an important contribution in identifying the wine types. This has an important role in the taste sensorial assessment of wine and contributes to its completion. The content in sugars gives the type of wine and has a direct relation with the geographical position of the wine region [5]. The samples with the highest sugar content (H = 10.45 g/l; E = 9.8 g/l) were appreciated fairly well by the taster (second place) considering the odour-intensity, odour – quality, taste – intensity, taste-quality parameters. This result is due to the fact that a higher content of sugars highlights and exacerbates the flavour, providing the wine with better taste.

Another parameter, acidity, provides physico-chemical stability to wine and gives its bright colour and fresh taste. Total acidity and volatile acidity are directly connected to its sensorial assessment. The acidity sour effect can be attenuated by the total sugar content.

The wine extract is crucial for its sensorial assessment. It gives corpulence, fullness, amplitude, generosity to wine.

A higher of solid content gives wine greater consistency. A wine with high alcoholic strength has higher extract content because it is made from concentrated musts that are rich both in sugars and other compounds. A significant association between total dry extract content and alcohol content has been found by comparing all the samples. A major correlation exists between total dry extract and the organoleptical parameters of taste-intensity and taste – quality, probably due to the higher sugar content in some of these wines. This correlation makes difficult to properly assess the corpulence of wine. For example: although samples D and G had a higher solid content (37.8 g/l and 31.33 g/l), they were less appreciated than sample C (29.26 g/l) because of the fact that they had a lower sugar content and higher acidity. This specific balance had a significant influence over the organoleptical assessment of taste-intensity and taste-quality parameters. Although, compared to the other samples analyzed, sample C is characterized by a low alcohol content (11.0% v/v) and a moderate content of total dry extract (29.26 g/l), it won the second place in consumer preferences (silver medal), perhaps due to a combination of relatively high sugar content (9.1 g/l) and lowest value of total acidity (4.1 g/l sulfuric acid). Its low acidity has created a sweet taste sensation, more intense compared with samples E, H, which although having a higher sugar content (9.8 g/l and 10.45 g/l) were rated as less sweet thanks to their higher acidity (4.73 g/l sulfuric acid, i.e. 5.22 g/l sulfuric acid).

The correlation between the results of tsensory testing and the analysis of physico-chemical parameters obtained for Royal Feteasca wine coming from all the eight wine regions of Romania are represented in Figure 1(a). The first two principal components explain 97.63% of the total variance (PC1 = 92.91% and PC2 = 4.72%). Concerning the first principal component, PC1, a very good correlation between the wines from regions H and C (r = 0.990), H and E (r = 0.997) was found and correlation coefficients are significant at the 0.01 level. Wines from regions E, H, C and D are strongly associated with the first principal component PC1. Compared to the second principal component, PC2, the quality of wine coming from region A is opposed to that of the wines coming from wine regions E, H and C. The second principal component is strongly associated with the quality of wine from region A, characterized by a high value of clarity (Cl) variable.

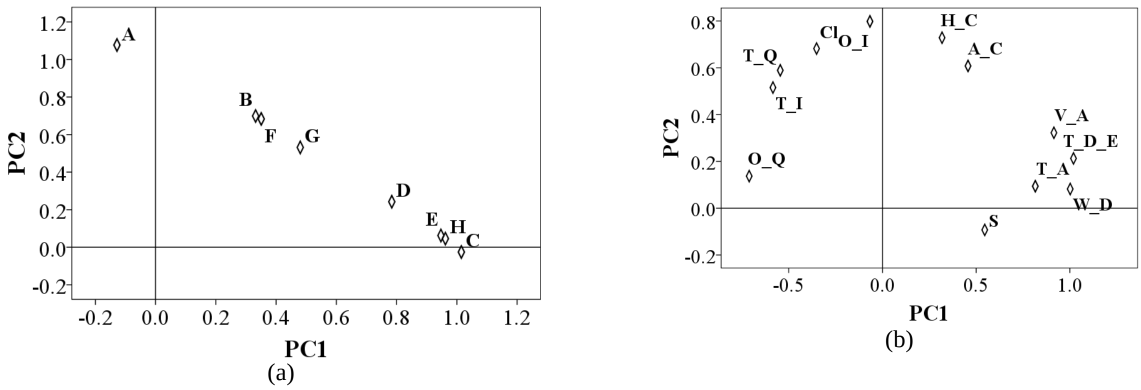

Figure 1. (a) Score plot PC1 and PC2 showing interrelationships among Royal Feteasc wines from eight regions of Romania; (b) Correlation loading plot of PC1 and PC2, showing interrelationships among sensory characteristics and physico-chemical parameters

PCA loadings of the physico-chemical parameters and the variables used in sensory wine evaluation are represented in Figure 1 (b). The two principal components represented here 64.83% and 15.09% of the total variance. The plot of PC1 vs. PC2 loadings shows, along the PC1 axis, a close association between the total acidity (T_A), density (W_D), total dry extract (T_D_E) and volatile acidity (V_A), variables strongly associated with this specific axis. In other words, PC1 extends along the maximum variance of these variables. In conclusion we can say that the total acidity, density, dry extract, total and volatile acidity parameters have a distinctive role in assessing the Royal Feteasca wine from regions C, H and E.

Another variable, opposed to the total dry extract parameter (T_D_E), but nevertheless contributing to PC1 is odour - quality variable (O_Q). PC2 distinguishes between clarity (Cl) and sugar content (S). Clarity (Cl) shows a positive effect on taste-quality (T_Q), taste – intensity (T_I) and a negative one on total acidity (T_A), density (W_D), total dry extract (T_D_E). Compared to the second principal component PC2, the intensity odour (O_I) variable is placed at the top while quality (O_Q) variable is placed at the bottom. PC2 clearly has something to do with discriminating between the specific variables of sensory analysis. Compared to the second principal component, odour - quality (O_Q), taste - quality (T_Q), taste - intensity (T_I), clarity (Cl) and odour - intensity (O_I) variables, are located on the left graph and the harmony - colour (H_C) variable is on the right. This leads to the observation that the contribution of the first variable to the appreciation of wine is less important than the one of the right. The taste - quality variable (T_Q) is opposed to alcoholic concentration (A_C). Significant direct correlations were obtained between density and volatile acidity (r = 0.835), respectively total dry extract (r = 0.941), and correlation coefficients are significant at the 0.01 level. Wine density and odour - quality is inversely correlated, r = - 0.712, given the significance level of 0.05. Total acidity is directly correlated with total dry extract, r = 0.869 (significant correlation coefficient at the 0.01 level), also with wine density, r = 0.769 (significant correlation coefficient at the 0.05 level). Volatile acidity is directly correlated with total dry extract, r = 0.807 and inversely correlated with odour - quality, r = - 0.771 (significant correlation coefficients at the 0.05 level). A very good correlation was obtained between the clarity and odour- intensity (r = 0.800), taste - intensity (r = 0.775), respectively taste-quality (r = 0.800), (significant correlation coefficients at the 0.05 level). This shows a relatively deterministic connection.

Conclusions

The Principal Component Analysis of the data set shows a high association between some physico-chemical parameters (density, total acidity, volatile acidity, total dry extract) and some of the sensorial characteristics of wine (odor - quality, taste-quality and panel score range). The correlation established with PCA between the determined physico-chemical parameters and the results obtained by sensory assessment has highlighted the best correlation. This is between density, total acidity, respectively volatile acidity on one part and taste - intensity, taste-quality, odour - intensity, odour - quality respectively clarity characteristics on the other. Wines from regions C, E and H have been best appreciated, receiving a silver medal, while physico-chemical parameters (density, total acidity, volatile acidity, total dry extract) had a key role in the assessment.

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