Interactions between Grape Maturity Indices and the Quality and Composition of Chenin blanc and Colombar Wines from Different Localities

L. P. ELLIS, P. C. VAN ROOYEN[1] AND C. S. DU PLESSIS

Viticultural and Oenological Research Institute, Private Bag X5026, 7600 Stellenbosch, Republic of South Africa.

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Three grape maturity indices viz. degrees Balling (°B), total titratable acidity (TTA) and the °B.pH product of musts were compared regarding their ability to predict optimum quality for Chenin blanc and Colombar wines. Comprehensive analytical data from 168 musts and corresponding wines for the 1978, 1979 and 1980 vintages from the Stellenbosch, Robertson and Lutzville areas were accumulated, and subjected to principal component analysis using variables and variable ratios selected by correlation to quality weighting. These results indicated that the two cultivars differed appreciably with respect to the value of all three measured indices. From this study it was not possible to select a specific index to predict optimum maturity in all cases. Optimum values for each index differed according to geographic locality.

Total soluble solids, expressed as degrees Balling (°B), is generally used in South Africa as an index for optimum grape maturity. Remuneration for grapes delivered at a cooperative wine cellar is usually based on °B alone. While most wineries demand a minimum sugar level, some even pay bonuses for grapes with a higher sugar content than the specified minimum. However, the use of a single parameter to predict optimum wine grape maturity does not always give satisfactory results (Berg, 1958; Du Plessis, 1976; Coombe, Dundon & Short, 1980). In studies on wines grape varieties and their relationship to climatic regions, Amerine & Winkler (1941) recommended the use of a °B/acid ratio as a maturity index, and later Singleton (1968) showed that °B/acid ratios could reflect wine quality.

La Rosa (1955) suggested the use of pH as a criterion of grape maturity in warm regions while Fanizza (1982) indicated that both °B and pH are important variables for determining grape maturity in such regions. Sinton *et al.* (1978) found a high correlation between wine aroma and the °B.pH product of grape juice.

More recently Du Plessis & Van Rooyen (1982) studied curvilinear relationships amongst several multiparameter indices and wine quality obtained by sensory evaluation and found promising results for the °B/TTA ratio and the °B.pH product of grape must. By relating red table wine composition to the indices °B, °B/TTA and °B.pH, Van Rooyen, Ellis & Du Plessis (1984) found that the °B.pH index gave a narrower optimum range, and in contrast to the two other indices gave similar results for both Cabernet Sauvignon and Pinotage. The purpose of this study was therefore to relate white table wine composition to these maturity indices and to evaluate the latter in terms of their ability to predict high quality for different wines. Data obtained from two white table wine cultivars produced in three distinct wine of origin regions were used. In contrast to previous studies, and due to the fact that regression methods were not used, wine quality was not used as a dependent variable in the final analysis, but as a guide to select independent variables and to identify a spectrum of high quality wines for the interpretation of the final results.

MATERIALS AND METHODS

Grape sampling and vinification procedures: Ninety-eight Chenin blanc wines from the Stellenbosch, Robertson and Lutzville areas, as well as 70 Colombar wines from the Robertson and Lutzville areas, were used in this study. The wines were from the 1978, 1979 and 1980 vintages. Sampling techniques at various degrees of maturity and vinification procedures were as described by Du Plessis & Van Rooyen (1982).

Must analysis: Total titratable acidity (TTA) was determined on centrifuged juice samples (750 g × 5 min.) by titrating with ç 0,1 M NaOH to pH 8,2. Total soluble solids (°B) was determined on the centrifuged samples by refractometer and corrected for grape sugars as suggested by Cooke (1964).

Wine analysis and sensory evaluation: A total of 36 parameters was determined by using the analytical methods set out in Table 1. Overall wine quality as well as aroma quality was evaluated by a panel of 14 judges using the system described by Tromp & Conradie (1979).

Categorisation of certain parameters: To facilitate data processing and interpretation of results, grape maturity

TABLE 1

Methods of analysis used in the study

Parameter	Method used
Alcohol (vol. %)	Pycnometer (Anon)
Total titratable acid ($mg.l^{-1}$)	Titration with NaOH to pH 8.2
pH	pH-meter
Phosphate ($mg.l^{-1}$)	Technicon Autoanalyser methodology (Anon)
Acetaldehyde ($mg.l^{-1}$)	Amerine & Ough (1975)
Total phenols ($mg.l^{-1}$)	Singleton & Rossi (1975)
Mg, Ca, Na, Cu, Mn, Fe, Zn ($mg.l^{-1}$)	Atomic Absorption (Std. VORI method)
Reducing sugars ($g.l^{-1}$)	Amerine & Ough (1975)
Tartaric acid ($g.l^{-1}$)	Rebelein (1973)
Total Higher alcohols ($mg.l^{-1}$)	Le Roux (1972)
Individual ester and higher alcohols	Marais & Houtman (1979)

1. Current address: Fruit and Fruit Technology Research Institute, Private Bag X5013, 7600 Stellenbosch, Republic of South Africa.

indices were classified into distinct categories (Table 2), in such a way that the full range was accommodated for each index, with more or less equal numbers of wines in each category.

TABLE 2

Categories used for different grape maturity indices

Category Number	Degrees Balling (°)	n	°Balling/Total titratable acid (°B/TTA)	n	°Balling.pH (°B.pH)	n
1	<19,0	13	<1,90	22	<62,00	20
2	19,0-19,6	25	1,90-2,09	20	62,00-64,99	21
3	19,7-20,3	20	2,10-2,29	18	65,00-67,99	18
4	20,4-21,0	23	2,30-2,49	21	68,00-70,99	22
5	21,1-21,7	10	2,50-2,69	18	71,00-73,99	18
6	21,8-22,4	22	2,70-2,89	21	74,00-76,99	18
7	22,5-23,1	24	2,90-3,09	12	77,00-79,99	15
8	23,2-23,8	18	3,10-3,29	17	80,00-82,99	16
9	>23,8	13	>3,29	19	>82,99	20

n = number of samples in each category.

Raw variables, added features and preprocessing of data: Each individual wine analysed was regarded as an "object" and each of the 36 parameters measured on the wines was defined as a "feature". The resulting data matrix was analysed using a batch process version of "ARTHUR" (Harper *et al.*, 1977). Preprocessing was done by employing the programmes TUNE (to generate feature ratios), AUTOSCALE (to normalise the data) and SELECT as set out by Van Rooyen *et al.*, 1982.

Variable reduction procedure: The programme SELECT, operating on a principal component principle, was used to select 10 final features by using correlation to property weighting, the latter being either overall or aroma quality, depending on the analysis. The application of principal component analysis (PCA) further reduced the actual number of variables to three or four eigenvectors with factor loadings for each of the 10 selected features, using the programmes KAPRIN, KATRAN and KAVARI as explained by Van Rooyen *et al.*, (1982). The programme KAVARI applied the Varimax rotation to PCA vectors to elucidate important features (Preston-Whyte, 1974). VARVAR was used to generate scatter diagrams of feature to property and feature to feature plots, coding objects according to the grape maturity index, wine quality and object number to facilitate interpretation of results.

RESULTS AND DISCUSSION

Overall quality as dependent variable: All measured variables (and their ratios) were subjected to the variable selection procedure, the latter employing the programme SELECT with correlation to quality weighting as basis for selection. The features thus selected are listed in Table 3.

From Table 3 the ratio of tartaric acid to total acidity appeared to be the most important variable, due to its dominant weight in the equation. Ethyl octanoate appears to be an important indicator of wine quality. This is in accordance with the finding of Du Plessis (1975), although he could not demonstrate any effect of ethyl octanoate itself on wine quality. After eigenvector rotation

TABLE 3

Features selected from all variables plus ratios using overall quality weighting

No.	Feature	Weight
1	Tartaric acid/Total Titratable acid	0,45
2	Ethyl octanoate	0,21
3	i-Amyl alcohol/2-Phenyl ethyl acetate	0,04
4	Total Titratable acid/Potassium	0,04
5	Zinc/Sodium	0,03
6	Manganese/Phosphate	0,01
7	2-Phenyl ethanol/i-Amyl alcohol	0,01
8	Calcium/Total phenols	0,01
9	2-Phenyl ethanol/Total titratable acid	0,01
10	i-Amyl alcohol/Total titratable acid	0,01

(VARIMAX procedure) the first five eigenvectors explained 80,1% of the total variance. The factor loadings for the features set out in Table 3 are listed in Table 4.

It can be deduced from Tables 3 and 4 that factor 1 concerns mainly volatile alcohols and TTA ratios, factor 2 is heavily weighted with calcium, total phenols and acid ratios, factor 3 with TTA to potassium ratios, factor 4 with ethyl octanoate and factor 5 with the manganese to phosphate ratio.

TABLE 4

Loadings for first five factors of the eigenvectors after Varimax rotation, with percentages explained variation

Feature	Factor 1 23,3%	Factor 2 18,9%	Factor 3 15,3%	Factor 4 12,1%	Factor 5 10,5%
1	0,066	-0,650	-0,55	-0,074	-0,288
2	0,076	0,055	0,001	-0,881	-0,119
3	-0,151	-0,177	-0,225	-0,177	-0,008
4	-0,075	-0,026	-0,769	-0,056	-0,052
5	-0,001	-0,117	0,006	0,013	-0,059
6	0,005	0,189	-0,051	0,110	0,944
7	0,588	0,052	-0,109	-0,303	0,097
8	-0,011	-0,701	0,006	0,146	-0,067
9	0,630	0,017	0,251	0,006	-0,004
10	0,457	0,011	0,527	0,242	0,038

Scatter diagrams representing plots of the above eigenvectors against overall wine quality showed that high quality wines (sensory scores above 60%) were obtained over a wide range for all three indices. A plot of factor 1 scores against quality serves as an example (Fig. 1), but similar results were obtained by plotting the other factors. In the case of °B as grape maturity index (Fig. 1), high quality wines fall in a very wide range, viz. between categories 1 and 9 (°B from 18,2-24,3). The range narrowed down somewhat when specific cultivars were compared, i.e. 6-9 for Chenin blanc and 1-7 for Colombar.

In the case of the °B/TTA maturity index, higher quality wines were classed into a wide range of this category i.e. 3-9 for Chenin blanc (°B/TTA from 2,12-3,3) and 1-8 (°B/TTA from 2,10-3,25) for Colombar (Fig. 2).

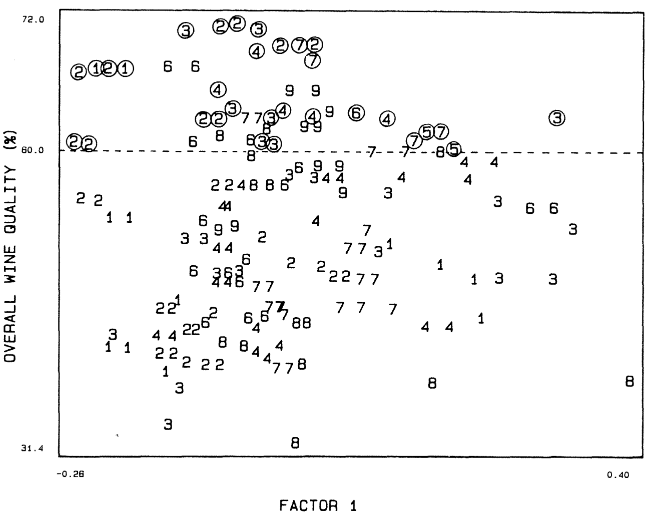

FIG. 1

Plot of overall wine quality rating against factor 1 (PCA analysis) for Chenin blanc and Colombar wines. Wines are coded according to °B category (Table 2). Colombar wines with quality ratings above 60% circled.

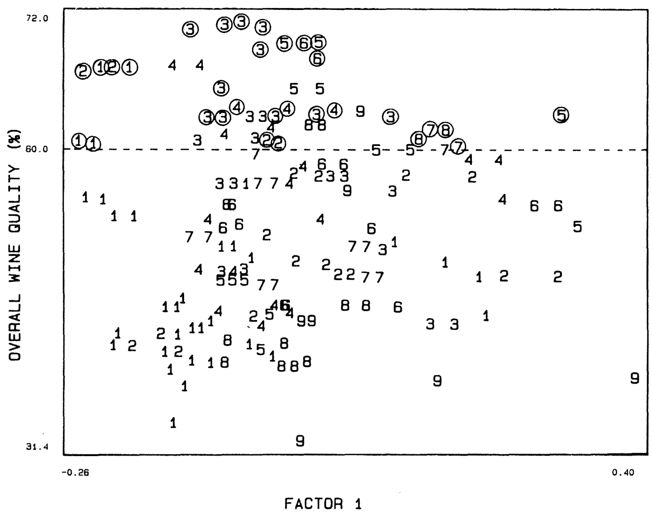

FIG. 2

Plot of overall wine quality rating against factor 1 (PCA analysis) for Chenin blanc and Colombar wines. Wines are coded according to °B/TTA category (Table 2). Colombar wines with quality ratings above 60% circled.

The °B.pH maturity index indicated a range from 4–9 for Chenin blanc (°B.pH from 69–85) and 1–8 (°B.pH from 58–82) for Colombar as illustrated in Fig. 3.

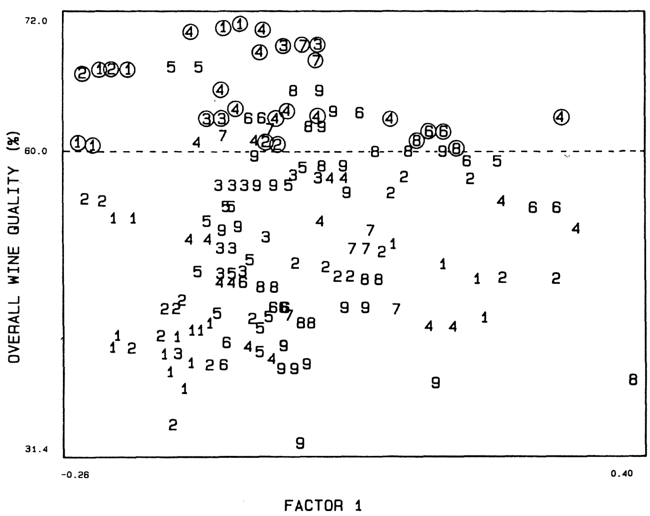

FIG. 3

Plot of overall wine quality rating against factor 1 (PCA analysis) for Chenin blanc and Colombar wines. Wines are coded according to °B.pH category (Table 2). Colombar wines with quality ratings above 60% circled.

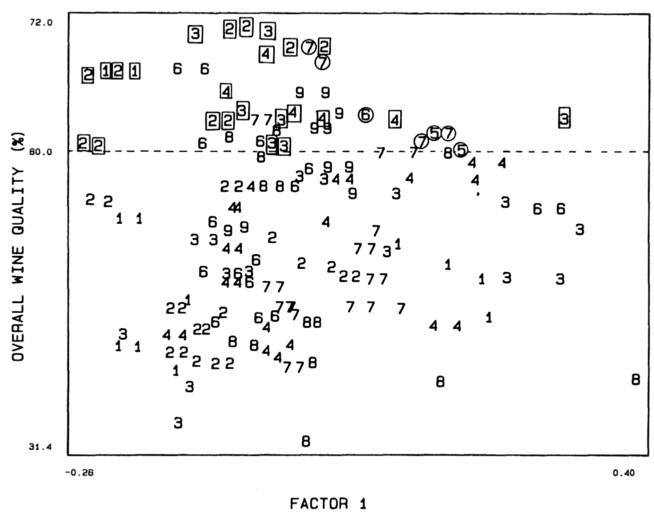

FIG. 4

Plot of overall wine quality rating against factor 1 (PCA analysis) for Chenin blanc and Colombar wines. Wines are coded according to °B category (Table 2). Colombar Lutzville (○) above 60%.
Colombar Robertson (□) above 60%.

When geographic regions are compared, the range in which high quality wines were obtained, decreases for all three measured indices. For example, the °B range containing high quality Colombar wines from the Robertson area is between categories 1–4 (°B 18,6–21,0) and 5–7 (° 21,1–23,1) for the Lutzville area (Fig. 4). The relative narrow index ranges wherein higher quality wines for each region were obtained, confirms that a grape maturity index is area-specific.

A plot of factor 2 against overall quality is given in Fig. 5, indicating a negative relationship between overall wine quality and factor 2 (calcium/total phenols and the tartaric/total phenols and the tartaric/total acid ratio).

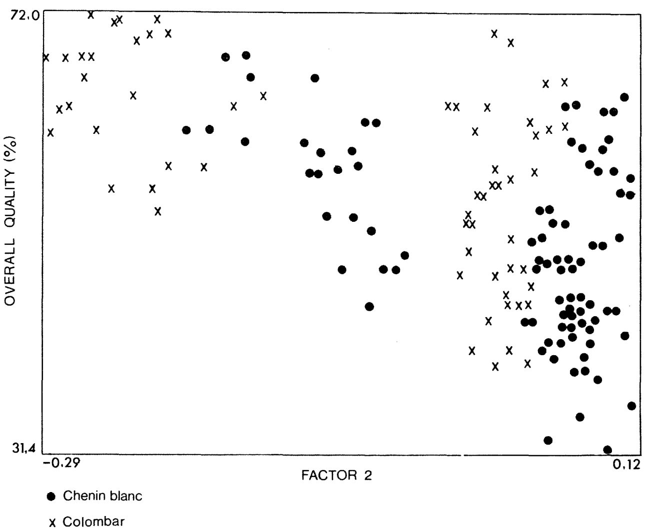

FIG. 5

Plot of overall wine quality rating against factor 2 (PCA analysis) for Chenin blanc (●) and Colombar (X).

Aroma quality as dependent variables: An additional analysis was executed using only wine volatiles as independent variables. Following the same selection procedure as set out before, a total of 10 features was again selected (Table 5).

The factor loadings for the first three of seven eigenvectors accounting for 76,5% of total variance, were as set out in Table 6.

It follows from Tables 5 and 6 that factor 1 is concerned mainly with 2-phenyl ethyl acetate and ethyl ester ratios, factor 2 with alcohol ratios and factor 3 with ethyl lactate and alcohol ratios.

A plot of factor 2 against factor 3 (Fig. 6) illustrates the differences in flavour profiles of the two cultivars within the same year. Subsequent eigenvector rotation resulted in factor loadings for the seven eigenvectors of which

TABLE 5

Features selected from volatiles data base using aroma quality weighting

No.	Feature	Weight
1	Hexanoic acid	0,499
2	Ethyl decanoate/2-Phenyl ethanol	0,083
3	2-Phenyl ethanol/Ethyl lactate	0,014
4	Hexyl acetate/Ethyl lactate	0,036
5	Di-ethyl succinate/Hexanoic acid	0,032
6	iso-Amyl alcohol/2-Phenyl ethanol	0,011
7	2-Phenyl ethyl acetate/Ethyl butyrate	0,012
8	Ethyl octanoate/2-Phenyl ethyl acetate	0,007
9	Di-ethyl succinate/Octanoic acid	0,008
10	Ethyl butyrate/2-Phenyl ethyl acetate	0,009

TABLE 6

Loadings for the first three factors of the eigenvectors with percentages explained variation

Feature number	Factor 1 39,3%	Factor 2 20,6%	Factor 3 16,6%
1	0,190	0,275	-0,331
2	0,385	-0,215	0,315
3	-0,215	0,068	-0,568
4	-0,268	-0,139	-0,531
5	0,262	0,440	-0,092
6	-0,042	-0,622	-0,015
7	-0,446	0,141	0,265
8	0,477	-0,016	-0,168
9	0,477	-0,192	-0,241
10	0,049	0,466	0,147

factor 3 (11,7% explained variation) had the highest loading (0,88) for hexanoic acid. The scatter diagram presenting a plot of this factor against aroma quality is given in Fig. 7, illustrating that an increase in the concentration of hexanoic acid leads to an increase in aroma quality. This might be the reason why hexanoic acid was selected as the most important variable in aroma quality weighting (Table 5).

Scatter diagrams depicting plots of the eigenvector scores against aroma quality illustrated that higher aroma quality was obtained over wide ranges for all three indices, but the ranges tended to be narrower for specific cultivars and regions (data not shown).

Table 7 is a summary of the grape maturity ranges in which a high correspondence with wine analysis profiles occurred for the two cultivars from the different regions. It can be seen that the ranges for all three maturity indices differed amongst regions and cultivars. For example, the °B/TTA ranges in which high quality wines occurred for the Stellenbosch area were 2,2–2,9 and 3,1–3,3 for the Lutzville area. High aroma quality was obtained at earlier stages of maturity compared to the results for overall quality rating.

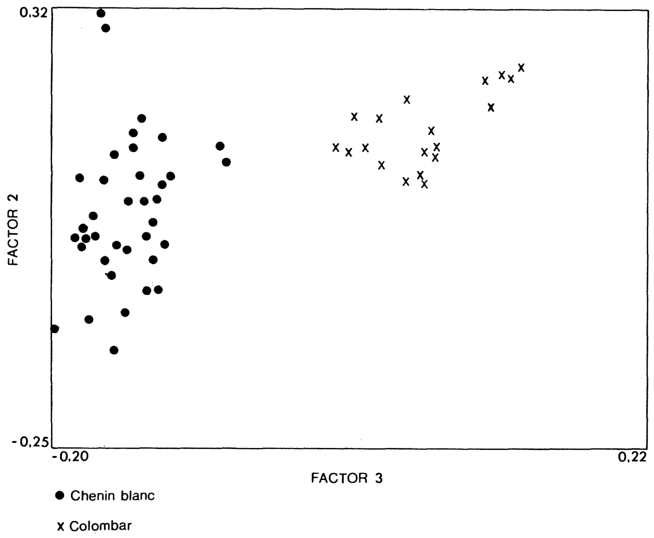

FIG. 6

Plot of factor 2 against factor 3 (PCA analysis) for Chenin blanc (●) and Colombar (X) wines from the 1979 vintage.

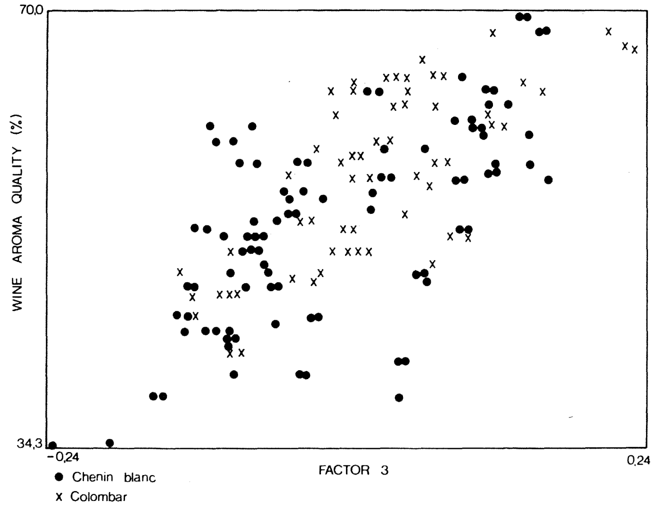

FIG. 7

Plot of factor 3 (PCA analysis) after eigenvector rotation (VARIMAX procedure) against wine aroma quality for Chenin blanc (●) and Colombar (X) wines.

TABLE 7

Grape maturity index ranges having a high correspondence with analysis profiles of quality wines

OVERALL WINE QUALITY - FULL VARIABLE SET

	CHENIN BLANC			COLOMBAR	
	Stellenbosch	Robertson	Lutzville	Robertson	Lutzville
°B	21,8–24,3	20,4–23,0	22,8–24,3	19,0–21,0	21,4–23,1
°B/TTA	2,2– 2,9	2,3– 2,6	3,1– 3,3	2,0– 2,6	2,4– 3,3
°B.pH	70,0–80,0	72,0–82,0	80,0–86,0	60,0–70,0	74,0–83,0

AROMA QUALITY - WINE VOLATILES

	CHENIN BLANC			COLOMBAR	
	Stellenbosch	Robertson	Lutzville	Robertson	Lutzville
°B	19,0–23,0	22,5–23,1	20,0–23,8	19,0–21,0	19,6–23,0
°B/TTA	1,9– 2,6	2,5– 2,9	2,0– 3,2	2,1– 2,6	2,0– 3,2
°B.pH	60,0–75,0	77,0–83,0	65,0–85,0	58,0–69,0	64,0–82,0

SUMMARY AND CONCLUSIONS

The results demonstrated that two white wine grape cultivars from different regions differed appreciably with respect to the maturity indices °B, °B/TTA and °B.pH. From this study it was not possible to select a specific index to predict optimum maturity in all cases. Optimum values for each index have to be determined for the conditions prevailing in a specific locality. This is probably due to the fact that the wines were made from grapes grown in regions where large differences in climatic conditions and viticultural practices occur.

Although there are some indications, it is obvious that predicting wine quality from analytical data will be a very difficult procedure. Although 36 parameters and 1 296 parameters ratios were utilized in this study, it was still impossible to determine which factors measurably contribute to wine quality. The high correlation of certain measured parameters, and parameter ratios with wine quality, need further investigation.

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