Food Chemistry 257 (2018) 376–381

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Bioactive compounds and quality parameters of avocado oil obtained by different processes

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ARTICLE INFO

Keywords:
Breda variety
Drying
Fatty acids

ABSTRACT

The objective of this study was to evaluate the quality of avocado oil whose pulp was processed through different drying and oil extraction methods. The physicochemical characteristics of avocados cv. Breda were determined after drying the pulp in an oven under ventilation (40 °C and 60 °C) and vacuum oven (60 °C), followed by the oil extracted by mechanical pressing or the Soxhlet method. From the approximately 72% pulp found in the avocado fruit, the 16% fraction is lipids. The quality indices evaluated in avocado oil showed better results when the pulp was dried at 60 °C under vacuum and oil extraction was done by the Soxhlet method with petroleum ether, whereas the bioactive compounds were better preserved when the avocado pulp was dried at 60 °C under ventilation and mechanical pressing was used for the oil extraction. Among the fatty acids found, oleic acid was the main.

1. Introduction

Avocado (*Persea americana* Mill.), a fruit plant with high productivity per unit area (Schaffer, Wolstenholme, & Whiley, 2013), belongs to Lauraceae family. It is cultivated in almost all Brazilian states. The largest producer (47.5%) of avocados is the state of São Paulo, followed by Minas Gerais (19.0%) and Paraná (11.2%) (Almeida & Sampaio, 2013). According to IBGE (2016), in the year 2015, the southeastern region produced 145,017 tons of avocados.

Considering the characteristics of the food habit of the Brazilian consumer (Holbach, 2012), the cv. Breda is the most consumed variety of the avocado in Brazil; it has a sweet flavor. The different varieties of avocados found in different regions of the Brazilian territory show a variable chemical composition. However, the sources of unsaturated fatty acids, fibers, potassium, vitamin B3, and bioactive compounds, such as vitamin E, carotenoids, and sterols, are considered independent of the variety. The fruits possess antioxidant, anti-inflammatory, antitumor, and antimicrobial activities (Daiuto, Vieites, Tremocoldi, & Vileigas, 2010).

According to the American Dietetic Association – ADA (1999), avocado is classified as a functional food owing to its high nutritional value and proven beneficial effects on human health. Avocado possesses similar oil content as that of olive oil, and similar relative proportion of fatty acids, predominating in both the oleic acid (Tango, Carvalho, & Soares, 2004).

Avocado oil is rich in omega fatty acids that are good for human health, especially in preventing cardiovascular diseases (Salgado, Danieli, Regitano-D'arce, Frias, & Mansi, 2008). Therefore, the use of avocado oil in human food is considered as a favorable option. However, a small volume of avocado oil produced in Brazil is used in the raw form, notably the unsaponifiable fraction, by the pharmaceutical and cosmetic industries, as it possesses epidermal regenerative properties (Tango et al., 2004).

In order to extract avocado pulp oil, several processes have been suggested such as centrifugation, hot extraction with hexane (Ortega et al., 2011), extraction with methanol, extraction with ethanol (Galvão, Narain, & Nigam, 2014) cold pressing, extraction with petroleum ether (Santos, Alicieo, Pereira, Ramos & Mendonça, 2014), microwave + pressing, pressing with oven-dried pulp at 60 °C or 45 °C + enzyme, petroleum ether extraction with oven-dried pulp at 60 °C or 45 °C + enzyme, ethanol extraction and oven dried pulp at 60 °C (Santana, dos Reis, Torres, Cabral, & Freitas, 2015), sono-physical processes (Martínez-Padilla, Franke, Xua, & Juliano, 2018), supercritical CO_2 and a CO_2/ethanol mixture as solvents (Corzzini, Barros, Grimaldi, & Cabral, 2017), simultaneous supercritical (Barros, Helena, Grimaldi & Cabral, 2017). However, the chemical characteristics of the

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https://doi.org/10.1016/j.foodchem.2018.03.048
Received 30 June 2017; Received in revised form 7 March 2018; Accepted 12 March 2018
Available online 13 March 2018
0308-8146/

oil obtained by different processes, especially considering the compounds present in the unsaponifiable fraction, have not been investigated. The extraction techniques that produce oil with high levels of bioactive compounds that preserve the properties and nutritional values associated with the fruit have attracted a growing interest (Kmiecik et al., 2011).

To determine the physicochemical characteristics of avocados of the Breda variety and to evaluate the effect of the pulp drying method and the oil extraction process on the quality and profile of fatty acids and bioactive compounds were the primary objectives of this study.

2. Materials and methods

2.1. Materials

2.1.1. Sample

A producer from São Sebastião do Paraíso/MG donated the cv. Breda avocados in September 2015, which included 23 fruits at an incomplete maturation stage. The fruits were wrapped in a paper, packed in a cardboard box, and kept at room temperature (28 ± 1 °C) until reaching the ideal degree of maturation, which was determined as a function of the pulp texture and the soluble solids content (7–8° Brix).

2.2. Methods

The physical parameters, such as the total weight of the fruit (Uranus US 20/2 scale), bark, pulp, and core weight, of these 23 avocado fruits were evaluated. Moreover, the total moisture, total dry extract, total sugar, reducing sugar, lipids, protein, crude fiber, ash, total soluble solids, titratable total acidity, and the pH of the pulp were also evaluated (AOAC, 1990). Initially, the fruits were sanitized in chlorinated water at 200 mg L^{-1} for 15 min, washed in running water, and then cut into pieces. In order to avoid enzymatic darkening, the pulp was separated and immersed in 1% citric acid solution for 15 min. Then, it was fractionated into three portions. Each portion was subjected to one of the drying methods: oven drying with air ventilation at 40 °C, oven drying at 60 °C (both using model MA035, Marconi), and vacuum oven at 60 °C (model Vacuoterm 6030A). The temperatures used in this study were based on the study of Santos et al. (2014). Drying was performed until a final moisture content of about 5–6% was obtained, independent of the methods used.

The dried samples were packed in polyethylene bags, protected from light, and stored in a freezer (−18 °C) until oil is extracted. The oil extraction was carried out by using two different processes: mechanical pressing and the Soxhlet extraction with petroleum ether (Santos et al., 2014). The dried pulp samples were pressed with a force of 9 tons using a mechanical press (Marconi) at room temperature.

Approximately 15 g of sample was weighed in a previously defatted filter paper cartridge for the extraction by the Soxhlet method. The process was conducted for a period of 6 h. Thereafter, the remaining solvent was discarded with nitrogen gas bubbling. The obtained oil extracts were stored in an amber glass and frozen at −18 °C.

The standards of the American Oil Chemists' Society (1992) were applied to determine acidity (A), peroxide (PI), iodine (II), refraction (RI), and electrical conductivity (C). The content of phenolic compounds, carotenoids, chlorophyll, tocopherol, antioxidant activity and fatty acid profiles were determined according to Montedoro, Servili, Baldioli, and Miniati (1992), Rodrigues-Amaya (2001), Zambiazi (1997), Brand-Williams, Cuvelier, and Berset (1995) and Hartman and Lago (1973), respectively. The fatty acid results were expressed as a percentage relative to the total fatty acids identified, compared to the retention times of the methyl esters containing the acids caproic, caprylic, caproleic, caproleic, lauric, dodecenoic, myristic, myristoleic, palmitic, palmitoleic, margicoic, heptadecenoic, stearic, oleic, linoleic, linolenic, arachidic, gadoleic, eicosadienoic, eicosatrienoic, tetraenoic, lignoceric, and nervonic (Sigma Chemicals Co.). The oil yield was calculated by the fat content considering the dryness.

2.3. Statistical analysis

The results were expressed in terms of means and standard deviations and were subjected the analysis of variance (ANOVA) and Tukey's test ($p < 0.05$) using Statistix 10 software.

3. Results and discussion

3.1. Physical parameters of avocado

The avocado fruits showed an average weight of 754.36 g, with 71.89% of the pulp, 21.22% of the core, and 6.89% of the bark. In the literature, weights have been found between 129.3 g and 750.18 g, with 9–82.6% of the pulp; 6.9–28% of the bark, and 10.1–27.9% of the core, for other varieties of avocados (Ouro Verde, Wagner, Campinas, Paulistinha, Fortaleza, Pedroso, Margarida, Hass, Fortuna, Quintal and Reis).

3.2. Physicochemical and bioactive analyses of the avocado pulp

Table 1 presents the results of the physicochemical evaluations and the contents of the bioactive compounds in the avocado pulp of the Breda variety. The value of lipids (Table 1) can be considered between low and medium, with high humidity as compared to other varieties. The lipid content of the pulp of the different varieties of avocado ranges from 5.3 to 31.1% and the pulp moisture content ranges from 57.2 to 87.9% according to Tango et al., (2004) and Oliveira et al. (2013). Lipid contents ranging between 5 and 35% in avocados of the Hass, Fuerte, Gloria, Collinson, Anaheim, Itzamna, Wagner, Ouro Verde, Carlsbad, Mayapan, Winslow, Quintal, Monte d'Este, MacDonald, Barker, Westin, Winslowson, Sinaloa, Victoria, Waldin, Linda, Simmonds, Fortuna, and Pollock varieties have also been reported by Borges and Melo (2016).

A high protein content was observed the pulp of Breda variety (1.73%) as compared to the values reported by Oliveira et al. (2013), between 0.74% and 1.9% of protein in eleven varieties of avocados (Ouro Verde, Wagner, Campinas, Paulistinha, Fortaleza, Pedroso, Margarida, Hass, Fortuna, Quintal, and Reis).

Total sugar content can be considered low as compared to the values reported in the literature (4.17–13.2%) (Ortega, López, & Torre, 2013) (Table 1). The fruits presented soluble solids content of 7–8° Brix, which is an indication of the ideal maturation condition (Santos et al., 2014).

Fiber and ash contents were also low, which conform to the results presented by Daiuto et al. (2010), who obtained 1.62% of fibers in

Table 1
Physicochemical characteristics and bioactive compounds in the avocado pulp of the Breda variety.

Determinations	Values
Humidity (%)	78.2 ± 0.2
Total dry extract (%)	21.8 ± 0.2
Total sugars (%)	6.4 ± 0.3
Reducing sugars (%)	2.4 ± 0.2
Lipids (%)	15.8 ± 0.6
Proteins (%)	1.7 ± 0.2
Crude fiber (%)	1.6 ± 0.4
Ashes (%)	0.6 ± 0.0
Total acidity (%)	0.5 ± 0.1
Soluble solids (° Brix)	8.1 ± 0.1
pH	6.5 ± 0.1
Carotenoids (mg β-Carotene kg^{-1})	4.63 ± 1.59
Chlorophyll (mg kg^{-1})	0.18 ± 0.0
Phenolic compounds (mg gallic acid kg^{-1})	97.3 ± 6.5
Antioxidant activity (% inhibition)	79.0 ± 1.0

Results expressed as mean ± standard deviation.