# Characterisation of viticultural and oenological practices in two French AOC in the middle Loire Valley: comparison of different methods to extract information from a survey among winegrowers

# Caractérisation des pratiques viticoles et œnologiques dans deux AOC du Centre Val-de-Loire: comparaison de deux méthodes d'extraction d'information à partir d'une enquête réalisée auprès des viticulteurs

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## Abstract

The type of wine is determined by environmental, plant materials and human factors. These factors are numerous and interact together, which makes it difficult to determine the hierarchy of their effects. We propose in this paper two methods to determine a hierarchy for these variables or their modalities. Using an inventory of agricultural, viticultural and oenological practices that are utilized for the production of Anjou Villages Brissac (AVB) or Anjou Rouges (AR) wines, it was attempted to determine for each of the variables whether their use differed significantly between the two appellations, and subsequently which of these practices were specific to each of the appellations.

Firstly, the variables and variable modalities were differentiated by a khi-squared distribution method. The database of the plots helped us to identify the practices which were used. An extraction of these plots was performed and the practices were classified by expertise.

Secondly, Classification and Regression Trees (CART) were used. This statistical method is non-parametric and non-linear and can, therefore, accommodate both continuous and categorical predictor variables. Variables can also be ranked in terms of their potential effect or relative importance. Using CART, the relative importance of each environmental, agricultural, viticultural and oenological variable in predicting whether a wine belonged to the appellation AVB or AR was determined and a final decision tree was constructed.

The final classification of variables using these different methods was compared and the observed differences were analysed. It remains to validate the hierarchical classification of the variables by means of experimentation with different technical itineraries on reference vineyards.

**Key words**: viticultural practices, oenological practices, global approach, CART, expertise.

## Introduction

Terroir is becoming increasingly important as a factor in the characterisation of wine, but also as a marketing selling point (Casabianca et al. 2005). The environmental and human factors that can affect wine typicity are numerous and interdependent, which makes it difficult to obtain relevant data and to determine the hierarchy of their effects. Surveys have been found to be the most efficient method to explore a large number of variables over a large area and have already been used for studies of vineyards (Thélier-Huché and Morlat, 2000; Bodin and Morlat, 2003) and other agricultural systems (Lucas et al. 2003; Ryder 2003).

A study focussing on the characterization of all terroir parameters, i.e. combination of variables relating to environment and know-how, started in 2006 in the Anjou Village Brissac area. This AOC may be claimed for a viticultural area that overlaps with the Anjou Rouges AOC. There are, however,

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differences in the guidelines for production of each of these AOCs (Table 1). This area is also characterised by differing agronomic potential for wine production, containing a number of different terroir units.

Variables can also be ranked in terms of their potential effect or relative importance. Both methods allow us to extract significant practices that are applied in the field and to discuss the relative importance of viticultural and oenological practices in the production of Anjou Villages Brissac wines.

| Anjou Villages Brissac | Anjou Rouge |
|---|---|
| 2 cultivars (Cabernet franc and Cabernet Sauvignon) | 6 cultivars |
| No limitations on minimum natural potential alcohol content. | Minimum natural potential alcohol content: 9 % |
| Harvest: Less than 50 hl/ha | Harvest: Less than 60 hl/ha |
| Grapes must come from vineyards that are at least 4 years old | No limitation on age of vineyard |
| Pruning: 12 buds maximum with 7 buds on the cane | Pruning: 12 buds maximum with 8 buds on the cane |
| Canopy height defined | Canopy height is not limited |
| Wines must be matured for at least one year. | No limit on maturation period |

**Table 1 Selected guidelines for production of wines in the AOC Anjou Villages Brissac and Anjou Rouge (INAO 1998; 1999).**

This paper presents and compares the results of two different methods of extraction of important practices in the wine production process of Anjou Villages Brissac and Anjou Rouges, using the same data-base.

## Materials and methods

**Study area:** Two protected Designations of Origin "Appellation d'Origine Contrôlée" (AOC) of the Middle Loire Valley (France) located to the south-east of Angers, namely, Anjou Villages Brissac (AVB) and Anjou rouge (AR) were studied. AVB AOC wines are produced from 93 ha within the 2400 ha that are authorized for production. AR AOC can also be produced from within this authorised area and these wines have become increasingly important economically (INAO 1998; 1999). A total of 182 AVB and 90 AR plots within the area authorized for production of AVB AOC were identified for survey.

**Survey:** An inventory (guided survey) of agricultural, viticultural and oenological practices that are used for the production of AVB or AR wines (41 wine producers) was performed for these identified plots. Practices and categories of practices were studied for these identified vineyards and related spatially with environmental variables.

**UTB and terrain model:** The soil types of the 272 plots have been classified according to a field soil model based on the type of the parent rock, the depth and the clay richness of soil, mainly in connection with the weathering level of the parent rock. Each soil type is considered as an homogeneous unit for grapevine production from the viewpoint of ecophysiological factors and is named, according to this method, as a Basic Terroir Unit (BTU) (Bodin and Morlat 2006).

The use of $Chi^2$ analyses and expertise is one possibility of statistical analysis of survey responses but classification and regression tree analyses (BREIMAN et al. 1984) offer another possibility. This statistical method is non-parametric and non-linear and can, therefore, accommodate both continuous and categorical predictor variables.

**Basic statistical analyses:** The first step of the basic statistical analyses was a classification of the responses for each variable into categories. The frequency of a response for each category of a variable was then calculated. A Chi-squared distribution was used to differentiate the AVB and AR plots statistically for the different categories of each variable. The practices were then classified using

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expertise and extracted from the database to find the plots that have the different combinations of viticultural and oenological variables that are characteristic of AVB or AR.

**CART statistical analyses**: Classification and regression tree analyses (BREIMAN et al. 1984) were used on a data set that consisted of survey variables and variables related to the characteristics and potential of the UTB on which each surveyed vineyard was situated. The dataset was grouped in different ways in order to exclude the effects of masking variables. The first analysis was performed on the complete data set. The second analysis was performed on the full data set with the exclusion of the variables that were determined by the regulations of the appellation (e.g. year of planting, row width, vine spacing, buds at pruning, grapevine height and duration of wine maturation). The third analysis was performed on the variables that were related to the natural features (UTB and environmental and plant material related survey variables), the fourth analysis on all viticultural variables and the final analysis on the oenological variables. The cost sequence was calculated to determine the optimum number of nodes in each tree and the relative variable importance was computed.

## Results and discussion

**Combination of statistical independence tests and expertise:** The variables and categories of variables were differentiated statistically. A $Chi^2$ distribution showed that for 38 variables, AVB and AR plots differed significantly. This group included 10 'farm strategy' variables (named F in Table 2), 18 'agronomic and viticultural' variables (named V in Table 2) and 10 oenological variables (named O in Table 2). As this statistical test cannot show the weight of each variable, expertise was used to assess the importance of each variable. Fourteen experts performed two tasks: Firstly they ranked the importance of each of the 38 variables (Table 2); secondly they identified which group of variables (F, V or O) had the greatest significance in determining whether Anjou Villages Brissac wines were produced from a specific vineyard (Fig. 1).

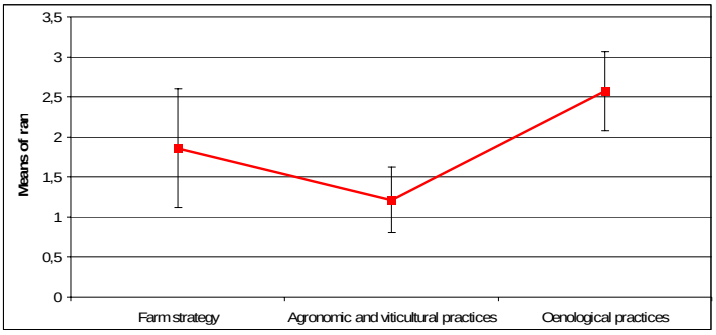


**Figure 1 Weight of each group of variables according to experts (farm strategy, agronomic and viticultural practices and oenological practices).**

| Most important variables (Ranked 1) | Least important variables (Ranked 3) |
|---|---|
| Vigour (V) | ……. |
| Time of veraison (V) | Row width (V) |
| Suited for wine style (O) | Fertilization (V) |
| Cultivar (V) | Winegrower diploma (F) |
| Max height of topping and trimming (V) | Wind exposure(V) |
| Drought symptoms (V) | Soil management under vines (V) |
| Percentage of well known wine in the winery (F) | Number of persons working on the farm (F) |
| Means of extraction (O) | Organic or conventional viticulture (V) |
| Soil management in rows (V) | Yeast inoculation (O) |
| Adapted to AVB (O) | Cuvée blending (O) |
| Rootstock (V) | Percentage of cheap wines in the winery (F) |
| ……. | Frost symptoms (V) |

**Table 2 Ranking of variables by experts. F = farm strategy variable, V = agronomic and vitiulctural variable, O = oenological variable.**

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Table 2 allows us to distinguish which viticultural and oenological practices are of importance for the production of Anjou Villages Brissac wines. Most experts agreed that the variables vigour, time of veraison and 'suited for wine style' were important in the production of Anjou Villages Brissac wines, while 'percentage of cheap wines' and frost symptoms were not considered as important factors for Anjou Villages Brissac wines. It is possible, therefore, to extract the 8 major agro-viticultural practices and the 7 major oenological practices. These 15 different practices, and their distribution between AVB and AR plots, could be use to plot different farming systems (combinations of farm strategies, agronomic and viticultural practices and Oenological practices).

Whether or not these specific combinations of practices were used was confirmed by extracting plots from the data base. This enabled the identification of 25 AVB plots and 11 AR plots (Fig. 2) with specific combinations of practices in the vineyard and cellar.

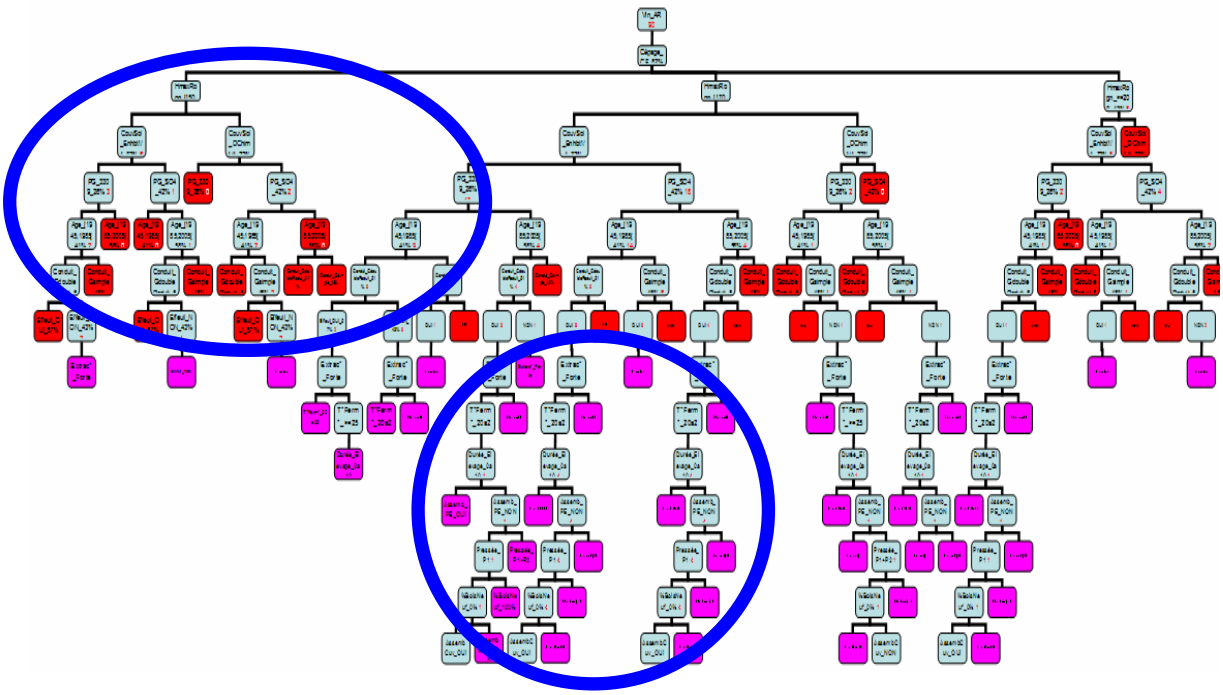

**Figure 2 Method of extraction of plots from a database. First variables (top of the tree) are agro-viticultural variables; the remaining variables (bottom of the tree) are oenological variables. Coloured boxes denote the end of a combination due to no further vineyards being extracted**

In reality certain combinations are not practiced (coloured boxes in Fig. 2), yet the vineyards that fall by the wayside in this classification exercise also produce AVB wines. This suggests that this methodology is not conclusive and that the weight of the different practices in determining whether a vineyard produces AVB wines should be further evaluated. In addition, the number of extracted plots is insufficient to establish a statistically valid network to continue to analyse the impact of different combinations of agro-viticultural and oenological practices. Perhaps each part of the tree (agro-viticultural or oenological) should be explored independently.

**CART analyses:** Analysis of the complete set of variables (UTB and survey) showed the strong influence of the producer on the decision as to whether AR or AVB is produced. The variable with the highest relative importance was the duration of maturation (100%), followed by whether the respondent believed that the environmental characteristics of the vineyard were best suited for the production of AVB (74%) or AR (61%). The final tree was constructed using only the variable “duration of maturation”, showing excellent distinction between AVB and AR (Fig. 3).

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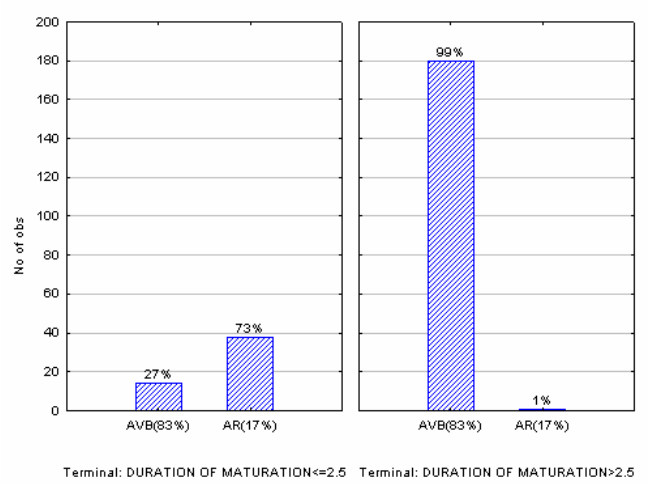


**Figure 3 Final classification tree for full data set of variables (UTB and survey variables) that determine the production of either AR or AVB wines.**

These results suggest that out of all the possible factors contributing to a wine being classified as AVB or AR, the one that has the final determining effect is the duration of maturation – whether the wine is aged more or less than ca. 10 months. However, this could be an artefact as the variable of "duration of maturation" is determined by the guidelines of the AVB AOC. If a wine is classified as AVB, it may not be bottled before 1 September of the year following harvest. It was therefore decided to remove all variables that could possibly be affected by the "cahier des charges" from the analysis and the analysis was repeated. In this case the most important variable was computed as "Aim of maturation (refinement)" (100%), followed by "means of extraction" (92%), "rack and return" (start of alcoholic fermentation) (83%), "rack and return" (not performed) (77%), time of leaf removal (68%) and suited for wine style (AVB) (68%). The final tree again showed good distinction between AR and AVB (Fig. 4).

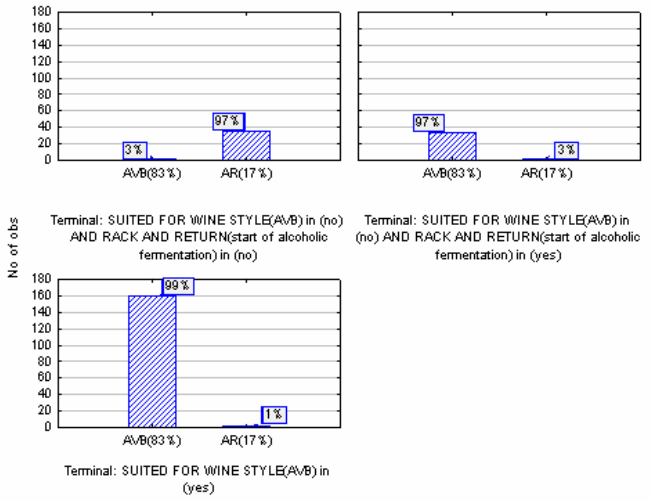


**Figure 4 Final classification tree for full data set of variables (UTB and survey variables – excluding variables affected by AOC guidelines) that determine the production of either AR or AVB wines.**

This tree showed that the primary node is determine by whether or not the respondent believes that a vineyard has environmental characteristics that are suited for the production of AVB wines. However, there is a secondary consideration, namely, whether or not the practice of "Rack and return" or délestage is performed at the start of alcoholic fermentation. Even if the environmental practices were not considered suitable for the production of AVB wines, if the must was racked and returned at the start of alcoholic fermentation, the wines went on to be classified as AVB.

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These two analyses would suggest a predominance of oenological techniques in the final determination of AVB wines and it was therefore decided to perform the CART analyses on the data grouped into natural features (UTB and survey responses relating to environment, plant material and natural adaptation or suitability for the production of AVB wines), viticultural (survey responses) or oenological (survey responses) data sets. As regards the natural features, once again whether or not the vineyard was suitable for the production of AVB wines was recognised as being important (82%). The age of the vines was recognised as being a determining factor for the good adaptation of a vineyard for the production of AVB wines (100%). The final tree is shown in Fig. 5. These results suggest that the belief that a vineyard is not ideally suited for the production of AVB can be counteracted by the age of the vines. Examination of the results of the CART analysis of the viticultural variables shows that the two most important variables are the number of times the vineyards are trimmed during a dry season (100%) and the row width (76%). However, the final tree includes variables with a lower relative variable importance (Fig. 6) and the final nodes do not provide as good discrimination as other trees. As regards the oenological variables, the duration of maturation was once again dominant and the final tree was not dissimilar to that for the full dataset.

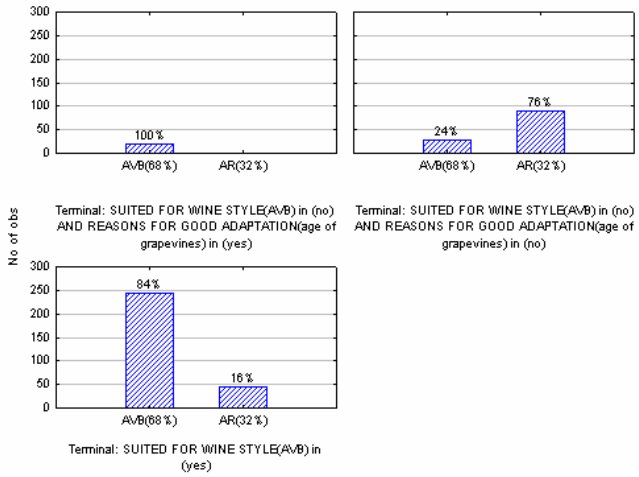


**Figure 5 Final classification tree for natural features (UTB and survey responses relating to environment, plant material and natural adaptation or suitability for the production of AVB wines) that determine the production of either AR or AVB wines**

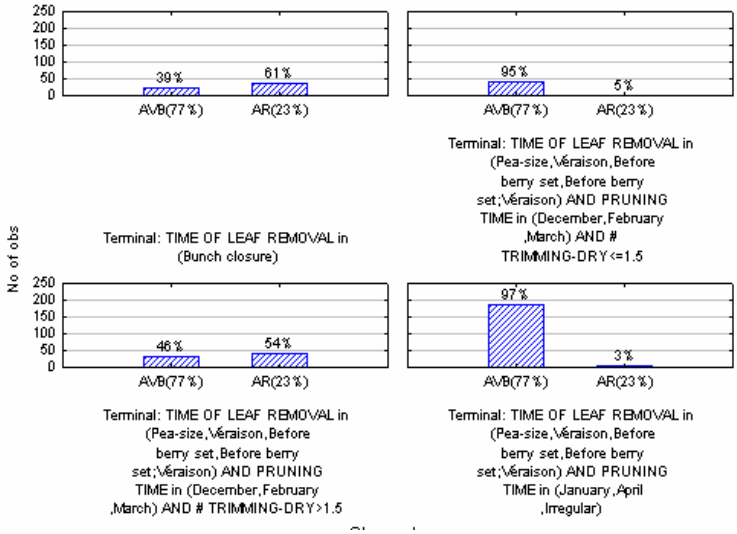


**Figure 6 Final classification tree for viticultural variables that determine the production of either AR or AVB wines**

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## Conclusions

The first data analytical methods showed the importance of agro-viticultural and oenological practices as determined by experts. It is interesting to note that there is a predominance of oenological characteristics associated with the production of AVB wines.

It would appear from the CART results that there are two variables that dominate, namely the duration of maturation, which is determined by the AOC guidelines, and whether or not the respondent believes that the vineyard is well suited to the production of AVB wines. It is important to note that for these analyses, as the data set was not split into separate training and test sets, the results have not been validated.

The final results of the two methods do not agree completely. The variable of duration of maturation that dominated the CART results was not classified as being particularly important by the experts and many of the variables that were classified as being important by the experts received particularly low scores for the CART analyses of the full data set minus the variables determined by the AOC guidelines. However, the belief that that a vineyard is well suited for production of AVB and the method used for extraction during winemaking were identified as being important both by CART and by the expert panel.

This would suggest that the opinion of the winemaker and the final choices in the cellar still dominate the choice to produce wine as AOC AVB. Anjou Villages Brissac, is however, a young appellation and the best vineyards for its production have perhaps not yet been identified and its renown not yet sufficiently established amongst the producers.

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