

The effects of a pressure extraction system on the quality parameters of different virgin pistachio (*Pistacia vera* L. var. *Larnaka*) oils

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RESUMEN

Efecto del sistema de extracción por presión en los parámetros de calidad de diferentes aceites vírgenes de pistachos (*Pistacia vera* L. var. *Larnaka*).

El pistacho es una magnífica fuente de aceite, puesto que a su alto contenido en materia grasa se añaden una elevada proporción de ácidos grasos insaturados y otros compuestos bioactivos como los polifenoles o los compuestos fenólicos. Se ha analizado el rendimiento y los parámetros de calidad del aceite extraído de cuatro tipos de pistacho de diferente calidad, usando dos tipos de prensas (hidráulica y de tornillo). El rendimiento de la extracción fue mayor cuando se empleó la prensa de tornillo, especialmente cuando los pistachos de mayor calidad (pistachos más grandes) se emplearon para la extracción del aceite ($40 \pm 2,12\%$). Con la prensa hidráulica, el rendimiento fue de alrededor del 30% para todos los tipos de pistacho. El color fue más oscuro en todas las muestras de aceite obtenido a partir de la prensa de tornillo. No se apreciaron diferencias significativas en cuanto a los valores de acidez libre y los parámetros K_{270} y K_{232} cuando se emplearon los pistachos de mayor calidad. En los pistachos de menor calidad, estos tres parámetros presentaron valores superiores, especialmente en los aceites obtenidos en la prensa de tornillo. Por otro lado, la estabilidad oxidativa fue mayor en los aceites obtenidos a partir de pistachos de la mayor calidad, independientemente del sistema de extracción utilizado. En los aceites obtenidos a partir de pistachos de menor calidad, la estabilidad oxidativa decreció significativamente.

PALABRAS CLAVE: Aceite – Calidad – Estabilidad oxidativa – *Pistacia vera* – Pistacho.

SUMMARY

The effects of a pressure extraction system on quality the parameters of different virgin pistachio (*Pistacia vera* L. var. *Larnaka*) oils.

Pistachios are a good source for oil extraction as they are rich in unsaturated fatty acids and other bioactive components like polyphenols and phenolic compounds. The yield and quality parameters of the oil extracted from four batches of pistachios with different sizes were analyzed. Two different pressure systems (screw press and hydraulic press) were used for oil extraction. The yield was higher when the screw press was used, especially when the highest quality pistachios (larger pistachios) were used to extract the oil ($40 \pm 2.12\%$). With the hydraulic press, the yield was around 30% for all pistachio types. The color of the oils extracted

with the screw press was darker than the oil extracted with the hydraulic press in all types of pistachios used. No significant differences were found in the acidity, K_{270} , and K_{232} values when high quality pistachios were used. When lower quality pistachios (smaller pistachios) were used, the values of these three parameters increased in comparison with larger pistachios. On the other hand, oil samples from lower quality pistachios obtained by the screw press showed the highest values. The oxidative stability was higher in the samples of oil from high quality pistachios, with no differences in regard to the extraction system. When lower quality pistachios were used, the oxidative stability was significantly lower.

KEY-WORDS: Oil – Oxidative stability – Pistachio – *Pistacia vera* – Quality.

1. INTRODUCTION

Nuts are nutrient dense foods rich in unsaturated fatty acids and other bioactive compounds like tocopherols, phytosterols, and phenolic compounds, with wide-ranging cardiovascular and metabolic benefits (Ros, 2010). Among these nuts, the pistachio (*Pistacia vera* L.) is an increasingly important crop, and one of the favourite nut trees in the world. It is widely cultivated in arid zones of the eastern Mediterranean and the US, and recently it is being introduced successfully in hot dry regions of Spain. Pistachios contain about 45-57% oil, with a high proportion of unsaturated fatty acids like oleic, linoleic and linolenic acids (Arena *et al.*, 2007; Tavakolipour *et al.*, 2010; Tsantili *et al.*, 2010). In addition, pistachios are a rich source of phytosterols and phenolic compounds (Phillips *et al.*, 2005; Tomaino *et al.*, 2010). These components have beneficial effects on human health, as phytosterols have been shown to reduce blood cholesterol and decrease the risk of certain types of cancer (Awad and Fink, 2000; Ostlund, 2004), whereas the phenolic compounds show antioxidant properties (Gentile *et al.*, 2007).

Edible oils play an important role in the food industry due to their nutritional properties and their influence on the taste and smell of food. The oils extracted from different seeds or nuts are an interesting culinary addition to provide new

organoleptic properties from a sensory point of view (Uriarte *et al.*, 2011).

Generally, pistachio oil is extracted using solvents such as hexane or diethyl ether (Bellomo *et al.*, 2009; Conte *et al.*, 2011). However, extraction with solvents may produce unpleasant smells and tastes in the resulting oil, which make it unsuitable for human consumption unless it is subjected to a refining process. In this aspect, pressure systems are more suitable for oil extraction as no chemical products are involved in the process. This extraction system produces a more pleasant product that may be used directly for cooking or fresh consumption, with all the benefits for human health derived from the chemical composition of pistachios.

In this work, the oil was extracted from pistachios by means of pressure. Two systems were used: screw press and hydraulic press. The yield of both methods and the quality characteristics of the pistachio oil extracted with the two systems were analyzed in order to determine possible changes occurring in the oil derived from the extraction systems. In addition, four different batches of pistachios differing in size were analyzed in order to determine their possible use for oil production in the industry: one commercial and three non commercial

2. MATERIALS AND METHODS

2.1. Sampling

Pistachios were kindly provided by “Pistachos de la Mancha” factory (Balazote, Albacete, Spain). They were collected from orchards surrounding the factory. Four batches of pistachios (*Pistacia vera* L., var. Larnaka) were used for this analysis: a commercial batch (labeled as Larnaka), and three batches of pistachios which are unsuitable for commercialization due to their small size or to the presence of defects like dark spots or broken kernels, labeled as A, B, and C. In Table 1 the average sizes of the different batches of pistachios are shown. The quality of pistachios is related to their size. Sample C is considered to have the lowest quality due to the small size of the kernels and the presence of dark spots, while the sample

Table 1
Weight, width and length
of the different types of pistachios used

| Type | Weight (g) | Width (mm) | Length (mm) |
|---------|-------------|-------------|-------------|
| Larnaka | 0.59 ± 0.10 | 8.80 ± 0.71 | 16.3 ± 1.64 |
| A | 0.54 ± 0.11 | 8.45 ± 0.60 | 16.2 ± 1.55 |
| B | 0.42 ± 0.08 | 8.10 ± 0.57 | 15.4 ± 1.78 |
| C | 0.28 ± 0.04 | 7.00 ± 0.53 | 13.5 ± 1.27 |

The values represent the average and standard deviation of 100 pistachios.

labeled as Larnaka is considered to have the highest quality, as the kernels are the largest ones and with complete absence of dark spots. Samples A and B are considered to have intermediate quality.

Moisture content was calculated by the difference in weight of 5 g sample before and after complete drying at 105 °C overnight using a desiccation oven with forced ventilation.

The oil was extracted with two different pressure systems (Figure 1): hydraulic press (Hidráulica Dumont S.A., Santiago, Chile) and screw press Komet Oil Press CA59G (IBG Monforts Oekotec GmbH & Co. KG, Mönchengladbach, Germany). For the hydraulic press, 200 g of pistachios were previously ground and subjected to a pressure of 60 kg cm⁻² for 10 min. For the screw press, 200 g of pistachios were introduced directly into the press. The tip was previously heated to ensure the correct extraction procedure. In both cases, 3 replicates were prepared for each type of pistachio.

After oil extraction, a centrifugation step was carried out in order to eliminate the remaining solid residues from the samples. The oil samples were stored at 4 °C in dark glass bottles to avoid oxidation until analysis. The analysis of samples was performed in a period of less than two weeks after oil extraction.

2.2. Analytical determinations

The color of the samples was measured with a Minolta CR-200 colorimeter (Minolta Co., Ltd., Osaka, Japan). The illuminant used was D65, with a viewing angle of 2°. The tristimulus values

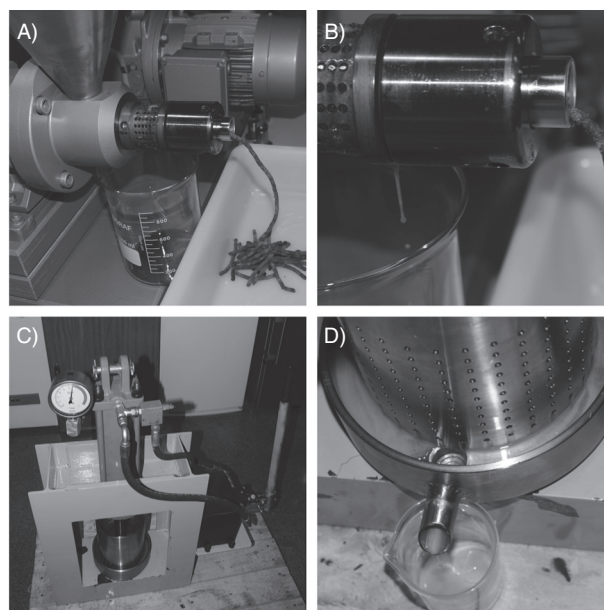


Figure 1

- A) Screw press Komet Oil Press CA59G (IBG Monforts Oekotec GmbH & Co. KG, Mönchengladbach, Germany).
B) Details of oil extraction with the screw press.
C) Hydraulic press (Hidráulica Dumont S.A., Santiago, Chile).
D) Details of oil extraction with the hydraulic press.

obtained were used to calculate the CIELAB chromatic coordinates L^* (lightness), a^* (redness), and b^* (yellowness), and color attributes C^* (chroma) and h^* (hue angle), as recommended by the Commission Internationale de l'Eclairage (CIE, 1986; McGuire, 1992).

Free acidity, given as % of oleic acid, was determined by titration of a solution of oil dissolved in ethanol/ether (1:1) with 0.1 M potassium hydroxide ethanolic solution (EEC, 1991).

K_{270} and K_{232} extinction coefficients were calculated from absorbance at 270 and 232 nm, respectively, with a UV/VIS spectrophotometer Jasco V-530 (Jasco Analitica Spain, Madrid, Spain), and a path length of 1 cm. For K_{270} , a 1% solution of oil in cyclohexane was used, while for K_{232} a 0.5% solution of oil in cyclohexane was used (EEC, 1991).

Oxidative stability was evaluated by the rancimat method (Gutiérrez, 1989). Stability was expressed as the oxidation induction time (hours), measured with the Rancimat 743 apparatus (Metrohm Co., Basel, Switzerland). An oil sample of 3.5 g was used, warmed to 100 °C under an air flow of 10 L h⁻¹.

The oil content of the pistachios was measured by a Soxhlet extractor (BUCHI Labortechnik AG, Flawil, Switzerland), using petroleum ether as solvent, for an extraction period of 6 h (AOAC, 1990).

2.3. Statistical analysis

Significant differences among varieties were determined by an analysis of variance, which applied a Duncan test with a 95% significance level ($P < 0.05$), using the SPSS programme, release 11.5 for Windows.

3. RESULTS AND DISCUSSION

3.1. Yield

The oil content of the pistachios was measured with a Soxhlet extractor. The measurements showed a percentage of fat between 54% in the Larnaka sample and 40% in sample C, with intermediate values for samples A and B (48% and 47%, respectively). These values agree with those reported by other authors (Arena *et al.*, 2007; Tsantili *et al.*, 2010; Panahi and Khezri, 2011), although certain ecotypes have been reported to have higher fat content values of up to 80% (Ghrab *et al.*, 2010). In addition, the moisture was also measured. All the samples showed values around 5%. Although the moisture of natural pistachios is about 40%, they are generally dried in the industry to avoid fungal proliferation, which may cause aflatoxin contamination (Bensassi *et al.*, 2010).

The yield for both extraction systems was determined (Figure 2). The highest yield was obtained for the sample Larnaka with the screw press (40 ± 2.12%). In general, when both

extraction methods were compared, a slight increase in the yield was observed for the screw press, although this difference was significant only when the oil was extracted from the pistachios labeled as "Larnaka". When pistachios of quality A, B, and C were used for oil extraction, the difference in the yield for both extraction systems was not significant. In addition, the yields obtained with the screw press showed more variation. Although the screw press is considered as a cold extraction system, it requires an increase in the temperature of the tip to obtain the best results. An increase in the temperature produces a better separation of the oil, which may affect the extraction yield. In some screw presses, the temperature is difficult to control and therefore the yield presents greater variations. The hydraulic press is easier to control, as the only parameters that influence the process are the pressure (which can be easily measured by a manometer installed in the press), the time and the amount of pistachios used. Our results showed that the yield obtained for all the samples with the hydraulic press was similar (around 30%), whereas significant differences between Larnaka and the other samples were observed with the screw press.

3.2. Color

The color parameters were expressed as L^* (color intensity or lightness), a^* (redness), b^* (yellowness), C^* (chroma, or intensity of color), and h^* (hue angle). Figure 3 shows the values of L^* , b^* , C^* , and h^* , where significant differences between both extraction methods were found for all the samples. The oil extracted with the screw press showed lower values of the 4 parameters, indicating darker, greener oils. A similar pattern has been observed when roasted seeds are used to produce oil (Lee *et al.*, 2004; Park *et al.*, 2011). As stated above, the screw press requires an increase in the temperature for a correct oil extraction. It originates the change in the color of the oil to dark, probably

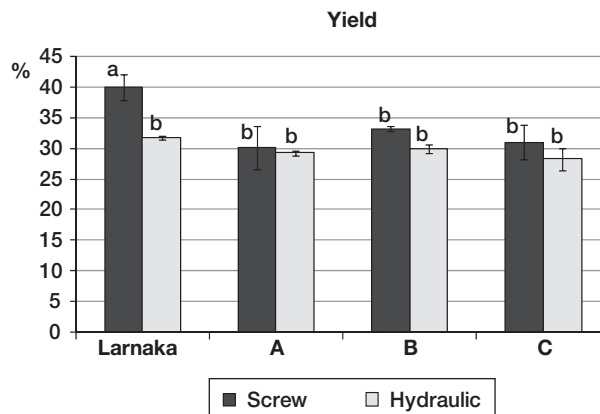


Figure 2

Yields of pistachio oil extracted with the screw press and the hydraulic press. Values represent the average and standard deviation of three replicates. Different letters on the bars indicate significant differences ($p < 0.05$) among samples (Duncan test).

due to the appearance of products from the Maillard reaction, caramelization or phospholipid degradation (Durmaz and Gökmen, 2011; Vaidya and Choe, 2011).

In the case of the oils obtained with the hydraulic press, lower values of L^* , b^* , C^* and h^* were observed when lower quality pistachio samples were used (Figure 3). The quality of the pistachios, especially the presence of dark spots on the kernel, is a parameter that may influence the color of the oil when a cold extraction system with no increase in the temperature is used. Therefore, it is important to make a selection of the pistachios in order to obtain lighter and more attractive colors in the oil. When the screw press is used, the effect of the quality of pistachio is hidden due to the appearance of Maillard reaction products, resulting in more similar color in the oils extracted from different types of pistachios.

3.3. Acidity, K_{270} , K_{232}

The acidity, measured as % of oleic acid, and the extinction coefficients K_{270} and K_{232} are parameters used to estimate the quality of the oil. The values obtained for acidity, K_{270} and K_{232} are shown in Figure 4. Lower values of acidity indicate the freshness of the samples, the good quality of the oil, and no chemical or enzymatic hydrolysis of glycerolipids. The highest values of acidity were observed in sample C for both extraction systems. With regard to the extraction effect, the oils obtained

from lower quality pistachios (B, C) showed significantly higher values of acidity when the screw press was used. Indeed, acidity may be affected by temperature, and thus, the oils obtained with the screw press present higher proportions of free fatty acids hydrolyzed from the glycerolipids. However, when high quality pistachios were used (Larnaka, A), the acidity values were similar regardless of the extraction system used. Hence, we cannot clearly exhibit the effect of temperature on the variations in acidity.

As for the ultraviolet spectrophotometric analysis, it indicates the degree of oil oxidation, with values expressed as specific extinction coefficients. The K_{232} and K_{270} are mainly indicative of the conjugation of dienes and trienes respectively. Figure 4 shows the values obtained for K_{270} and K_{232} in the oil samples extracted with the different systems. The oils extracted with the screw press present higher values of both attributes for all the samples except for the pistachios of the best quality (Larnaka), where the values are similar. In addition, differences were also observed depending on the sample analyzed. The highest values were obtained when the pistachios of the lower quality (B, C) were used to extract the oil.

3.4. Oxidative stability

Another important parameter to study oil quality is oxidative stability. It refers to the susceptibility of the oil to lipid oxidation, which causes rancid odors

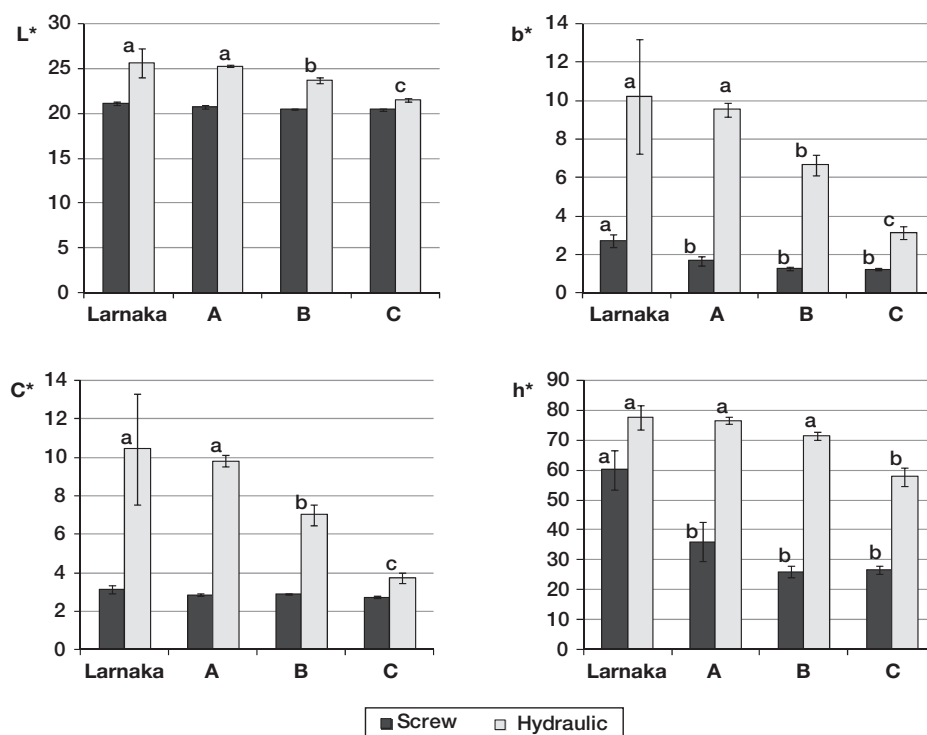


Figure 3

Color characteristics of the pistachio oil samples extracted with the screw press and the hydraulic press. L^* : lightness; b^* : yellowness; C^* : chroma; h^* : hue angle. Values represent the average and standard deviation of three replicates. Different letters on the bars indicate significant differences ($p < 0.05$) among samples (Duncan test).

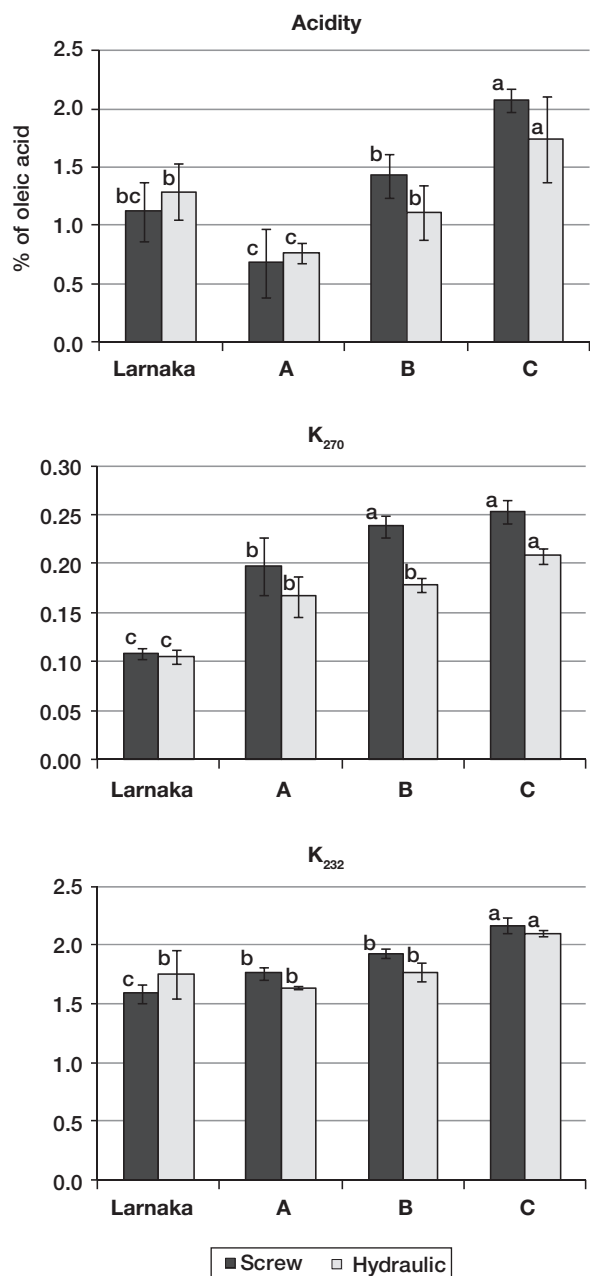


Figure 4

Acidity and spectrophotometric analysis (K_{270} , and K_{232}) of pistachio oil samples extracted with the screw press and the hydraulic press. Values represent the average and standard deviation of three replicates. Different letters on the bars indicate significant differences ($p < 0.05$) among samples (Duncan test).

and flavors. Pistachio nuts are known to have a high concentration of polyphenols and tocopherols with antioxidant properties (Gentile *et al.*, 2007), and pistachio oil has been reported to exhibit a high antioxidant capacity, similar to that of extra virgin olive oil (Arranz *et al.*, 2008). The results of the oxidative stability of the virgin pistachio oils extracted with both pressure systems are shown in Table 2. The highest induction time was obtained in the commercial pistachios labeled as Larnaka, with no differences for both extraction systems (47.07 ± 1.19 screw press; 47.76 ± 4.70 hydraulic press). When compared to olive oil, the most highly valued

oil among edible oils, these values are similar to those obtained for oils from the varieties *Arbequina* or *Leccino* from various locations (Aguilera *et al.*, 2005; Pardo *et al.*, 2007), although it is considerably lower than oils from other varieties like *Picual* or *Cornicabra* (Pardo *et al.*, 2011).

Similar values of oxidative stability have been reported in other studies (Arranz *et al.*, 2008), and make pistachio oil one of the most stable among nut oils. Other data reported showed that pistachio oil has an oxidative stability lower than hazelnut or macadamia nut oils, but higher than walnut, peanut, cashew, pine nut and almond oils (Arranz *et al.*, 2008; Miraliakbari and Shahidi, 2008; Kochhar and Henry, 2009). However, the oil obtained from lower quality pistachios (A, B, and C) did show significantly lower values for oxidative stability (Table 2).

It has been reported that seed roasting may improve the oxidative stability of the oils (Wijesundera *et al.*, 2008; Durmaz and Gökmen, 2011). When the oil is extracted with the screw press, the differences in the color obtained suggest that temperature is an important factor in this system. This could explain the significant increase in the induction time of the oil from the lower quality pistachios (samples B, C) when the screw press is used, in comparison with the hydraulic press. However, as mentioned above, we found no differences when the high quality pistachios are used. On the other hand, the oil from the lowest quality pistachios (C) showed significantly lower values of oxidative stability than the oil from the highest quality pistachios (Larnaka) when the same extraction system is considered. This supports the idea that pistachio quality plays an important role with respect to oxidative stability. Indeed, the richer the pistachios are in monounsaturated fatty acids and antioxidant compounds, the more resistant the oil will be to autooxidation, whatever the temperature. This result is consistent with those of K_{232} and K_{270} , since only oils from pistachios of higher quality (Larnaka) were not affected by the extraction system.

4. CONCLUSIONS

Two pressure oil extraction systems (screw press and hydraulic press) are evaluated with regard to yield and quality parameters to obtain virgin pistachio oil. Yields were slightly higher when the screw press was used, especially with pistachios of the highest quality. However, although the screw press is considered as a cold extraction system, it requires the heating of the tip in order to obtain optimum performance, and the yield may be affected by the fluctuation in temperature, which leads to a higher variation in the yield.

Differences in the color of the oil were observed. The screw press produces darker oils than the hydraulic press due to the accumulation of Maillard reaction products derived from the higher

Table 2
Induction time (hours) for the oils obtained from different types of pistachios extracted with the screw press and the hydraulic press. Values were obtained with the rancimat method, at a temperature of 100°C with an air flow of 10 L/h

| | Induction Time (hours) | | | |
|-----------|------------------------------|------------------------------|-------------------------------|------------------------------|
| | Larnaka | A | B | C |
| Screw | 47.07 ± 1.19 ^{a, a} | 30.23 ± 2.33 ^{a, c} | 33.12 ± 0.49 ^{a, bc} | 36.91 ± 1.48 ^{a, b} |
| Hydraulic | 47.76 ± 4.70 ^{a, a} | 30.07 ± 1.92 ^{a, b} | 30.21 ± 1.29 ^{b, b} | 30.65 ± 1.53 ^{b, b} |

^{a, b} Different letters in the same row indicate significant differences in the extraction system used ($p < 0.05$).

^{a, b, c} Different bold letters in the same line indicate significant differences among the pistachio types ($p < 0.05$).

The values represent the average and standard deviation of three replicates.

temperatures required by the screw press. In addition, the quality of the pistachios may affect the color of the oil obtained.

As for acidity, K_{270} , and K_{232} , no significant differences were observed in both systems when high quality pistachios are used to produce oil. Similar data were obtained for oxidative stability. When lower quality pistachios were used, the acidity, K_{270} , and K_{232} , values increased, especially in the screw press samples, while oxidative stability decreased.

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