QUALITY EVALUATION OF WATERMELON VARIETIES (*CITRULLUS VULGARIS* S.)

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ABSTRACT

The physical-chemical quality (pulp firmness, soluble solid content, sucrose, D-glucose and D-fructose concentrations and color measured by tristimulus colorimetry) and sensory quality (flavor, texture and color) of thirteen varieties of watermelon were studied. Quantitative differences were established between the varieties as was the relation between the instrumental and sensorial determinations. The triploid (3n) varieties, Apirena, AR-3404 and AR-3406, and the diploid (2n), Sugar Baby, showed the highest soluble solids and total sugar values, although the first group was preferred by consumers as regards the three attributes studied. Instrumental analysis of color made it possible to separate clearly the varieties.

INTRODUCTION

Camara *et al.* (1995) define quality as a set of internal and external characteristics that can be appreciated by our senses and which differentiate samples of the same product. In agreement with this definition, watermelon quality is immediately linked with its exterior appearance (size, shape, rotting,

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exterior humidity, defects, etc.) and secondly, with other parameters such as ripeness, aroma, flavor, color and texture.

Sensory evaluation of a foods or other products is an analysis of its quality by our senses (Anzaldúa-Morales 1994), and this evaluation is as important as analytical techniques such as physical-chemical and microbiological methods. In the particular case of watermelon, sensory evaluation criteria should be complemented with parameters instrumentally determined for the proper characterization of the product. Among those used for such characterization are the determination of the soluble solids content, the quantitative and qualitative determination of sugars and the measurement of fruit firmness and internal color, etc. (Elmstrom and Davis 1981; Brown and Summers 1985; Chisholm and Picha 1986; Bassi and Selli 1990; Burgos *et al.* 1993; Gil *et al.* 1993). In addition, resistance to handling and transportation, the need to comply with commercial requirements at the destination and correct labeling are new factors to be taken into account (MAPA 1988).

This study describes the sensory and physical-chemical quality of thirteen varieties of watermelon and correlations between the sensorial and instrumental methods of evaluating quality.

MATERIAL AND METHODS

Plant Material and Experimental Design

Thirteen varieties of red-fleshed watermelon grown in the province of Albacete, Spain, were analyzed: the diploids (2n), Crimson Sweet, Isola, Panonia, Sugar Baby, Sugar Bell and Sweet Marvel (which produce small fruit weighing less than three kg) and Florida Giant and Klondike (which produce fruit weighing in excess of three kg); the seedless triploids (3n), Apirena, AR-3404, and AR-3406, both groups widely available throughout Spain; and the varieties, Antigua and Recueja, traditionally cultivated and available only in the province of Albacete, Spain. The plants were field-sown in random blocks of four replicates at the experimental station of the Escuela Técnica Superior de Ingenieros Agrónomos de Albacete. Twelve randomly selected ripe melons of each replicate (48 melons per cultivar) were analyzed. Analytical determinations were made immediately after harvesting.

Analytical Determinations

A Bertuzzi FT 011 penetrometer with an 8 mm diameter punch was used to determine pulp firmness and the results are expressed in kPa. The fruit were cut transversely in half and one measurement was made directly in the heart of the fruit and other measurements were made in each of the quadrants, making a total of five measurements per fruit.

The soluble solids content (SS) was determined with an Atago PR-100 digital refractometer and the results expressed as °Brix. A Boehringer enzymatic kit (combination test) was used to determine the sucrose, D-glucose and D-fructose contents. Samples for the above test were prepared from fresh material taken from the heart of the fruit which was triturated to extract the juice. The results are expressed in g/100 mL of sample solution. Sweetness values were calculated on the basis of those reported by Eisenberg (1955). Values used were as follows: fructose = 157.5, glucose = 67.5, and sucrose = 100. Summation of the products of the relative sweetness values and the percentage of each sugar provides a sample sweetness index.

Color of the melon flesh was measured in three different points of the watermelon center with a Minolta CR-200 colorimeter to obtain the CIELAB L^*, a^*, and b^* parameters, with reference to D65 illuminant and an angle of vision of 2°, a^*/b^* ratio, chroma (C^*), hue angle (H^*) were calculated. Additionally calculated were the $1000a^*/(b^*+L^*)$ (Burgos *et al.* 1993), $1000a^*/(b^*\times L)$ (Jimenez-Cuesta *et al.* 1981) and $2000a^*/(L^*\times C^*)$ (Carreño *et al.* 1995) indices. These indices help establish the normalization of the color since different chromatic parameters are simultaneously included. The $1000a^*/(b^*+L^*)$ index has been used successfully in other agricultural crops (tomatoes, strawberries, etc.) and this led us to consider its use in this study.

Sensory Evaluation

The test chosen for assessing the degree of satisfaction by verbal hedonic scale (Table 1) is included within the affective tests and permitted to evaluate the preference or the degree of satisfaction of the judges with a product (Anzaldúa-Morales 1994). The panel of judges was composed of 36 consumers who judged the flavor, texture and color of the watermelon. A scale of nine was used for each parameter (-4, preference minimum, to +4, preference maximum). Each parameter was analyzed separately from the others and no more than five samples were tested per session as to avoid boredom or satiation. The tasting sessions were carried out in several supermarkets in the city of Albacete, the tasters representing a variety of ages and classes. The only prerequisite was that the person chosen should be a habitual consumer of watermelon.

Statistical Analysis

Qualitative attributes of the varieties were analyzed using SPSS/PC* statistical program. Linear correlations among parameters were established using a least square fitting program.

TABLE 1.
TASTING SESSION FORM FOR SENSORY ANALYSIS

Name:---------- Date: ----------

Product: **WATERMELON** Attribute: **FLAVOR**

Taste the watermelon samples and mark with a cross (**X**) the corresponding qualification for each sample.

	SAMPLES						
SCALE	275	803	996	415	319	761	620
I like very, very much	---	---	---	---	---	---	---
I like a lot	---	---	---	---	---	---	---
I like quite a lot	---	---	---	---	---	---	---
I quite like	---	---	---	---	---	---	---
I neither like nor dislike	---	---	---	---	---	---	---
I dislike	---	---	---	---	---	---	---
I dislike quite a lot	---	---	---	---	---	---	---
I dislike a lot	---	---	---	---	---	---	---
I dislike very, very much	---	---	---	---	---	---	---

RESULTS AND DISCUSSION

Table 1 shows the tasting form and Table 2 summarizes the mean value obtained for each of the varietal sensory attributes of flavor, texture and color,

TABLE 2.

MEAN VALUES OF THE PHYSICAL-CHEMICAL AND SENSORIAL PARAMETERS OF THE VARIETIES TESTED

Variety	Type	Flavor	Texture	Visual color	Firmness (kPa)	Soluble solids (Brix)	Sucrose (g/100ml)	Glucose (g/100ml)	Fructose (g/100ml)	Total sugars (g/100ml)	Sweetness*
Crimson Sweet	2n	0.6 e	1.4 d	1.0 cd	101.9 e	10.2 c	1.45 de	2.75 c	3.83 b	8.03 c	934 cd
Florida Giant	2n	0.6 e	0.9 e	-0.4 e	133.3 b	9.7 cd	1.22 f	2.85 c	3.48 c	7.55 d	862 d
Isola	2n	0.4 f	-0.4 g	-0.1 e	88.2 f	10.0 c	1.69 c	1.97 e	4.85 a	8.61 b	1066 b
Klondike	2n	0.8 cd	1.3 d	0.0 e	107.8 d	9.6 cd	2.05 b	1.87 e	3.75 b	7.67 d	922 cd
Panonia	2n	-0.6 g	0.4 f	1.5 c	156.8 a	9.1 d	1.03 g	2.76 c	3.90 b	7.79 cd	904 e
Sugar Baby	2n	0.3 f	0.8 e	-0.8 f	98.0 e	10.8 b	2.46 a	2.49 cd	4.24 a	9.19 a	1082 b
Sugar Bell	2n	0.9 bc	1.4 d	0.8 d	117.6 bc	10.2 c	2.68 a	2.78 c	3.05 d	8.51 b	936 cd
Sweet Marvel	2n	0.8 cd	0.4 f	1.4 c	107.8 d	9.8 cd	1.05 g	3.65 b	3.14 d	7.84 c	846 e
Apirena	3n	1.3 b	2.1 b	1.9 b	137.2 b	11.4 a	1.77 c	3.25 b	4.67 a	9.69 a	1132 a
AR-3404	3n	1.8 a	2.4 a	2.4 a	117.6 bc	11.0 a	1.44 de	4.35 a	3.58 c	9.37 a	1002 c
AR-3406	3n	1.0 bc	1.8 b	2.4 a	127.4 bc	11.0 a	1.55 de	3.42 b	3.82 b	8.80 b	988 c
Antigua	Traditional	1.1 b	1.1 d	0.6 d	166.6 a	9.6 cd	1.22 f	2.25 b	3.95 b	7.31 d	895 d
Recueja	Traditional	0.7 ed	0.5 f	-0.9 f	78.4 f	10.0 c	1.22 f	3.68 b	3.52 c	8.42 b	925 d

(*) Sweetness values were calculated as suggested by Eisemberg (1955).
Each value is the mean of the 48 samples. Means followed by the same letter within column sections do not differ significantly.

and significant ($P < 0.05$) differences obtained among the varieties. In general, the triploid varieties AR-3404, AR-3406, and Apirena were preferred by the panel of consumers/judges.

Antigua and Panonia were firmest (Table 2). The triploids, Apirena, AR-3406, and AR-3404, had intermediate values and Recueja melons had the least resistance to the penetrometer. The triploid melons, AR-3404, AR-3406 and Apirena, had highest concentration of SS; Klondike and Florida Giant were lowest. Total sugars were highest in the triploids, AR-3404 and Apirena, and lowest in Antigua. SS content did not always reflect total sugars. Amounts of sucrose were highest in Sugar Baby and Sugar Bell and represented ca 30% of total sugars. Fructose and glucose in Crimson Sweet were similar to those reported by Elmstrom and Davis (1981). Glucose was highest in AR-3404, representing 46% of total sugars, and lowest in Klondike, representing 24% of total sugars. As regards sweetness the triploids and the diploids, Sugar Baby and Isola, were ahead of the others, which was to be expected given their higher content of total sugars.

Table 3 summarizes the correlation of coefficients and significance among physical-chemical and sensorial characteristics. The flavor was acceptably correlated with texture and SS content but less correlated with sweetness and glucose. As expected the SS content, total sugars and sweetness were closely correlated. Possibly a higher value of the correlation coefficient between flavor and SS content was not obtained because not always for a consumer/judge did a high SS content necessarily constitute a better flavor. The low correlation between flavor and total sugars suggests that aromatic components are also important. Lastly, visual color was also correlated with texture.

As regards the cartesian coordinates which define color, note the wide range of values which the ripe watermelons showed for the a^* component (red), which were greater than those for the b^* (yellow) component (Table 4), and was highly correlated with visual color. The polar coordinates, chroma (C^*) and hue angle (H^*) reached maximum values in the triploid varieties, AR-3404 and Panonia, and the diploid Sugar Baby, respectively. The $1000a^*/(b^* + L^*)$ index showed maximum values in the triploids varieties and the diploid Panonia.

When the visual color of the varieties was represented versus the $1000a^*/(b^*+L^*)$ index the varieties are clearly separated (Fig. 1). In the lower part the varieties of least visual and instrumental color appeared (Florida Giant, Isola, Klondike and Sugar Baby). In the case of Recueja, a variety of similar characteristic, the low luminosity (L^*) of the flesh seemed to be responsible for its low visual evaluation and its distance from the previously mentioned group, since it showed normal values of red component (a^*). The triploid varieties, AR-3406, AR-3404 and Apirena, appeared in the top right of the figure, being much superior to the others as regards their colorimetric values. The rest of the varieties assayed appeared in an intermediate position, between both groups.

TABLE 3.

CORRELATION COEFFICIENTS AND SIGNIFICANCE AMONG PHYSICAL-CHEMICAL AND SENSORIAL PARAMETERS

	Flavor	Texture	Visual color	Firmness	Soluble solids	Sucrose	Glucose	Fructose	Total sugars
Flavor	1.00								
Texture	0.73 ***	1.00							
Visual color	0.39 **	0.61 **	1.00						
Firmness	-0.03 NS	0.29 *	0.46 **	1.00					
Soluble solids	0.63 ***	0.65 **	0.38 **	-0.19 *	1.00				
Sucrose	0.13 NS	0.22 *	-0.22 *	-0.28 *	0.41 **	1.00			
Glucose	0.48 *	0.43 **	0.52 **	-0.07 NS	0.44 **	-0.35 *	1.00		
Fructose	-0.15 NS	-0.13 NS	-0.08 *	0.00 NS	0.30 *	0.09 *	-0.41 **	1.00	
Total sugars	0.41 **	0.45 **	0.29 **	-0.28 *	0.91 ***	0.42 **	0.43 **	0.39 **	1.00
Sweetness	0.21 *	0.25 **	0.08 NS	-0.20 *	0.77 **	0.49 **	-0.03 NS	0.77 ***	0.86 ***

NS, *, **, ***, represent not significant and significant differences at the 0.05, 0.01 and 0.001 levels, respectively.

TABLE 4

CIELAB CHROMATIC COORDINATES (L^*, a^*, b^*), a^*/b^*, CHROMA (C^*), HUE ANGLE (H^*) AND $1000a^*/(b^*+L^*)$, $1000a^*/(b^*xL^*)$ AND $2000a^*/(L^*xC^*)$ INDICES OF THE VARIETIES STUDIED

Variety	L^*	a^*	b^*	a^*/b^*	C^*	H^*	(1)	(2)	(3)
Sweet Marvel	42.06 d	25.35 cd	15.78 c	1.60 bc	29.86 c	31.89 c	438.27 d	38.19 b	40.37 b
AR-3406	46.03 c	30.45 b	17.01 b	1.79 b	34.88 b	29.19 d	483.02 c	38.89 b	37.93 c
Antigua	48.49 bc	27.59 c	18.29 b	1.51 c	33.10 b	33.53 bc	413.14 d	31.10 c	34.37 d
Klondike	55.16 a	22.63 e	12.99 d	1.74 b	26.09 d	29.85 d	332.06 e	31.58 c	31.45 e
Apirena	38.59 e	30.96 b	17.88 b	1.73 b	35.75 b	30.01 d	548.25 a	44.87 a	44.88 a
Sugar Baby	54.12 a	18.36 e	14.72 c	1.25 e	23.54 e	38.73 a	266.70 f	23.04 d	28.82 f
Recueja	46.43 c	24.69 d	13.87 c	1.78 b	28.32 d	29.31 d	409.54 d	38.33 b	37.55 c
Crimson Sweet	47.38 c	26.67 c	13.05 c	2.04 a	29.69 d	26.08 e	441.33 d	43.13 a	37.34 c
AR-3404	37.37 e	32.21 a	20.29 a	1.59 c	38.07 a	32.21 c	558.61 a	42.48 a	45.28 a
Panonia	42.84 d	32.16 a	20.47 a	1.57 c	38.12 a	32.47 c	507.97 b	36.67 b	39.38 b
Florida Giant	43.79 d	15.76 f	9.52 e	1.66 bc	18.41 f	31.14 d	295.62 f	37.80 b	39.09 b
Isola	50.66 b	19.23 e	13.62 c	1.41 d	23.56 e	35.30 b	299.15 f	27.87 d	32.22 e
Sugar Bell	42.37 d	26.95 c	18.31 b	1.47 d	32.58 c	34.19 b	444.13 d	34.73 c	39.04 b

(1) $1000a^*/(b^*+L^*)$ (2) $1000a^*/(b^*xL^*)$ (3) $2000a^*/(L^*xC^*)$

Table 5 shows the correlation coefficients between subjective rankings for visual color and the colorimeter values. The highest degrees of correlation were observed for the $1000a^*/(b^*+L^*)$ index, the red components (a^*) and chroma (C^*). For this reason, we suggest that these parameters could be used to predict the preference of consumers for the color of a particular variety (redfleshed).

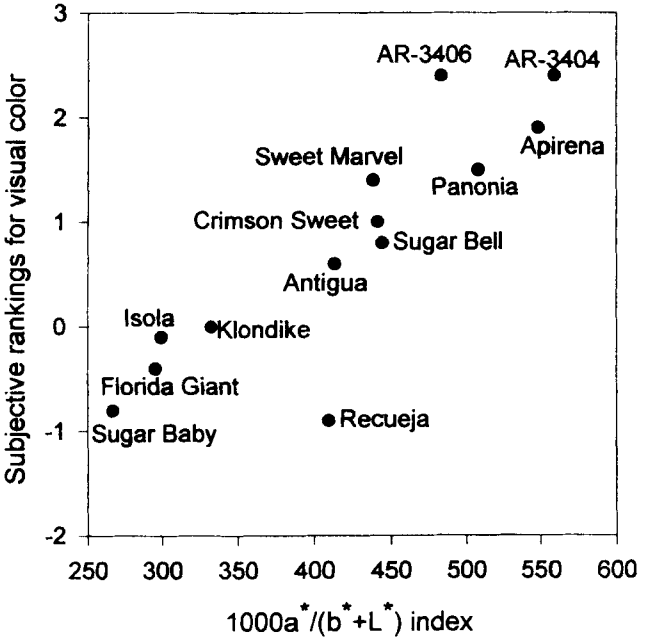

FIG. 1. REPRESENTATION OF THE SUBJECTIVE RANKING FOR VISUAL COLOR OF THE VARIETIES TESTED VERSUS $1000a^*/(b^*+L^*)$ INDEX

TABLE 5.
CORRELATION COEFFICIENT BETWEEN SUBJECTIVE RANKINGS FOR VISUAL COLOR AND THE COLORIMETER VALUES

Colorimeter values	Subjective rankings for visual color
L*	0.67**
a*	0.84***
b*	0.69**
a*/b*	0.28 NS
C*	0.83***
H*	-0.32 NS
1000a*/(b*+L*)	0.87***
1000a*/(b*xL*)	0.64**
2000a*/(L*xC*)	0.71**

NS,*,**,***, represent no significant differences at the 0.05, 0.01 and 0.001 levels, respectively.

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REFERENCES

ANZALDÚA-MORALES, A. 1994. La evaluación sensorial de los alimentos en la teoría y la práctica. (S.A. Acribia, ed.) pp.70-79, Zaragoza, Spain.

BASSI, D. and SELLI, R. 1990. Evaluation of fruit quality in peach and apricot. Adv. Hort. Sci. *4,* 107-112.

BROWN, A.L. and SUMMERS, W.L. 1985. Carbohydrate accumulation and color development in watermelon. J. Amer. Soc. Hort. Sci. *110*(5), 683-687.

BURGOS, V., ROCA, M. and ALBI, M.A. 1993. Estudio comparativo de la calidad en nueve cultivares diferentes de tomate industrial. Actas del III Simposio Nacional sobre Maduración y Postrecolección de Frutos y Hortalizas. pp. 401-406, Sevilla, Spain.

CAMARA, Mª.M., DÍEZ, C. and TORIJA, M.E. 1995. Evaluación de la calidad de zumos, néctares y concentrados de frutas. Alimentación, equipos y tecnologia. *6,* 113-116.

CARREÑO, J., MARTÍNEZ, A., ALMELA, L. and FERNÁNDEZ-LÓPEZ, J.A. 1995. Proposal of an index for the objective evaluation of the colour of red table grapes. Food Res. Intl. *28,* (4), 373-377.

CHISHOLM, D.N. and PICHA, D.H. 1986. Effect of storage temperature on sugar and organic acid contents of watermelon. HortSci. *21*(4), 1031-1033.

COREY, K.A. and SCHLIMME, D.V. 1988. Relationship of rind gloss and groundspot color to flesh quality of watermelon fruits during maturation. Scientia Hort. *34,* 211-218.

EISENBERG, S. 1955. Sugars in the baking industry. Adv. Chem. Ser. *12,* 78-82.

ELMSTROM, G.W. and DAVIS, P.L. 1981. Sugars in developing and mature fruits of several watermelon cultivars. J. Amer. Soc. Hort. Sci. *106*(3), 330-333.

GIL, R.Mª., GUTIÉRREZ, F. and ALBI, M.A. 1993. Evolución de las propiedades físicas, químicas y organolépticas del fresón. Actas del III Simposio Nacional sobre Maduración y Postrecolección de Frutos y Hortalizas; pp. 401-406, Sevilla, Spain.

JIMÉNEZ-CUESTA, M., CUQUERELLA, J., MARTÍNEZ, J. and JAVAGA, J.M. 1981. Determination of a color index for citrus fruit degreening. Proc. Int. Soc. Citriculture. *2*, 750–753.

MAPA, 1988. Normas de calidad para sandías. Dirección General de la Producción Agraria. Ministerio de Agricultura, Pesca y Alimentación. Madrid, Spain.