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Reliability of the Spanish Official Method for Colour of Red Wines in Comparison with the CIE 1931-(x, y) Method*

F. J. Heredia & M. Guzman Chozas

Department of Nutrition and Food Science, Faculty of Pharmacy, University of Sevilla, 41012 Sevilla, Spain

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ABSTRACT

The Spanish official method for determining the colour of a wine is based on a simplified adaptation of the selected ordinate method from CIE. Forty-seven samples of Spanish red wines from twelve 'origin appellations' have been tested by both methods. Differences between the chromatic variables calculated by both methods have been obtained for determining the reliability of the Spanish method. An interval of chromatic variables in which differences oscillated within a narrow range and another interval with a linear increase of differences were found. Some chromatic parameters show cutpoints between the two sets of samples. A discriminant analysis for classifying wines in the two sets has been carried out.

INTRODUCTION

Spanish regulations (Presidencia del Gobierno, 1981) have adopted the OIV Recommendations (OIV, 1969) and the so-called Rapid Method (Sudraud, 1958) for the chromatic characterization of red wines. This approach is a simplified version of a more rigorous procedure (Berg *et al.*, 1964) based on the CIE 1931-(x, y) selected ordinate method.

Some authors (Negueruela & Echavarri, 1983) have observed that, for some 'Rioja' wines, significant differences were found when the above chromatic methods were applied to the same wine samples. In this study the reliability of the OIV method, in comparison with the CIE method, is

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discussed. This reliability is dependent on some chromatic parameters inherent in the analyzed red wines.

MATERIALS AND METHODS

Materials

Samples
Forty-seven representative samples of Spanish red wines from twelve 'origin appellations' (*Alicante, Ampurdán-Costa Brava, Campo de Borja, Cariñena, Jumilla, La Mancha, Navarra, Ribeiro, Rioja, Valdepeñas, Valencia, Yecla*) have been considered in this study. The samples were selected at random, following the criterion of an adequate representativity, according to their production and consumption. All the wines were bottled and commercialized samples. The samples studied showed no turbidity, so previous centrifugation or filtration process was not necessary.

Apparatus
Experimental absorbences were measured in a Bausch & Lomb 'Spectronic 2000' spectrophotometer provided with a continuous X-Y recorder 333508. 'Hellma' precision glass cells with 1, 2, 5, 10 mm pathlengths were used.

Methods

The methods proposed for computing chromatic parameters were the following: the Reference Method and the Rapid Method (Sudraud, 1958; OIV, 1969), in force in Spanish Regulations (Presidencia del Gobierno, 1981); the CIE 1931-(x, y) Colorimetric System (Hardy, 1936); CIELUV and CIELAB Uniform Color Spaces (CIE, 1978). Absorbence measurements were carried out within a time interval of an hour after the bottles were opened; this action avoids the effect of colour instability with time elapsed (Heredia & Guzmán, 1988).

Data were processed using a Digital VAX-11/785 computer. Statistical analyses were performed using the BMDP software (BMDP, 1981).

RESULTS AND DISCUSSION

The differences (δ) between the respective chromatic parameters obtained by both methods have been chosen as objective indices of reliability of the OIV method. In Table 1 chromatic parameters for the wine samples, such as chromaticity coordinates (x, y), luminance (Y), lightness (L^*), purity (P),

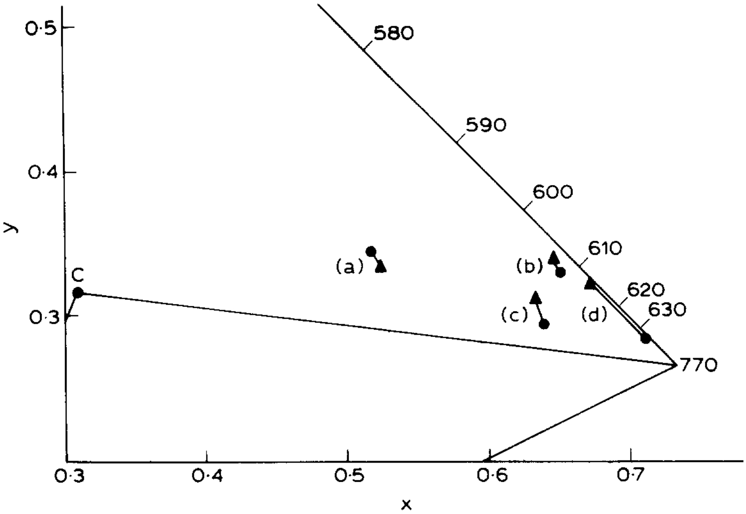

Fig. 1. Section of the chromatic diagram showing displacements of chromaticity (δ_c) by both methods (▲, OIV method; ●, CIE method) for four cases: (a) Valdepeñas; (b) Rioja; (c) La Mancha; (d) Ribeiro.

saturation (s^*_{uv}), dominant wavelength (λ_d), chroma (C^*_{uv}, C^*_{ab}), hue angle (h_{uv}, h_{ab}), tint (Tn) and colour intensity (CI) are offered.

Displacements between the significant parameters from CIE 1931-(x, y) and OIV methods for all the samples were calculated. Chromaticity (x, y) is a bidimensional variable whose displacements (δ_c) were computed too. For a given sample, δ_c corresponds to the length of the segment formed between the colour points (x, y) calculated by CIE and OIV methods, respectively (Fig. 1). By plotting each δ value versus each of the values for the chromatic

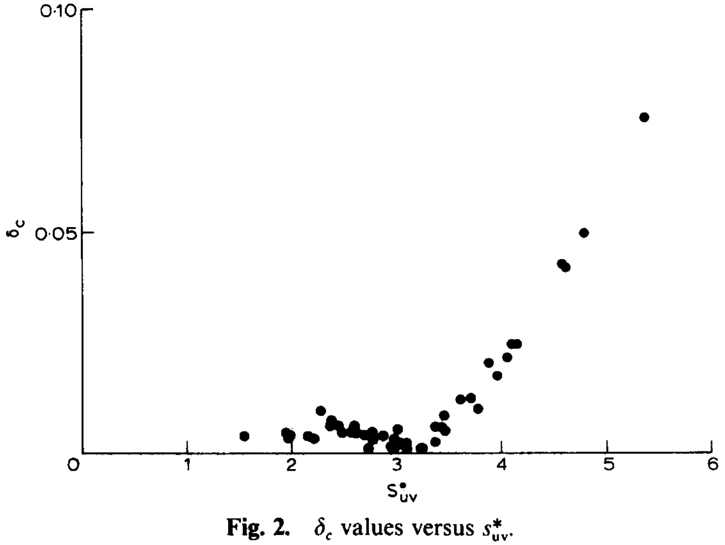

Fig. 2. δ_c values versus s^*_{uv}.

TABLE 1
Chromatic Parameters of the Wine Samples

	Origin appellation[a]					
	(1)	(2)	(3)	(4)	(5)	(6)
λ_{max}	506·667 ± 5·081[b]	490·783 ± 39·558	510·600	514·600	509·800 ± 4·214	524·200
A_{max}	2·079 ± 0·407	2·225 ± 0·528	1·359	2·010	2·458 ± 0·310	5·330
CI	3·957 ± 0·722	4·140 ± 0·897	2·557	3·620	4·555 ± 0·399	8·620
Tn	7·435 ± 9·002	1·433 ± 13·116	7·842	21·306	16·982 ± 12·809	62·731
OIV						
x	0·613 ± 0·026	0·616 ± 0·029	0·521	0·607	0·640 ± 0·014	0·675
y	0·336 ± 0·009	0·339 ± 0·001	0·331	0·317	0·328 ± 0·006	0·321
Y(%)	9·958 ± 2·896	10·155 ± 3·370	16·459	10·791	8·403 ± 0·768	2·638
λ_d	608·735 ± 3·492	607·677 ± 3·769	607·898	616·312	611·729 ± 2·243	614·472
P(%)	86·137 ± 6·210	87·877 ± 6·803	60·502	79·545	91·294 ± 2·231	99·190
CIE 1931 (x, y)						
x	0·613 ± 0·031	0·615 ± 0·034	0·520	0·602	0·641 ± 0·017	0·710
y	0·335 ± 0·013	0·339 ± 0·016	0·335	0·319	0·325 ± 0·010	0·287
Y(%)	9·793 ± 3·029	10·037 ± 3·593	16·759	10·376	7·894 ± 1·021	2·482
λ_d	609·142 ± 4·832	607·992 ± 5·889	606·141	615·075	613·005 ± 4·200	634·453
P(%)	85·896 ± 6·304	87·679 ± 6·765	61·069	78·881	90·921 ± 1·993	99·197
CIELUV						
u^*	105·234 ± 2·886	104·162 ± 4·496	91·454	113·732	111·796 ± 3·920	84·748
v^*	28·363 ± 4·913	29·710 ± 6·246	26·873	24·813	26·145 ± 2·378	12·289
L^*	36·956 ± 5·770	37·137 ± 6·795	47·955	38·509	33·697 ± 2·190	17·839
C^*_{uv}	109·070 ± 3·361	108·448 ± 5·300	95·321	116·407	114·840 ± 3·406	85·635
h_{uv}	15·055 ± 2·413	15·846 ± 2·962	16·375	12·307	13·189 ± 1·521	8·251
s^*_{uv}	3·008 ± 0·437	3·004 ± 0·511	1·988	3·023	3·421 ± 0·315	4·801
CIELAB						
a^*	52·248 ± 2·157	51·328 ± 2·508	45·566	57·278	56·155 ± 2·733	52·855
b^*	53·707 ± 15·568	60·500 ± 15·349	31·274	38·178	74·683 ± 0·579	58·000
L^*	36·956 ± 5·770	37·137 ± 6·795	47·955	38·509	33·697 ± 2·190	17·839
C^*_{ab}	75·507 ± 11·939	79·886 ± 12·127	55·266	68·835	93·459 ± 1·503	78·470
h_{ab}	44·850 ± 7·611	48·744 ± 7·147	34·464	33·685	53·074 ± 1·439	47·657

parameters listed in Table 1, it was inferred that in some instances (such as Y_{CIE}, L^*, P_{CIE}, s^*_{uv}, h_{uv}) samples behave according to two distinguishable patterns, as follows: an interval (set I) of chromatic parameter values in which δ oscillates within a narrow range, and another interval (set II) in which a linear increase of δ values was observed (Fig. 2). A cutpoint was found between the two sets. Table 2 lists the values for δ, together with their statistics, for the two mentioned sets.

The displacements of the chromaticity points (δ_c) in OIV against CIE 1931 plots are shown in Table 3. This table offers, for each of the chromatic parameters shown, the cutpoint delimiting the two sets, and the number of

TABLE 1—*contd.*

	Origin appellation[a]					
	(7)	(8)	(9)	(10)	(11)	(12)
λ_{max}	509·267 ± 1·890	468·800 ± 54·144	517·000	502·500	513·857 ± 4·192	507·867 ± 3·445
A_{max}	2·822 ± 1·341	2·212 ± 1·202	15·100	3·360	2·802 ± 0·851	1·496 ± 0·427
CI	5·270 ± 2·314	3·712 ± 1·099	25·400	6·170	5·133 ± 1·633	2·838 ± 0·843
Tn	15·406 ± 18·278	−5·803 ± 11·935	78·232	17·745	22·255 ± 12·105	5·999 ± 7·191
OIV						
x	0·638 ± 0·032	0·594 ± 0·039	0·677	0·666	0·639 ± 0·044	0·550 ± 0·053
y	0·331 ± 0·007	0·348 ± 0·011	0·323	0·328	0·321 ± 0·007	0·335 ± 0·008
Y(%)	7·576 ± 4·163	12·763 ± 5·010	0·005	4·920	6·684 ± 4·205	16·669 ± 5·072
λ_d	610·715 ± 2·806	604·485 ± 4·019	614·067	611·901	614·775 ± 3·120	607·210 ± 4·022
P(%)	91·562 ± 6·838	84·379 ± 8·652	100·00	98·577	89·239 ± 12·646	69·035 ± 13·930
CIE 1931 (x, y)						
x	0·648 ± 0·049	0·594 ± 0·040	0·731	0·679	0·650 ± 0·054	0·547 ± 0·053
y	0·320 ± 0·024	0·348 ± 0·014	0·269	0·316	0·308 ± 0·010	0·337 ± 0·008
Y(%)	7·359 ± 4·091	12·863 ± 5·348	0·200	4·609	6·324 ± 4·320	16·835 ± 5·395
λ_d	615·765 ± 11·428	604·268 ± 4·673	663·188	616·819	621·063 ± 6·152	606·086 ± 4·272
P(%)	91·435 ± 6·959	84·549 ± 8·438	100·000	98·447	88·691 ± 12·878	69·073 ± 13·571
CIELUV						
u^*	102·346 ± 14·144	102·951 ± 2·815	9·666	99·431	99·059 ± 13·174	99·876 ± 11·288
v^*	23·921 ± 8·966	33·518 ± 6·527	1·106	20·668	18·977 ± 3·901	29·682 ± 2·889
L^*_{uv}	31·122 ± 10·633	41·618 ± 8·293	1·806	25·589	28·536 ± 9·290	47·398 ± 7·124
C^*_{uv}	105·211 ± 15·712	108·425 ± 2·883	9·729	101·557	100·890 ± 13·485	104·288 ± 10·593
h_{uv}	12·828 ± 3·314	18·010 ± 3·416	6·526	11·742	10·795 ± 1·495	16·736 ± 2·778
s^*_{uv}	3·583 ± 0·893	2·686 ± 0·512	5·389	3·969	3·735 ± 0·729	2·273 ± 0·584
CIELAB						
a^*	53·609 ± 1·322	49·179 ± 3·114	13·755	53·621	54·163 ± 4·050	48·648 ± 5·939
b^*	51·083 ± 7·955	52·966 ± 14·821	3·113	70·589	56·263 ± 16·937	42·296 ± 18·739
L^*	31·122 ± 10·633	41·618 ± 8·293	1·806	25·589	28·536 ± 9·290	47·398 ± 7·124
C^*_{ab}	74·226 ± 5·091	72·770 ± 11·828	14·103	88·645	79·064 ± 11·227	65·205 ± 16·466
h_{ab}	43·408 ± 4·760	46·335 ± 7·028	12·752	52·779	44·961 ± 10·276	39·540 ± 8·360

[a] The origin appellations, together with the sample size (n), are as follows: (1) Navarra ($n = 6$); (2) Rioja ($n = 12$); (3) Campo de Borja ($n = 1$); (4) Cariñena ($n = 1$); (5) Ampurdán-Costa Brava ($n = 3$); (6) Ribeiro ($n = 1$); (7) Alicante ($n = 3$); (8) Jumilla ($n = 5$); (9) Valencia ($n = 1$); (10) Yecla ($n = 1$); (11) La Mancha ($n = 7$); (12) Valdepeñas ($n = 6$).
[b] Data are the mean ± SD of n samples.

samples classified in each set, according to the cutpoint of the chromatic parameter in question. For set I the mean values together with the range of chromatic parameters are shown. For set II, given that a linear distribution was obtained, the regression line and correlation coefficient (r^*) are offered. Although most of the samples were placed within set I, where the simplified method (OIV) might be applied with enough reliability, a considerable

TABLE 2
Differences for Several Representative Parameters in the Two Sets

Differences (δ)	*Mean*	*Standard deviation*	*Standard error*	*Coefficient of variation*
Set I				
δ_x	0·003	0·002	0·000 3	0·655 10
δ_y	0·003	0·002	0·000 4	0·766 17
δ_Y	0·285	0·215	0·034 9	0·752 58
δ_{λ_d}	1·485	1·722	0·279 3	1·159 68
δ_P	0·366	0·362	0·058 7	0·987 16
δ_c	0·005	0·003	0·000 5	0·647 92
Set II				
δ_x	0·025	0·013	0·004 5	0·543 40
δ_y	0·025	0·013	0·004 4	0·523 57
δ_Y	0·281	0·165	0·055 0	0·586 74
δ_{λ_d}	14·586	9·364	3·121 4	0·641 97
δ_P	0·107	0·116	0·038 8	1·092 23
δ_c	0·035	0·019	0·006 3	0·533 22

percentage of the samples (set II) were affected by an appreciable error. It was noted (Table 3) that this error was present as a linear function of the value of the chromatic parameter that was being considered.

A Stepwise Discriminant Analysis (SDA) was carried out between set I and set II. The twenty-five variables used to perform the SDA were chosen in a stepwise manner: at each step an F statistic was computed from a one-way analysis of variance on each remaining variable for the two sets. The variable that added the most to the separation of the sets (largest value of F) was entered into the discriminant function. Each case was classified into a group according to the classification functions. For the samples under study, classification functions were as follows:

$$z_{\text{I}} = 15{\cdot}898 \,.\, Y_{\text{CIE}} - 126{\cdot}348 \,.\, s^*_{\text{uv}} - 271{\cdot}895$$
$$z_{\text{II}} = 17{\cdot}469 \,.\, Y_{\text{CIE}} - 143{\cdot}333 \,.\, s^*_{\text{uv}} - 345{\cdot}067$$

At step zero the variable saturation, s^*_{uv} (from CIELUV system), was chosen. This means that this is the best discrimination parameter between the two sets.

The classification functions (z_{I}, z_{II}) can be used to classify new samples into the sets; depending on whether ($z_{\text{I}} > z_{\text{II}}$ or $z_{\text{II}} > z_{\text{I}}$) the sample is located within set I or set II, respectively. If a wine is located in set I we can use (with sufficient reliability) the OIV method, but if the wine is located in set II we must use the CIE 1931-(x, y) method.

TABLE 3
Distribution of Wine Samples for δ_c Values

Chromatic parameter	Cutpoint	Set I			Set II		
		N^a	Mean value × 10^3	Range × 10^3	N^a	Regression line	r^*
Y_{CIE}	5·0	38^b	4·56	13·35	9^c	$y = 7{\cdot}49.10^{-2} - 1{\cdot}19.10^{-2}.x$	−0·980
S_{CIE}	39·0	34^c	4·40	13·16	13^b	$y = -6{\cdot}26.10^{-1} + 6{\cdot}73.10^{-3}.x$	0·732
λd_{CIE}	612·0	30^c	3·61	9·04	17^b	$y = -1{\cdot}11 + 1{\cdot}83.10^{-2}.x$	0·926
L^*	28·0	38^b	4·56	13·35	9^c	$y = 8{\cdot}23.10^{-2} - 2{\cdot}35.10^{-3}.x$	−0·974
s^*_{uv}	3·6	35^c	3·97	10·51	12^b	$y = -1{\cdot}26.10^{-1} + 3{\cdot}68.10^{-2}.x$	0·991
h_{uv}	13·1	30^b	3·61	9·04	17^c	$y = 1{\cdot}24.10^{-1} - 9{\cdot}42.10^{-3}.x$	−0·905
CI	5·0	35^c	4·44	13·11	12^b	$y = 3{\cdot}60.10^{-3} + 3{\cdot}09.10^{-3}.x$	0·833
Tn	12·0	30^c	3·90	9·60	17^b	$y = -3{\cdot}42.10^{-3} + 8{\cdot}78.10^{-4}.x$	0·804

[a] Number of samples.
[b] Samples with a chromatic parameter value > cutpoint.
[c] Samples with a chromatic parameter value ≤ cutpoint.

REFERENCES

Berg, H. W., Ough, C. S. & Chichester, C. O. (1964). The prediction of perceptibility of luminous-transmittance and dominant wavelength differences among red wines by spectrophotometric measurements. *J. Food Sci.*, **29**, 661–67.

BMDP Statistical software (1981). Department of Biomathematics. University of California Press, Los Angeles, CA.

CIE (1978). *Recommendations on Uniform Color Spaces, Color Difference Equations, Psychometric Color Terms.* CIE Publication No. 15, suppl. 2. Bureau Central de la CIE, Paris, 1971.

Hardy, A. C. (1936). *Handbook of Colorimetry.* The Technology Press, Cambridge, MA, pp. 32–48.

Heredia, F. J. & Guzmán, M. (1988). Application of chromatic parameters to follow time-dependent spoilage of wines. *Acta Alimentaria*, **17**, 103–11.

Negueruela, A. I. & Echavarri, J. F. (1983). Colorimetría en vinos de Rioja. *Opt. Pura y Apl.*, **16**, 97–106.

OIV (1969). *Recueil des Méthodes Internationales d'Analyse des Vins.* Office Internationale de la Vigne et du Vin, Paris.

Presidencia del Gobierno (1981). *Métodos de análisis de productos derivados de la uva.* Orden de 17 de Septiembre de 1981 (BOE de 14 de Octubre).

Sudraud, P. (1958). Interpretation des courbes d'absorption des vins rouges. *Ann. Technol. Agr.*, **7**, 203–8.