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Factor analysis for the choice of a criterion of wine grape (*Vitis vinifera*) maturity in warm regions

by

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Analyse de facteurs pour le choix d'un critère de maturité des raisins de cuve dans les régions chaudes

Résumé. — Nous avons appliqué l'analyse de facteurs en vue de choisir un critère pour la maturité du raisin. Cette analyse a permis de réduire six variables à deux facteurs. Le premier facteur comprend le pH, l'acidité totale, °B/acidité, dont le pH a le plus haut «loading». Le second facteur a le plus haut «loading» pour le °Balling. Nous suggérons d'attacher de l'importance au pH et au °B quant à la détermination du degré de maturité des variétés de raisins de cuve dans le commerce provenant de plantes obtenues par croisements dans les régions chaudes.

Introduction

One of the most important factors contributing to the quality of a grape variety is the composition of the must, which is affected by the date of maturity. Payment for wine grapes is based on total soluble solids measured by °Balling or by other hydro-metric units.

BERG and OUGH (1977) developed °Balling ranges of optimum wine quality for a number of table wine varieties. In studies on wine grape varieties and their relations to climatic regions, AMERINE and WINKLER (1963) recommended the use of °Balling/acid ratio. OUGH and SINGLETON (1968) showed that °Brix/acid ratios could reflect wine quality. LA ROSA (1955) suggested the use of pH as a criterion of grape maturity in warm regions. High correlation between aroma and °Brix × pH of grape juice was found by SINTON *et al.* (1978). According to WINKLER (1954), the crop level affects the quality of wine.

This study has been carried out to find, using a factor analysis, variables suitable as indicators of grape maturity for commercial varieties or for cross progenies in warm regions, such as Apulia (south Italy).

Materials and methods

20 wine grape varieties, French Colombard, Trebbiano, Verdeca, Greco, Peverella, Sangiovese, Montepulciano, Malvasia bianca, Negro amaro, Barbera, Malvasia nera, Chenin blanc, Barberone, Aleatico, Nebbiolo, Teroldego, Ruby Cabernet, Cilieggiolo, Rubired, Lambrusco Maestri, were grown in 3 localities, Ortanova (Foggia), Mola (Bari), Castellaneta (Taranto) in Apulia.

All varieties were grafted on the same rootstock (34 E. M.), overhead arbor trained and treated in the same way. The °Balling, pH, total acidity, yield of each variety were

taken from 10 plants (NESBITT and KIRK 1972) of a completely random design for 5 years as reported in a previous paper (FANIZZA 1982).

The data of n correlated variables could be expressed in terms of $p < n$ uncorrelated variables through a factor analysis. The basic factor model may be put in the form of

$$Z_j = a_{j1}F_1 + a_{j2}F_2 + \dots + a_{jp}F_p + d_jU_j \quad (j = 1, 2, \dots, n),$$

where the F 's, a 's and dU 's refer to the factors, loadings and residual errors, respectively. The estimate of loadings was obtained using the principal factor procedure (HARMAN 1960), and for rotation of factor matrix the varimax method (KAISER 1958) was applied; since the calculations were complex they were done by a computer using a special factor analysis program (BARR *et al.* 1976).

Results and discussion

The mean values of 24 wine grape varieties for 6 variables important for grape maturity, have been reported in a previous work (FANIZZA 1982), while in this paper the correlation matrix (Table 1) of the variables and the results of the factor analysis (Table 2) are reported.

Table 1
Correlation matrix of 6 variables in 20 wine grape varieties (*Vitis vinifera*)
Matrix de corrélation de 6 variables dans 20 variétés de raisins de cuve (*Vitis vinifera*)

Variables	pH	Total acidity	Yield	°B × pH	°B/acidity
°B	0.36	-0.26	0.17	0.97**	0.63*
pH		-0.70*	0.04	0.57**	0.74*
Total acidity			0.04	-0.41*	-0.87**
Yield				0.16	0.01
°B × pH					0.75**

* = $P \leq 0.05$.

** = $P \leq 0.01$.

According to Table 2, the 6 variables can be reduced to 2 hypothetical factors, which together explain 80 % of the variance of the original variable, with 20 % unexplained being a largely random variation.

The 1st factor accounts for a large portion of the total variance (50 %), and it includes variables such as pH, total acidity, °B × pH, °B/acidity.

The value of loadings (Table 2) shows the relative contribution of the individual variable to each factor; variables which have relatively high positive loadings on each factor are positively intercorrelated as a group, while variables having high negative loadings are positively intercorrelated as a group, and negatively correlated with those variables having positive loadings. The 1st factor, which shows intercorrelations, as a group, among pH, total acidity, °B × pH, °B/acidity, may be interpreted as "acidity" factor. For the 1st factor, the pH has the highest loading (0.91) and the highest communality (0.94) and it can be considered the most important character of grape maturity in warm regions.

Table 2

Results of factor analysis of wine grape varieties (*Vitis vinifera*)Résultats de l'analyse de facteurs de variétés de raisins de cuve (*Vitis vinifera*)

Traits	Factors		Commun- ality
	I	II	
°B	0.44	0.81	0.73
pH	0.91	-0.11	0.94
Total acidity	-0.84	0.07	0.83
Yield	0.22	0.65	0.47
°B × pH	0.86	0.34	0.91
°B/acidity	0.81	-0.28	0.84
Factor variance	3.04	1.74	
% of factor variance	63.5	36.3	100.00
% of total variance	50.7	29.11	79.81

The 2nd factor accounts for 29 % of the total variance and includes °Balling and yield, but only °Balling could represent the second important variable for grape maturity in warm regions.

This analysis suggests that the pH is the most important variable contributing to wine grape quality in warm regions followed by °Balling.

Payment for wine grapes, based on °Balling alone, seems not to be satisfactory in warm regions, while under conditions where grapes often do not ripen (cold environment) and where excess acidity is a regular problem, sugar content is an important criterion of harvesting.

In conclusion, pH and then °Balling are important variables for determining the maturity of commercial wine grapes or of seedlings obtained by crossing in warm regions.

Summary

Factor analysis has been applied to choose a criterion of wine grape (*Vitis vinifera*) maturity. Thus, six variables could be reduced to two factors. The first factor includes pH, total acidity, °B × pH, °B/acidity, but pH has the highest loading. The second factor has the highest loading for °Balling. pH and °Balling are suggested to be important variables for determining the maturity of wine grapes in warm regions.

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Eingegangen am 5. 6. 1982

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