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Usefulness of physical parameters for pistachio cultivar differentiation

Adrián Rabadán*, José E. Pardo, Ricardo Gómez, Andrés Alvarruiz, Manuel Álvarez-Ortí

Escuela Técnica Superior de Ingenieros Agrónomos y de Montes, Universidad de Castilla-La Mancha, Campus Universitario, Albacete, Spain

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ABSTRACT

Pistachio kernel characteristics are influenced by cultivar on a greater way than other tree nuts. Previous studies have focused on the analysis of chemical traits of pistachio cultivars, with little attention been paid to differences in their physical parameters. To solve this disregard, differences in the physical traits of twenty different cultivars from nine different countries are evaluated in this study. To identify the cultivar effect, all pistachio varieties were grown in the same plot to remove environmental and land management effects on kernel traits. Regarding kernel size, significant differences were found in the kernel length and width, but not in the relation length/width. Significant differences in the colour of pistachio by-products, pistachio oil and flour, were found. Colour parameter b* in oils and L* in flours allowed the differentiation of 25% and 40% of considered cultivars, respectively. The differences in the fatty acid profile of cultivars seems to affect oil viscosity, allowing the calculation of the content in oleic and linoleic acids with the viscosity data. Viscosity values ranged from 59.71 mPa s in *Kerman* to 63.93 mPa s in *Avdat*. By grouping the considered cultivars depending on their origin countries, significant differences were found in the kernel length and oil viscosity but not in the colour parameters (L*, a*, b*). This study certifies the usefulness of some physical parameters to confirm authenticity of kernels and pistachio by products depending on the cultivar and its origin.

1. Introduction

The identification of differences between pistachio cultivars has focused in the chemical parameters, mainly fatty acids, tocopherols and phytosterols (Arena et al., 2007; Tsantili et al., 2010; Catalán et al., 2016) paying little attention to physical parameters. However, physical characteristics of pistachio kernels and pistachio by-products are important properties in the pistachio market. In particular, size and colour have been reported as some on the most important characteristics in the kernel market (Seferoglu et al., 2006). Moreover, if pistachios are used to obtain secondary products, such as oils, viscosity appears as a main parameter to consider as it is related to oil quality and the design of any engineering process related to its industrial production.

Consumers prefer greener and larger pistachios (Balta, 2002; Tsantili et al., 2010), that also have been reported to produce the best quality oils (Álvarez-Ortí et al., 2012). Although a more intense taste has been attributed to smaller kernels (Kallsen et al., 2009). Cultivars that produce the largest pistachios (as Iranian *Kerman*) are widely preferred for direct consumption. The correlation of length and width of kernels has been related to the cultivar origin (Caruso et al., 1998), although subsequent studies have revealed the limited scope of established correlations (Tsantili et al., 2010).

Colour is an important parameter in pistachio quality. Major pigments in pistachios are chlorophylls and carotenoids. Chlorophylls (*a* and *b*) provide pistachios with their characteristic bright green colour while the predominant carotenoid, lutein, gives them a yellow colour (Giuffida et al., 2006). Beyond its active role in pistachio coloration, these pigments show antioxidant properties that increase the nutritional benefits of pistachio consumption (Hsu et al., 2013). Raw pistachios have a chlorophyll content of about 9.72 mg per kg of wet weight and a lutein content of 8.12 mg/kg of wet weight (Pumilia et al., 2014). Studies have analysed the differences in the colour of pistachio kernels depending mainly on their origin (Zakynthinos and Rouskas, 1994; Agar et al., 1998; Bellomo and Fallico, 2007) or the influence of roasting on the colour of kernels or by-products (Pumilia et al., 2014; Ling et al., 2015, 2016). Beyond direct measures in kernels, the variations that appear on the colour of pistachio products because of the cultivar effect should be quantified, as their influence in the product quality is crucial.

Pistachio oil has become an interesting product, with potential for future development (Catalán et al., 2016). To maximize its commercial opportunities, quality should be controlled from origin, and the cultivar effect must be considered. Within oil parameters, viscosity is related to oil processing and oil quality. Research has proved that oil viscosity is related to the temperature of the oil (Ginner et al., 1996; Sadat and

* Corresponding author.
E-mail address: adrian.rabadan@uclm.es (A. Rabadán).

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Khan, 2007; Kumar et al., 2013), the degree of unsaturation (Kim et al., 2010; Oliveira et al., 2016) and the triglyceride composition of the vegetable oil (Geller and Goodrum, 2000; Sadat and Khan, 2007). The study of the correlation between rheology and the chemical composition of vegetable oils has been verified for popular edible vegetable oils used for frying (Kim et al., 2010) paying little attention to direct consumption oils such as pistachio oil. Conte et al. (2011), suggested the existence of differences in the viscosity of oils obtained from three different pistachio cultivars, but a deeper analysis with a significant number of cultivars should be performed.

The selection of the cultivar and the location have been reported to have major influence on the characteristics of pistachio kernels (Seferoglu et al., 2006; Tsantili et al., 2010). Few studies have analysed the differences attributed to the cultivar effect by using pistachio cultivars that have been grown in the same plot (Tsantili et al., 2010, 2011). When cultivars are grown in the same plot, the influence of ecological conditions (Silver et al., 1984; Seferoglu et al., 2006) and management practises (Sánchez-Bel et al., 2008; Carbonell-Barrachina et al., 2015) are removed, allowing the identification of the true cultivar effect on pistachio characteristics.

The objective of this study is to analyse the physical differences that appear in pistachios because of the cultivar effect by controlling the effects of the environment and the land management. The kernel size, the colour of the pistachio oil and pistachio flour and the oil viscosity were studied attending to its utility for cultivar and origin differentiation.

2. Materials and methods

2.1. Plant material

Pistachios were collected at an experimental orchard in the Centro de Mejora Agraria el Chaparrillo of Ciudad Real in the south of Spain in 2015. Twenty different cultivars (*Aegina, Ajamy, Albina, Ashoury, Avdat, Avidon, Batoury, Boundoky, Bronte, Iraq, Joley, Kastel, Kerman, Larnaka, Lathwardy, Mateur, Napoletana, Ouleimy, Sfax* and *Sirora*) with nine different origins (Iran, Iraq, Syria, Israel, Cyprus, Greece, Italy, Tunisia and Australia) were evaluated. One kilogram of pistachios were collected from every one of the three trees analysed within each cultivar. Pistachios were picked at the most appropriate harvest date for each cultivar.

2.2. Analysis

Oil extraction was carried out using a hydraulic press (MECAMAQ Model DEVF 80, Vila-Sana, Lleida, Spain). The remaining pressing cake was ground and sieved to obtain a pistachio flour with particle size lower than 1 mm. Pistachio flour is then a by-product of pistachio oil extraction, although it can be also considered as the main production objective (Rabadán et al., 2017).

The colour of the oil samples was measured using a spectrophotometer UV/Vis Jasco V-530 (Jasco Analytical, Madrid, Spain). Oil was placed in quartz cuvettes (1 cm path length) for their analysis. N-hexane was used as blank reference. The colour of the flour was measured by reflection in five random zones with a Minolta CR-200 colorimeter (Minolta Camera Co., Ltd., Osaka, Japan) in each flour. The illuminant used was D65. The tristimulus values obtained were used to calculate the CIELAB chromatic coordinates: L∗ (brightness), a∗ (red–-green component), b∗ (yellow–blue component) as recommended by the Commission Internationale de l'Eclairage (CIE, 1986). Chroma values (C*) were calculated using the expression:

$$C^* = (a^{*2} + b^{*2})^{1/2}$$

In order to determine fatty acids composition (%), the methyl-esters were prepared by vigorous shaking of a solution of oil in hexane (0.2 g in 3 ml) with 0.4 ml of 2 N methanolic potassium hydroxide solution, and analysed by GC with a Hewlett-Packard (HP 6890) chromatograph equipped with a FID Detector. A fused silica column (50 m length × 0.25 mm i.d.), coated with SGL-1000 phase (0.25 μm thickness; Sugerlabor), was used. Helium was employed as a carrier gas with a flow through the column of 1 ml min^{-1}. The temperatures of the injector and detector were set at 250 °C with an oven temperature of 210 °C. An injection volume of 1 μL was used (Regulation EEC 2568/91, corresponding to AOCS method Ch 2-91).

Viscosity was measured by a rotary viscometer test method (Visco Basic Plus, Fungilab S.A.) using the method described by Xu et al. (2007).

2.3. Statistical analysis

Significant differences among varieties were determined by ANOVA and Duncan test with a 95% significance level ($P < 0.05$) using the SPSS programme, release 23.0 for Windows. To select the most convenient method for cultivar differentiation using colour parameters, the variable that created the most groups using the Duncan test was selected.

3. Results and discussion

3.1. Kernel size

Differences can be found in the size of pistachios obtained from different cultivars, even when controlling the effect of the environment and the land management. The pistachios kernel length and width reported in our study are in general smaller than previously observed in those studies that considered the whole nut (with shell) (Tsantili et al., 2010). Attending to the length and width of kernels, three different groups can be identified ($p < 0.01$) (Fig. 1). Cultivars *Kastel* (Israel), *Sirora* (Australia) and *Kerman* (Iran) produced the larger pistachios, while *Boundoky* pistachios (Syria) were the smallest. However, most of the cultivars are included in an intermediate group that showed average size.

Attending to the kernel form, Italian, Greek and Tunisian varieties are considered elongated (length/width > 1.80), while Iranian, Turkish and Syrian are considered ovoid (length/width > 1.50–1.80) (Caruso et al., 1998). Our Greek (*Aegina*) and Italian cultivars (*Napoletana* and *Bronte*) met this rule, but only one of the two Tunisian cultivars did. The cultivars from the middle-East region presented a wide variability of kernel forms, with eight cultivars within the proposed range l/w = 1.50–1.80 (*Ajamy, Ashoury, Avidon, Batoury,*

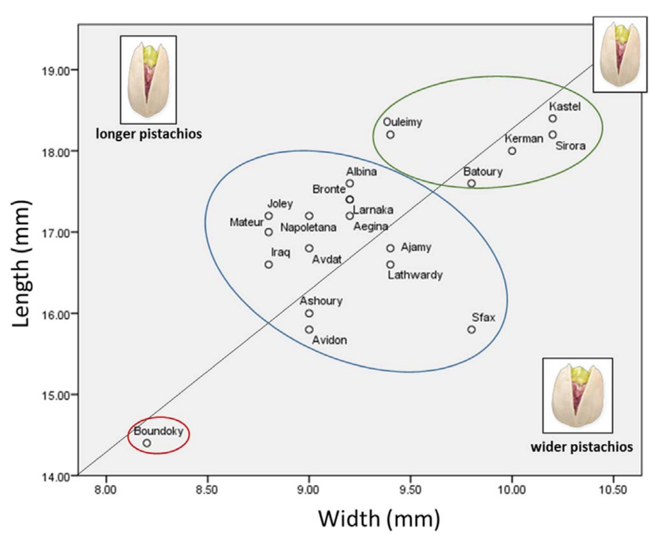

Fig. 1. Length and width of pistachio kernels from twenty pistachio cultivars grown in the same plot.