GRASAS Y ACEITES, 64 (4),
JULIO-SEPTIEMBRE, 442-452, 2013,
ISSN: 0017-3495
DOI: 10.3989/gya.132312

Determination of the characteristic sensory profiles of Aloreña table-olive

By **H. Galán-Soldevilla**✉, **P. Ruiz Pérez-Cacho** and **J.A. Hernández Campuzano**

Universidad de Córdoba. Laboratorio de Estudios Sensoriales. Departamento de Bromatología y Tecnología de los Alimentos. Campus de Rabanales-Edificio Darwin. 14070 Córdoba (Spain)
✉ Corresponding author: bt1gasoh@uco.es

RESUMEN

Determinación de los perfiles sensoriales característicos de la aceituna Aloreña

La aceituna Aloreña es una variedad de aceituna de mesa autóctona de la comarca del Valle del Guadalhorce (Málaga, España) que posee unas características propias que la distingue del resto de variedades, siendo las propiedades sensoriales las que mejor la diferencian. Para estudiar los atributos sensoriales que mejor definen a los tres tipos de elaboración de la aceituna Aloreña (verdes frescas, tradicionales y curadas) se utiliza la técnica del perfil sensorial. La selección de atributos sensoriales se realiza mediante discusión grupal en mesa redonda y utilizando análisis multivariante. Los datos obtenidos de los perfiles sensoriales se analizan utilizando un modelo mixto de análisis de la varianza (anidado x factorial) y un análisis canónico. Los resultados del análisis de varianza indican que las principales diferencias entre estilos de elaboración se deben a los atributos frutado, sabor amargo y firmeza ($p < 0.05$) y que las diferencias entre muestras, dentro de cada estilo de elaboración, se deben a todos los atributos estudiados ($p < 0.001$). El test de medias de Duncan y el análisis canónico muestran que todas las muestras son diferentes dentro de cada estilo de elaboración.

PALABRAS CLAVE: Aceituna de mesa – Análisis descriptivo – Atributos sensoriales – Vocabulario sensorial.

SUMMARY

Determination of the characteristic sensory profiles of Aloreña table-olive

Aloreña olives are unique to and typical of the Guadalhorce region (Málaga, Spain). They possess some specific characteristics which make them an excellent product that is differentiated from the other olive varieties. The sensory profile technique was used to study the sensory attributes which best characterize the three processing styles of Aloreña table-olives. The characteristic descriptors are identified according to the round-table method and multivariate analysis. Sensory profile data obtained were analyzed using a mix of Nested Design ANOVA and Factorial ANOVA and by a canonical analysis. The effect of the factor processing style was significant only for three descriptors: fruit odor, bitter taste and firmness ($p < 0.05$) whereas the effect of the samples nested in each processing style was significant for all the attributes ($p < 0.001$). Duncan's post hoc test and the canonical analysis showed that all samples were different within each processing style.

KEY-WORDS: Descriptive analysis – Olive fruit – Sensory attributes – Sensory lexicon.

1. INTRODUCTION

Aloreña table-olives are seasoned cracked olives of the Aloreña variety that conserve their stone intact and are attached to the stalk. Their external color is usually green, greenish-yellow or light brown, depending on their degree of fermentation. They have a crunchy texture and a bitter taste, making them especially distinctive from the seasoned olives prepared from other varieties. They are characterized by the presence of a low level of oleuropein (the bitter component of the olive) that does not need any treatment with sodium hydroxide to sweeten it, and by the typical local products contained in the seasoning like fennel, thyme, garlic and peppers (Arroyo-López *et al*., 2008a). There are three different processing styles of Aloreña table-olives: fresh green olives, traditional olives and cured olives (BOJA nº 215, 2009/11/04). Aloreña olives are unique to and typical of the Guadalhorce region (Málaga, Spain). This area includes a total of 19 municipalities spread between the Sierra de las Nieves and the Guadalhorce Valley. This valley, surrounded by a group of mountains in the north and slightly influenced by the sea, has unique climatic characteristics which have promoted this variety's quality.

Although sensory characteristics are determinant in defining a foodstuff, sensory studies concerning table olives are scant (Kanavouras *et al*., 2005; Panagou *et al.,* 2006; Gonzalez *et al*., 2007; Marsilio *et al.,* 2008; Aponte *et al*., 2010; Lanza *et al*., 2010; Valencic *et al*., 2010).The use of these sensory profiles may contribute to the identity of Aloreña olives by means of a sensory quality certification (Scintu del Caro *et al.,* 2010).

The first step involved in generating a sensory profile is to develop a wide number of relevant descriptive terms. Once the initial list of vocabulary has been generated, the selection of the main descriptors must be performed. Multivariate techniques have been used for selecting the relevant descriptive terms that can differentiate among products. In a following step, a definition of each descriptor will be given and a suitable reference product will also be assigned to each of these descriptors. Once the panel has assimilated

all the perceptions associated with the descriptors and is capable of quantifying the perception in relation to reference product, a sensory profile can be established (ISO 1994; Barcenas *et al.*, 1999; Drake *et al.,* 2001; Galán-Soldevilla *et al.*, 2005; Pérez-Cacho *et al.,* 2005).

The aim of this study was to establish the sensory profiles of the three processing styles of Aloreña table-olives in order to obtain a certified product (PDO Aloreña olives from Malaga). A lexicon (terms, definitions and references) for describing the odor, texture and flavor of Aloreña table-olives is also provided.

2. MATERIAL AND METHODS

2.1. Samples

2.1.1. Table-olives used in the generation and selection of the sensory attributes

Aloreña table-olives (fresh green, traditional and cured olives) were provided by local producers during the 2006/2007 growing season. A series of samples of Aloreña olives that display the most important specific characteristics was tasted in order to obtain the characteristic sensory profiles.

The olive samples were taken directly from commercial containers and placed in normalized tasting glasses (IOOC 1987) each with a minimum of 5 olives covered in brine from which the seasonings were previously removed. The glasses were covered with watch glasses and kept closed for at least 1 hour at room temperature before tasting. Mineral water was used for mouth rinsing between each sample.

2.1.2. Table-olives used in the sensory profile

For the sensory profile, 15 different Aloreña extra or first grade table-olives (IOOC 2004) from the 2009/10 growing season of the three processing styles were analyzed: 7 fresh green olives, 4 traditional olives and 4 cured olives.

2.2. Sensory characterization

2.2.1. Generation and selection of the sensory attributes

The procedure followed to obtain the vocabulary is based on ISO standards (ISO 1994; ISO 2003). Nine sessions of 1 to 2 hours each were conducted in order to develop the sensory profile: 5 preliminary ones were held to establish the test conditions and to generate and define the vocabulary and 4 sessions for the selection of the lexicon. Four to five samples, labeled with 3-digit random numbers were served, one-at-a-time, over a session. Samples were randomly allotted to sessions.

The sensory terms were generated individually by the assessors in the tasting booths using the "unguided free selection" technique (Guerrero 1999; Pérez-Cacho *et al.*, 2005) and the sensory attributes were selected in accordance with ISO (1994).

The data were analyzed using Statistica 8.0 (StatSoft, Inc., Tulsa, OK USA). Principal Component Analysis (PCA) was used to reduce the number of attributes and the sensory profile sheet for the sensory analysis of table-olives was made. Finally, the Kruskall-Wallis test was carried out to examine the discriminatory ability of each descriptor selected.

2.2.2. Sensory profile

The sensory profiles of the three processing styles were assessed in 15 samples using the sensory profile sheet developed by the trained panel in the previous step. Three sessions of 1 hour (4-5 samples/session) were conducted to complete the analysis. Sample preparation, serving and tasting procedures were also established (Galán-Soldevilla and Ruiz Pérez-Cacho 2010). The appearance attributes were assessed by the whole panel on the complete sample before carrying out the tasting. Next, in each sample, first the odor was evaluated, then the flavor (aromas, basic tastes, and trigeminal sensations) and, finally, the texture attributes. The evaluation of the odor was made by direct aspiration of the air over the tasting glass in 2 phases: first with the glass kept still to detect any possible defects, and then after shaking it gently to determine the different odor attributes.

Data analysis was carried out with the Statistical Analysis System 9.2. (SAS Institute Inc., Cary, NC, USA) and an SPSS 17.A mixed of Nested Design ANOVA and Factorial ANOVA (Xijk = Processing style + Sample (processing style) + Assessor + (Assessor x Processing style) were used to evaluate the sensory profile data. Duncan's post hoc test was applied to detect significant differences among the samples. A canonical analysis was used to group similar samples within each processing style in order to define the sensory profile of Aloreña olives.

2.2.3. Assessors

Nine (3 male, 6 female) highly trained panelists from the Sensory Laboratory at Córdoba University, (Spain), aged 27 to 55 , participated in this study. The Assessors were selected and trained following international standards (ISO 1985; ISO 1993; ISO 2003; ISO 2008). The selection of assessors was based on detection, recognition and discrimination tests and on the ability of candidates to memorize and communicate sensory impressions (Perez-Cacho *et al.,* 2005). These panelists had completed 300 h of basic training in all aspects of sensory analysis and had prior experience in the quantitative descriptive analysis of different products (Galan-Soldevilla *et al.,* 2005; Pérez-Cacho *et al.,* 2005;

Pérez-Cacho *et al.,* 2008). In addition, the panel had undergone 15 hours of specific training in table-olives.

2.2.4. Sensory laboratory

Testing was carried out in the sensory laboratory located at the University of Córdoba (Córdoba, Spain), equipped with a round table for training sessions and individual booths, in accordance with the international standards (ISO 2007).

3. RESULTS AND DISCUSSION

3.1. Generation and selection of sensory attributes

The sensory terms were generated individually by the assessors in the tasting booths using the "unguided free selection" technique (Damasio and Costell, 1991; Guerrero, 1996; Montouto-Graña *et al.,* 2002; Pérez-Cacho *et al*., 2005). Next, the panel leader held a discussion to come to an agreement on the descriptors and a consensus lexicon was developed. The initial working list (Table 1) included 59 terms: 3 for appearance, 24 for odor, 27 for flavor and 5 for texture attributes.

In the following panel sessions (round-table method), the initial working list was reduced in accordance with international standards (ISO 1994). Firstly, the appearance attributes were excluded from the analysis because they would be qualitatively assessed by the whole panel on the complete sample before carrying out the tasting. Next, the 19 negative odor/aroma attributes were omitted from the initial list because they did not describe the product. In addition, some odor/aroma descriptors were grouped in a single term: ripe fruit and green fruit as fruit and spices/herbs and fresh

Table 1
Preliminary descriptors developed in the lexicon generation for Aloreña table olives

Appearance	Odor	Aroma	Basic tastes	Trigeminal sensations	Texture
	Positive attributes	*Positive attributes*			
Hue	Green fruit	Green fruit	Salty	Astringent	Firmness
Luminance	Ripen fruit	Ripen fruit	Acid	Pungent	Crunchy
Uniformity of color	Green	Spices/herbs	Bitter	Piquant	Fibrous
	Spices/herbs	Fresh vegetable		Fresh	Floating stone
	Fresh vegetable	Green pepper			Separation of peel
	Green pepper	Red pepper			
	Red pepper	Garlic			
	Garlic	Fennel			
	Fennel	Thyme			
	Thyme	Wood			
	Lactic	Olive oil			
	Hay				
	Wood				
	Olive oil				
	Negative attributes	Negative attributes			
	Musty/humid	Musty/humid			
	Winey/vinegary	Winey/vinegary			
	Alpechin/vegetable water	Alpechin/vegetable water			
	Fermentation	Fermentation			
	Alcohol	Rancid			
	Rancid	Rancid butter			
	Rancid butter	Soap			
	Soap	Lupin			
	Lupin	Burnt tire			
	Burnt tire				

Table 2
Sensory attributes and references developed for Aloreña table-olives

Sensory attribute	Definition	References
Fruity odor/aroma	Odor/aroma characteristic of fresh olives, either ripe or unripe.	Extra virgin olive oil from Aloreña variety
Green odor	Odor/aroma characteristic of newly cut grass	1 drop of cis-3-hexen-1-ol in 50 ml of water or newly cut grass
Seasoning odor/aroma	Odor/aroma characteristic of spices and herbs added to the Aloreña	Mixture of spices used in seasoning of Aloreña olives
Green pepper odor/ aroma	Odor/aroma characteristic of fresh green pepper	Fresh green pepper
Red pepper odor/aroma	Odor/aroma characteristic fresh red pepper	Fresh red pepper
Garlic odor/aroma	Odor/aroma characteristic of fresh garlic	Fresh garlic
Fennel odor/aroma	Odor/aroma characteristic of fresh fennel	Fresh fennel
Thyme odor/roma	Odor/aroma characteristic of fresh thyme	Fresh thyme
Wood odor/aroma	Odor/aroma characteristic of wood	Wood shaving in 60 ml flask
Hay odor	Odor of dried grass	Dried grass wrapped in aluminum paper
Lactic odor	Odor characteristic of lactic acid	Yoghurt
Olive oil odor/aroma	Aroma characteristic of fresh oil from olive perceived through the back of the nose.	Extra virgin olive oil from Aloreña variety
Salty	Basic taste produced by aqueous solutions of substances like sodium chloride	2 g of salt is dissolved in 1 liter of water. 30 ml of dissolution in 50 ml plastic cup
Bitter	Basic taste produced by diluted aqueous solutions of caffeine	0.3 g of caffeine is dissolved in 1 liter of water. 30 ml of dissolution in 50 ml plastic cup
Acid	Basic taste produced by aqueous solutions of substances like citric acid.	0.3 g of citric acid is dissolved in 1 litter of water. 30 ml of dissolution in 50 ml plastic cup
Astringent	Complex sensation accompanied by shrinking of the skin of mucosa surface in the mouth, produced by substances such as kaki tannins	A piece of kaki
Pungent	Causing a sharp sensation of the nasal mucosa membranes	Vinegar of wine
Piquant	Causing a sharp sensation of the buccal mucosa membranes	Virgin oil from the Picual olive variety
Fresh	Sensation of reduced temperature experienced as a result of exposure to certain substances such as menthol or anise.	Sensation perceived during mastication of fennel (leaves).
Firmness	Mechanical property of texture related to the strength required to attain a certain penetration of the olive.	Gordal olive with stone
Crunchy	Mechanical property of texture related to the cohesion and strength necessary to break an olive with the teeth.	Gordal olive with stone
Fibrous	Geometrical property of texture related to the perception of strands oriented in the same direction	A portion of celery
Floating stone	Aloreña variety conserves its stone intact and is attached to the stalk.	Aloreña olive-table
Separation of peel during mastication	Texture attribute that evaluates the separation of the olive peel during mastication	Aloreña olive-table

vegetable as seasoning, resulting in 33 attributes. The sensory attributes, definitions and references are shown in Table 2. Generally, the descriptors resulting from the preliminary generation are numerous and many of them are later discarded on the basis of being vague, redundant, quantitative, synonyms, antonyms or non-discriminating terms (Stone and Sidel, 1993; ISO, 1994; Barcenas *et al*., 1999; Drake *et al.,* 2001; Galán-Soldevilla *et al*., 2005; Pérez-Cacho *et al.,* 2005; Retiveau *et al*., 2005; Riu-Amatell *et al*., 2008; Talavera-Bianchi and Chambers, 2008; Drake *et al.,* 2010).

According to ISO (1994), to reduce the number of attributes and determine the most significant among them, each term was evaluated using a scale ranging from one (very slight perception) to five (very intense), and zero (0) equivalent to an absence of perception for the attribute considered (ISO 1994). Next, the tasting list was made up and 14 descriptors were rejected before the PCA analysis: 3 had the same intensity in all the samples (fibrous, floating stone and separation of peel during mastication), 7 had low number of mentions (olive oil odor, red pepper odor/aroma, fennel odor/aroma and thyme odor/aroma) and 4 were grouped (garlic odor/aroma and green pepper odor/aroma) within the "seasoning" term. It is worth mentioning that the seasoning odor and aroma are strongly influenced by the garlic or by green pepper odor and aroma. Also, it should be noted that four additional terms, although previously found to be representative of the samples, were finally not perceived in any of them and they were eliminated from the list: hay odor, wood aroma, piquant and fresh (Byrne *et al*., 2001; Drake *et al.,* 2001; Pérez-Cacho *et al.,* 2005).

PCA was then employed as a final step for selecting the attributes that best characterized the samples (ISO 1994). The resulting 15 descriptors (5 odor attributes: fruit, green, seasoning, wood and lactic; 3 aroma attributes: fruit, olive oil and seasoning; 3 basic tastes: salty, acid and bitter; 2 trigeminal attributes: astringent and pungent and 2 texture attributes: firmness and crunchy) were subjected to a PCA on the correlation matrix. A two-factor model that explains 57.7% of total variance was selected based on eigenvalue values and on the contribution of descriptors to the relevant axes. This percentage of variance explained is rather low but it allows us to select the main attributes characterizing the table olives. Other authors have found a similar percentage of variance values with sensory data (Lee *et al*., 2001; Riu-Aumatell *et al.,* 2008).

Figure 1 represents the plot of the attributes on the plane defined by the first two components. The first dimension selects the main sensory attributes that define the Aloreña table-olive (fruit odor and

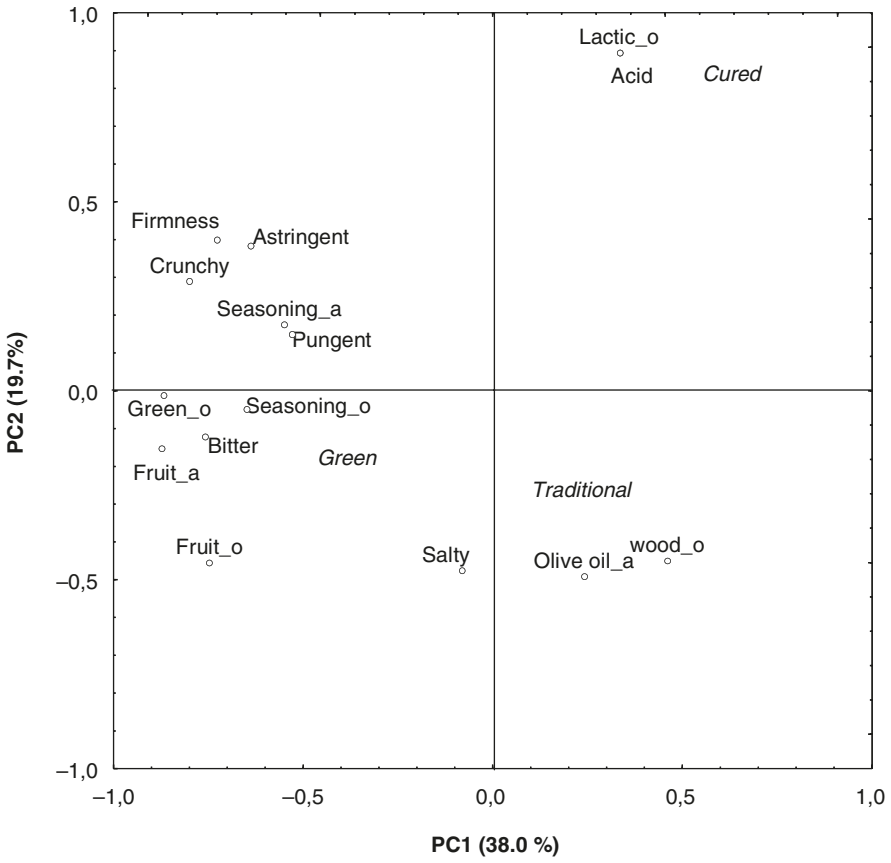

Figure 1
PCA loadings plot of the 15 terms selected by the sensory panel on the first two factors (PC1 vs. PC2).

aroma, green odor, seasoning odor, bitter taste, firmness and crunchy) and separates the green table-olives from the rest of the processing styles on the basis of their green odor attribute. The second dimension separates the cured Aloreña table-olive from the rest of the samples by their lactic odor and acid taste. Thus, Figure 2 shows the score plot for the table-olive samples using the first two factors: the first group is composed of green Aloreña olive samples (1, 4, 6, 7, 10, 12 and 14), the second group is formed by traditional olive samples (2, 3, 5, 8, 9 and 13) and the third group is composed of the cured sample (11).

For the selection of descriptive attributes, factor loading values on both factors were taken into account together (Table 3). In this study, those terms not showing a high discriminatory power were rejected, unless their quality of representation was high (values of over 0.65). Thus, 9 descriptors were maintained to characterize Aloreña table-olives: 4 for odor (fruit, green, seasoning and lactic), 1 for aroma (fruit), 2 for basic tastes (acid and bitter) and 2 for texture (firmness and crunchy). The Kruskall-Wallis test indicated that all attributes selected significantly discriminated among samples ($p < 0.001$). Finally, 4 attributes were added by the panel in a round-table discussion in order to achieve a better characterization of the Aloreña table-olives in accordance with ISO (1994): overall odor intensity, overall aroma intensity, seasoning aroma and piquant.

If we compare our findings with other research works, it is observed that although there are many works dealing with the sensory characterization of extra virgin olive oils, there are very few related to table olives (Kanavouras *et al.*, 2005; Panagou *et al.*, 2006; Gonzalez *et al.,* 2007; Marsilio *et al.,* 2008; Aponte *et al.*, 2010; Lanza *et al.,* 2010; Valencic *et al.*, 2010). What is more, those works only give information on the appearance (color), texture (firmness) and basic tastes (salty, acid and bitter) and not on the odor/aroma attribute characterizing them. However, the International Olive Council has recently published a method for the sensory assessment of table-olives in order to classify them into commercial categories (IOOC, 2008). This document proposes some odor defects that agree with our sensory findings (abnormal fermentation, musty, rancid or winey-vinegary) but not positive odor and aroma attributes.

3.2. Sensory profile

The results of the ANOVA carried out on the samples are reported in Table 4. Green odor, lactic odor and acid taste are not included in this analysis because the green odor attribute is only evaluated for the green olives and the other 2 attributes for the cured ones. The effect of the factor processing style was significant only for three descriptors: fruit odor, bitter taste and firmness ($p < 0.05$) whereas the effect of the samples nested in each processing style was significant for all the attributes ($p < 0.001$). There was no significant differences among the assessors except for overall odor intensity and seasoning aroma ($p < 0.05$). For the (assessors x processing style) interaction effect, representing the panel's performance, 4 attributes out of 10 were

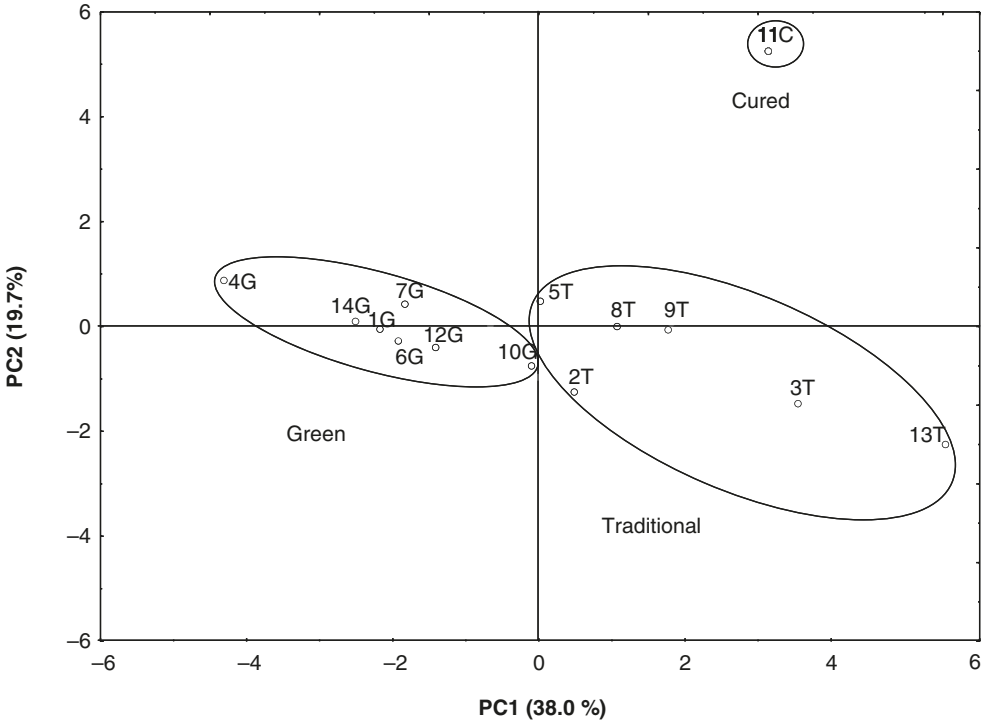

Figure 2
PCA score plot of table-olives using the first two factors (PC1 vs. PC2) obtained from the PCA by the sensory panel.

Table 3
Loadings on the first two dimensions of PCA on the correlation matrix

	Factor 1	Factor 2
Fruit_o	–0,746647	–0,457762
Green_o	–0,864435	–0,015482
Seasoning_o	–0,645813	–0,052511
wood_o	0,465849	–0,453082
Lactic_o	0,337687	0,890799
Hardness	–0,725660	0,396970
Crunchy	–0,797972	0,284669
Bitter	–0,757340	–0,122927
Salty	–0,076766	–0,479144
Acid	0,339569	0,891561
Fruit_a	–0,870473	–0,158639
Olive oil_a	0,246646	–0,493226
Seasoning_a	–0,545734	0,173156
Astringent	–0,636097	0,379105
Pungent	–0,524271	0,146915

Table 4
Nested Design ANOVA and Factorial. F and probability values

Attributes	Factor	F	p
Intensity_o	Style	2.31	0.1421
	Sample (style)	103.34	0.0001
	Assessor	3.12	0.0141
	Style x Assessor	2.70	0.0084
Fruit_o	Style	7.68	0.0071
	Sample (style)	113.40	0.0001
	Assessor	1.12	0.3607
	Style x Assessor	1.76	0.0885
Seasoning_o	Style	3.14	0.0801
	Sample (style)	70.75	0.0001
	Assessor	1.06	0.3925
	Style x Assessor	3.81	0.0005
Intensity_a	Style	0.79	0.4765
	Sample (style)	86.38	0.0001
	Assessor	1.65	0.1617
	Style x Assessor	2.29	0.0235
Fruit_a	Style	0.51	0.6144
	Sample (style)	115.90	0.0001
	Assessor	0.32	0.9000
	Style x Assessor	0.35	0.9622
Seasoning_a	Style	0.46	0.6426
	Sample (style)	135.65	0.0001
	Assessor	2.52	0.0392
	Style x Assessor	2.87	0.0054
Bitter	Style	36.14	0.0001
	Sample (style)	50.26	0.0001
	Assessor	1.25	0.2099
	Style x Assessor	1.57	0.1113
Piquant	Style	3.04	0.0854
	Sample (style)	84.07	0.0001
	Assessor	0.26	0.9332
	Style x Assessor	0.70	0.7230
Crunchy	Style	1.39	0.2863
	Sample (style)	22.14	0.0001
	Assessor	0.64	0.6671
	Style x Assessor	1.73	0.0953
Firmness	Style	4.77	0.0299
	Sample (style)	25.50	0.0001
	Assessor	1.33	0.2641
	Style x Assessor	1.62	0.1217

significantly different: odor intensity, seasoning odor, aroma intensity and seasoning aroma. It is worth mentioning that the odor and aroma intensities are strongly influenced by the seasoning odor and aroma. The main sensory differences among the three processing styles were due to a loss in the green odor/aroma notes in traditional and cured olives and the development of lactic odor and an acid taste in the cured olives. In addition, the data showed a decrease in the intensity values of fruit odor and aroma, bitter taste and firmness from the green to the cured olives. These results could be related to the manufacturing process: olives are kept in brine until their delivery when they are seasoned, developing a lactic fermentation over a more or less variable period of time (a minimum of 3 days at a refrigeration temperature for green olives, a minimum of 20 days at room temperature for traditional ones and a minimum of 90 days for cured ones). ANOVA analysis also indicated that there were differences between samples for all the attributes within each processing style and it was due to the way that they were prepared as well.

Duncan's post hoc test was applied to detect significant differences among the samples (Tables 5, 6 and 7) and the data showed that all samples were different within each processing style. Next, a canonical analysis was used to group similar samples within each processing style in order to define their sensory profiles (Figure 3-5). For green olive samples, the first two functions (79.7% of total variability) joined samples in four different groups: samples 1, 4 and 5; sample 2; sample 3; and samples 6 and 7. For traditional olive samples, all the samples were independent groups (83.6% of total variability) and for the cured one (96. 6% of total variability), samples were grouped into three batches: sample 12; samples 13 and 14; and sample 15.

Finally, the panel evaluations of the appearance of the olive samples showed that the fresh green ones had a light green coloring, the traditional ones a straw yellow one and the cured ones were brown.

Therefore, green olives were characterized by their green color, odor and aroma of green, fruit and seasoning, their bitter taste and firm and crunchy texture. The main differences observed between the four different sensory profiles were due to the intensity values of fruit and seasoning

Table 5
Green olive mean sensory scores and corresponding Duncan's significant difference at p ≤ 0.05

Attribute	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7
Odor intensity	6.4a	7.1b	7.1b	6.5c	6.4a	6.3a	6.2a
Fruit odor	6.1a	7.2b	3.8c	6.9d	4.8e	6.4af	6.4f
Green odor	1.8a	2.7b	1.7a	2.0ac	2.1c	2.0ac	2.7b
Seasoning odor	6.5a	7.3b	7.2b	6.3ac	6.5a	6.4a	6.1c
Aroma intensity	5.3a	6.7b	6.9b	5.2ac	4.9c	6.2d	5.8e
Fruit aroma	3.5a	5.7b	2.7c	2.9d	3.7e	6.2f	5.3g
Seasoning aroma	5.6a	6.7b	6.7b	5.1c	5.3c	3.7d	4.5e
Bitter	6.2a	7.2b	7.3b	6.2a	5.4c	6.9d	6.4a
Piquant	4.0a	6.4b	3.8ad	1.8c	3.0d	3.0d	3.4d
Crunchy	7.0a	6.3bd	7.4a	6.0b	6.8ad	7.0ad	5.1c
Firmness	5.2a	6.2b	5.8b	4.7cd	5.1ad	5.8b	4.5c

Means with the same letter are not significantly different with p ≤ 0.5.

Table 6
Traditional olive mean sensory scores and corresponding Duncan's significant difference at p ≤ 0.05

Attribute	Sample 8	Sample 9	Sample 10	Sample 11
Odor intensity	4.7a	6.7b	5.4c	5.0a
Fruit odor	3.7a	4.9b	3.7a	3.2c
Seasoning odor	4.9a	6.2b	5.1a	5.3a
Aroma intensity	5.3a	6.5b	5.4a	3.6c
Fruit aroma	3.3ad	3.4a	5.4b	2.9cd
Seasoning aroma	5.4a	6.9b	3.1c	3.3c
Bitter	4.5a	6.8b	3.7c	5.2d
Piquant	7.5a	4.6b	2.1c	5.3d
Crunchy	6.6a	6.6a	7.0a	5.6b
Firmness	3.9a	4.9b	4.2a	4.1a

Means with the same letter are not significantly different with p ≤ 0.5.

Table 7
Cured olive mean sensory scores and corresponding Duncan's significant difference at p ≤ 0.05

Attribute	Sample 12	Sample 13	Sample 14	Sample 15
Odor intensity	4.0a	6.4b	6.6b	7.0c
Fruit odor	2.2a	4.4b	4.6b	3.2c
Seasoning odor	3.8a	6.3b	6.4b	7.0c
Lactic odor	2.2a	2.3a	3.0b	1.5c
Aroma intensity	4.9a	6.1b	6.1b	6.2b
Fruit aroma	1.9a	4.6b	4.4b	3.1c
Seasoning aroma	4.3a	6.0b	5.1c	6.2b
Bitter	2.6a	2.0bc	2.5ac	1.8b
Acid	2.0a	3.5b	4.0c	2.0a
Piquant	2.9a	1.6b	1.8b	2.5c
Crunchy	7.0a	5.9b	5.1c	5.1c
Firmness	5.2a	3.8b	3.6b	4.8c

Means with the same letter are not significantly different with p ≤ 0.5

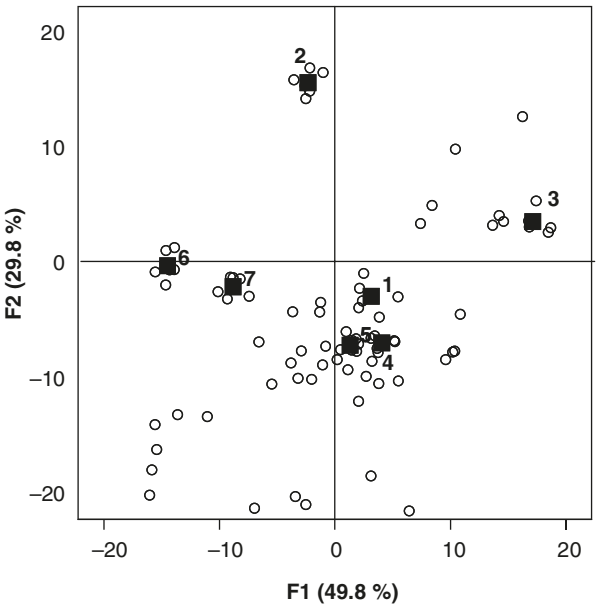

Figure 3
Scores on the first two canonical functions for the green olive samples

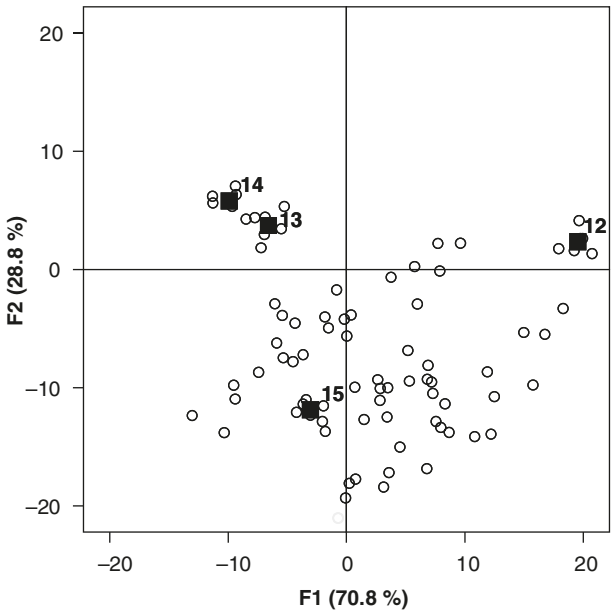

Figure 5
Scores on the first two canonical functions for the cured olive samples.

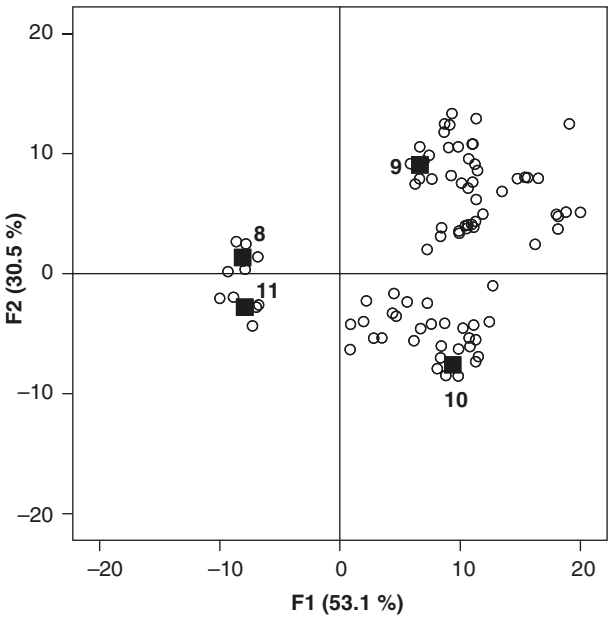

Figure 4
Scores on the first two canonical functions for the traditional olive samples.

odor/aroma and piquant attributes (Table 5 and Figure 3). The traditional ones were characterized by having a straw yellow color, fruity and seasoning odor and aroma, a bitter taste and a firm and crunchy texture. The main sensory differences among samples were due to the intensity values of fruit and seasoning odor/aroma, bitter taste and piquant attribute (Table 6 and Figure 4). It is worth mentioning that traditional samples show a decrease in their fruit odor/aroma and their bitter taste intensity values from the beginning until the end of the growing season. Cured olives develop a deep lactic fermentation, acquiring a lactic odor and an acid taste. The differences observed among the three different groups of samples were due to the intensity values of the fruit and seasoning odor/aroma, lactic odor, piquant and crunchy and firm texture (Table 7 and Figure 5).

It worth mentioning that Aloreña olives are marketed until perceptible sensory defects appear. It is important to highlight the large number of traditional samples presenting sensory defects which were clearly perceptible to the panel. This was due to the way that they were prepared as the olives were kept in brine with no refrigeration, with their sensory profile evolving throughout the season, losing their fruity and green odor attributes and bitter taste and with defects appearing over time. Different alternative storage systems for preventing such changes and preserving the freshness of the olive fruits are being studied (Arroyo-López *et al.*, 2007; Arroyo-López *et al.*, 2008a; Arroyo-López *et al.*, 2008b; Arroyo-López *et al.*, 2009).

4. CONCLUSIONS

A sensory lexicon and its standard references were developed by a trained panel. The lexicon provided will help researchers to describe the sensory characteristics of other olive varieties and can be of considerable benefit to olives producers.

ACKNOWLEDGEMENTS

Special thanks go to the UCO sensory panel members for their voluntary participation and to Professor Andrés Muñoz Serrano for the statistical analysis. We express our gratitude to “Grupo

de Desarrollo Rural Valle del Guadalhorce", Málaga (Spain) for providing funds to conduct this research project. We should also like to thank the local commercial producers in the area for their participation in the panel.

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Recibido: 12/12/12
Aceptado: 23/4/13