Associazione
Istituzione
Libera
Università
Nuorese

AILUN
Via Pasquale Paoli, s.n
08100 Nuoro - Italy
Tel.: +39 0784 226200
Fax: +39 0784 203158
http://www.ailun.it

Introduction

The colour of wine is the characteristic most immediately recognizable by the consumer and represents an element of major importance in the definition of the quality and peculiarity of the product.
On the other hand the colour of wines is not only an aestethic element, their chromatic characteristics being closely connected to the chemical composition, and consequently linked to the processing of grapes, must and wines during the wine making and to a series of environmental influence factors, including ageing and preservation conditions.

It has consequently a great importance to understand in what way the different production conditions affect the colour of the final product, and how it is possible to control them in view of the standardization of the colour of a specified wine in successive vintages.

At present wine colour is usually valued through visual analysis, in accordance with prefixed chromatic categories, with all limits due to the subjectivity and non repeatibility of valuation. Objective instrumental measurements, on the contrary, could allow repeatibility and comparability in space and time.

The research activity of AILUN in the field of wine colorimetry started from these reflections. Our work began with a cooperation with the University of Porto (Dept. of Physics – coordinator of the research: Prof. Olivério D.D. Soares) for developing a new spectrophotometric standard procedure for the measurement of the colour of wine [1]. The procedure is based on the CIE recommendations on the measurement of colour [2] and make use of the CIELAB colour coordinates L*, a*, b* (L*, C*, h) (see below for more details).

The procedure has been then adapted to in situ measurements carried out with portable fiber optics spectrophotometers. A first small research project (called OPTITEC) based on this procedure was aimed at examining the overall evolution of the colour of wine during all the production path, with particular reference to the effect of different techniques of maceration, to the evolution in different kinds of tank and to other usual ‘cellar operations’ such as e.g. decantings, solfitations, etc. In order to do this, some local enterprises were involved in the project, and some of their productions were monitored in situ during the full period of production until bottling.

This first investigation studied macroscopic evolution of the colour, not taking into account in detail the chemical causes of the change of colour. The effect of the main chemical parameters and environmental factors involved in the colour modifications (pH, free SO_2 content, temperature, conditions of preservation, etc.) was studied only in general on some sample (test) wines, mainly in order to individuate the colour coordinates (CIELAB) more adapt to the possible monitoring of such parameters.

Next step of our research is to establish correlations between the chemical compounds of wine (in particular those responsible for the colour: anthocyanins, tannins, etc.) and colour in terms of CIELAB coordinates. AILUN is now running a new research program based on a systematic sampling of wine during

production with extensive measurement of its chemical components and parameters in parallel with colour measurement. The research is carried out in collaboration with Sardinian winemaking enterprises and a regional Research Center in agriculture (notably enology) which in particular will perform the chemical measurements. The realization of a database of colorimetric characteristic of Sardinian wines is also envisaged, along with the definition of colorimetric regions of tipicity of different tipologies of wine in the CIELAB space.

The research field has been recently extended to the measurement of the colour of grapes; in this preliminary phase a reflectance fiber optics probe connected to a portable spectrometer is used for the in situ measurements. In the above mentioned new research project the study is intended to start from the grapes, foreseeing the measurement of their chromatic evolution in parallel with chemical parameters during the ripening.

The development and adoption of the new procedure for wine colour measurement 'in situ' allowed to achieve some objectives [3]. Among others: the possibility of assessment and comparison of different processing techniques (notably maceration techniques) with regard to the extraction of colour from pomace, and its following stability; the possibility of having at any moment of the production cycle immediate information about the chromatic characteristics of the product, comparable with historical data concerning different vintages and/or products and which can be correlated to processing techniques and chemical composition; the possibility of objectively define regions of chromatic tipicity for different tipologies of wines.

Procedure for measuring colour of wine and grapes in situ

The measurement of colour is internationally based on the CIE recommendations [2]. In this document, starting from the measure of the full spectrum of the coloured object in the visible region, the colour is described in terms of three quantities. The document defines (by means of tables) standard illuminants, standard observers and measurement geometries that allow, along with the measured transmittance spectrum, the calculation of the so called Tristimulus values X, Y, and Z. Starting from these values it is possible to calculate the three CIELAB colour coordinates: L*, a*, b* (or, alternatively, L*, C*, h, perfectly equivalent). In particular, the recommendation suggests the use of D65 illuminant, standard observer 1964 and spectral range 360-830 nm, with sampling interval equal to 1 nm.

The European Regulation about wine colour measurement [4] contains on the other side two methods, a reference one and an usual one. The reference method defines the Tristimulus values, but on the basis of the measurement of the transmittance at only four wavelengths (Table 1). The colour is then expressed in terms of three quantities: relative luminosity (Y value expressed in %), dominant wavelength and purity, the last two calculated by means of a graphical procedure that makes use of diagrams based on the use of the CIE standard illuminant C and CIE 1931 standard observer.

The usual method specifies two quantities: intensity and tonality, calculated from the measurement of the absorbance at three different wavelengths (Table 1). The colour is defined by these two quantities only.

Reference Method	Usual Method
TRISTIMULUS VALUES	
$X = 0{,}42 \cdot T_{625} + 0{,}35 \cdot T_{550} + 0{,}21 \cdot T_{445}$	INTENSITY $I = A_{420} + A_{520} + A_{620}$
$Y = 0{,}20 \cdot T_{625} + 0{,}63 \cdot T_{550} + 0{,}17 \cdot T_{495}$	TONALITY $N = A_{420} / A_{520}$
$Z = 0{,}24 \cdot T_{495} + 0{,}94 \cdot T_{445}$	

Table 1. Expressions for the calculation of the colour of wines according to the EEC Regulation N. 2676/90

The two methods of measure come from a document published by OIV (Organisation Internationale de la Vigne et du Vin) [5], the Organization that defines internationally the measurement methods concerning wine and grapes. The methods don't follow the CIE recommendations about colour measurements and moreover don't assure satisfying results.

The procedure for colour measurement of must and wine we are proposing is based on an adaptation and optimization of the aforementioned CIE recommendations [2] to the wine, following a series of investigations on the more suitable parameters to be adopted and on the influence factors affecting the measurements [6].

The procedure for the measurement of the colour of grapes is at present in a definition and improvement phase. It is based on the use of a fiber optics probe for reflectance measurements that allows an illumination/viewing geometry 45°/45°. The repeatibility of the measurement is assured by means of a suitably shaped probe holder.

In both cases (must and wine, grapes) the colour is expressed by means of the CIELAB colour coordinates (L*, a*, b* or (preferably) L*, C*, h). The coordinates L*, C*, h are strictly related with the visual properties transparency, intensity of colour and tonality of colour respectively. The value of the colour coordinates should be given along with the uncertainty in the measurement, expressed according to the relevant international recommendations [7].

The procedures have been adapted for the use with diode array portable spectrometers. In this case the sampling interval and spectral bandwidth are imposed by the instrument characteristics. The measured spectra are then transferred to the reference conditions by means of a transfer calibration and the colour coordinates are calculated. This step introduces an error that has to be evaluated in the calculation of the total uncertainty of the measurement.

The procedures allow objective instrumental measurements, repeatable in space and time and comparable with other measures made through the same technique. Moreover it allows to take measures in situ, avoiding problems connected with the transport of the sample to the laboratory and giving the possibility of immediate and non-destructive colour valuations.

Examples of application

We report some examples of application of the procedures for colour measurement

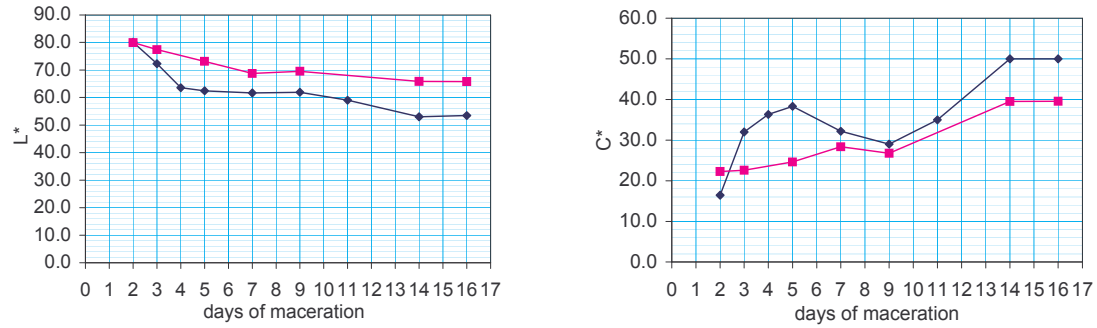
1) <u>Monitoring of maceration</u>

The chromatic evolution of the must during the maceration was monitored for two different processing techniques applied to two portions of the same lot of harvested grapes:

J0FT – Maceration with daily punching-downs (usual technique)

J0FD – Maceration with daily délestage (experimental technique)

Figure 1 reports the behaviour of the colour coordinates L*, C*, h during the maceration and their values at dejuicing.



	DEJUICING (DAY 14)			
	L*	C*	h	
J0FT	**53,437** ± 0,071	**50,009** ± 0,028	**0,153** ± 0,017	
J0FD	**65,810** ± 0,170	**39,539** ± 0,029	**4,356** ± 0,179	ΔH*
Colour difference between J0FD e J0FT	**12,373** ± 0,184	**-10,469** ± 0,040	**4,203** ± 0,179	**3,261** ± 1,009
	ΔE* = **16,533** ± 0,141			

Figure 1. Chromatic evolution of must during maceration for different processing techniques
J0FT - Maceration with daily punching down
J0FD - Maceration with daily délestage

2) Aging in barrique-barrels

The effect on red wine colour of aging in barrique-barrels was taken into consideration. The wine contained in a concrete tank of capacity 250 hl was decanted in barrique-barrels of 225 l and 350 l and in a smaller concrete tank (140 hl). The colour evolution in the three different kinds of containers was then

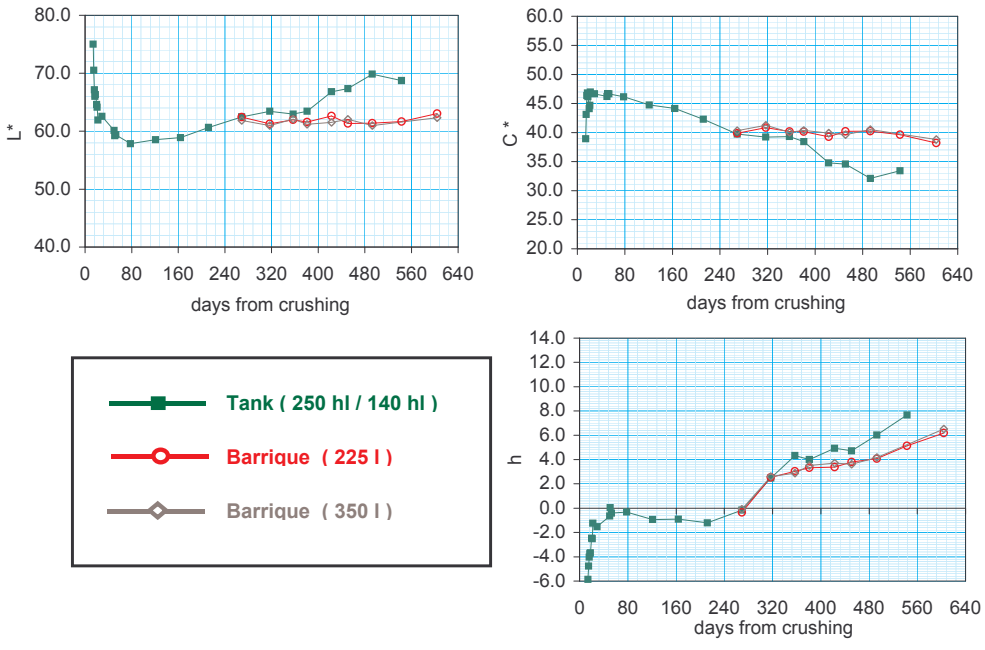


Figure 2. Effect on colour evolution of aging in different kinds of container

monitored. Figure 2 reports the results of the study. Barrique-barrels appear to stabilize the colour of wine; their capacity seems not to produce recognizable differences in colour evolution.

3) Chromatic characterization of different tipologies of wine

A colorimetric database of Sardinian wines is being realized, with the use of the standardized procedure for the measurement of the colour of wine above mentioned. As an example figure 3 reports in the CIELAB colour space the position of some samples of three different tipologies of Sardinian wines (Cannonau di Sardegna DOC, Monica di Sardegna DOC, vins nouveaux).

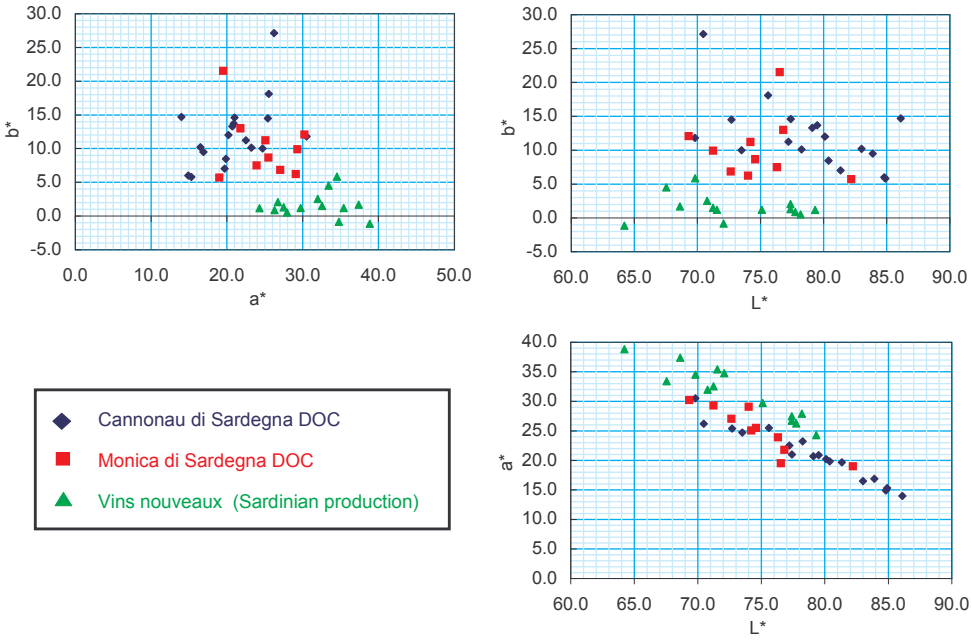


Figure 3. Colorimetric characterizations of wines in CIELAB space

4) Colour of grapes

Figure 4 reports the reflection spectra at harvest time of two different wine grape cultivars (Cannonau and Carignano). The measurements have been carried out using the procedure for measurement of the colour of grapes above mentioned.

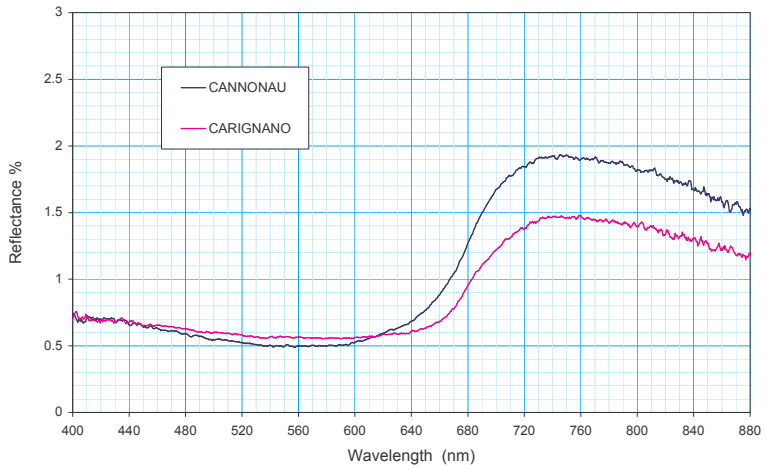


Figura 4. Reflectance spectra of different grape varieties

Bibliography

[1] O.D.D. Soares - "Spectrocolorimetry in Wines", FV 1017-2914/230196, *Office International de la Vigne et du Vin (OIV)*, Paris, 1996

[2] Publication CIE N. 15.2 - "Colorimetry", *Commission Internationale de l'Éclairage*, Wien, 1986

[3] G. Mignemi - "Controllo colorimetrico dei vini durante il processo di vinificazione" in "Atti di colorimetria 2002", *Centro Editoriale Toscano,* Firenze, 2002

[4] CEE – "Commission Regulation (EEC) No 2676/90 of 17 September 1990 determining Community methods for the analysis of wines", *Official Journal L 272 , 03/10/1990 P. 0001 - 0192*, 1990

[5] Office International de la Vigne et du Vin (OIV) - "Recueuil des Méthodes Internationales d'Analyse des Vins", AO 1-14, 1969

[6] O.D.D. Soares, G. Mignemi, P. Barros - "Collaborative Studies in Wine Spectrocolorimetry", 36th Session, Subcommittee Analytical Methods, *Office International de la Vigne et du Vin (OIV)*, Paris, 1996

[7] ISO/TAG4/WG3 - "Guide to the Expression of Uncertainty in Measurement", *ISO (International Organization for Standardization)*, Genève, 1993

Contact

Ing. Giuseppe Mignemi
AILUN
Optical Technologies Department
Via Pasquale Paoli, sn
08100 Nuoro - Italy
Tel.: +39 0784 226200
Fax: +39 0784 203158
e-mail: gmignemi@ailun.it