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Study of the Influences by Geographical Origin in Chemical Characters, Sugars, and Antioxidant Activity of Portuguese Autochthonous *Prunus Armeniaca* L.

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Abstract

Chemical characterization and antioxidant activity are two of the most important nutritional quality factors in many horticultural crops and have many biological activities and benefits to human health. Fruit physical characters and antioxidant compounds of *Polida* apricot cultivar, an autochthonous fruit and the most representative Portuguese cultivar, from different geographic regions, were evaluated. Some physical parameters related to fruit quality and climacteric conditions, such as color angle (h^o), moisture, pH, water activity (a_W), tritatable acidity (TA), soluble solids content (SSC), were analyzed. Phytochemical traits and antioxidant capacity were also analyzed. Results revealed a remarkable variation in total phenol content (from 4938.6 to 7967.2 mg of GAE/100g fresh weight) and highest content of total carotenoids in fruits collected in south of Portugal. The antioxidant activity revealed significant differences ($p < 0.05$) between apricot fruit samples (with and without peel). Positive correlations were observed between chemical profile and antioxidant activity with geographical areas presenting different climacteric conditions. Taking into account the reduced shelf life of fresh apricot fruit and to ensure that these fruits reach consumers with maximum nutritional and functional properties, it is advisable to cultivate them in geographic areas with intense radiation exposition. This semicomprehensive analysis begins to characterize the phytochemical profile of Portuguese apricot fruit and illustrates the main differences between them in distinct geographical areas.

Keywords: *prunus armeniaca* L., portuguese autochthonous apricot fruit, chemical characterization, antioxidant activity (DPPH assay), sugars content, climacteric conditions, HPLC

Abbreviations: a_W—water activity; BHT—2,6-bis (1,1-dimethylethyl)-4-methyphenol; DIP—2,6-dichlorophenol-indophenol; DPPH—2,2-diphenyl-1-picrylhydrazyl; FW—Fresh weight; GA—Gallic acid; GAE—Gallic acid equivalent; h^o—hue angle; HPLC—High performance liquid chromatography; SSC—soluble solids content; TA—tritatable acidity.

1. Introduction

Foods that are cultivated and used by humans for thousands of years sometimes acquire folklore and have superstitions attached to them. Apricot is one of them. This golden orange fruit with its

sweet, velvety skin and, smooth textured, is steeped in multicultural folklore. This was how apricot became associated with medicine in China; but then, among several cultures, apricot has enjoyed a status as a promoter of health and well-being. Apricot is considered by many to be one of the most delicious temperate tree fruit. The fruit of apricot tree is an excellent source of vitamin A, vitamin C and potassium, usually described with antianemic and astringent properties.

Exceptional fruit quality requires a balance of sugar and acidity as well as a strong apricot aroma. Mediterranean countries, including Portugal, supply the greatest world apricot production. Apricot varieties cultivated in this area belong to *Prunus armeniaca* L. species and to the European eco-geographical group. The ever-growing concerns of consumers toward health and safety attributes of foods emphasized the role of the agronomic practices and climacteric conditions as one of the main determinant of food quality. Bioactive compounds (vitamins, phenolics) play a role in plant defense mechanisms as well as in the antioxidant expression of the plant. The concentration and composition of those compounds in plants, fruits and vegetables is influenced by a number of factors (Dragovic-Uzelac et al., 2007; Jiménez et al., 2008).

Apricot (*Prunus armeniaca* L.), from Rosaceae family, is a rich source of vitamins and minerals and is one of the most familiar crops worldwide (Yigti et al., 2009). Fresh apricot fruit contains carbohydrates, ascorbic acid, β-carotene, niacin and thiamine. Organic acids, phenols, volatile compounds, esters and terpenoids have also been isolated (Ruiz et al., 2005). Several studies have correlated color with pigment of different fruits and vegetables usually related with the presence of poliphenolics and carotenoids compounds recognized as bioactive compounds with high antioxidant activity (Arias et al., 2000). The importance of carotenoid content in apricot (*Prunus armeniaca* L.) is recognized not only because of the color that they impart but also because of their protective activity against human diseases (Ruiz et al., 2008). Numerous other carotenoids are present in apricots but in small amounts (<2%) such as phytoene, phytofluene, β-carotene, lycopene, *α*-cryptoxanthin, and lutein (Marty et al., 2005; Ruiz et al., 2008). Apricots have been described as one of the most important dietary sources of provitamin A (Bureau and Bushway, 1986; Ozturk et al., 2009). There is some information about the beneficial effects of β-carotene and vitamins as antioxidants but their effects when consumed in foods are not well defined (Krinsky, 1998; Krinsky, and Johnson, 2005). Phenolic secondary metabolites play an important role in plant-derived food quality, as they affect quality characteristics such as appearance, flavour and health-promoting properties, however, the phenolics presents in each fruit depends on several factors, including internal (genetic) and environmental (agronomic) factors, technological treatments applied during postharvest storage of fruits and vegetables, as well as processing and storage of the processed products. The major phenolic compounds described in apricot fruits are chlorogenic and neocholorogenic acids, (+)-catechin, (-)-epicatechin and rutin (Radi et al., 1997). Although these phenolic compounds are known to be strong antioxidants, Scalzo and colleagues (2005) found that antioxidant activity in apricot fruit was not only correlated with its phenolic content. The consumer preference for apricot is greatly influenced by its sugar content. Lately, there is a considerable interest in determining the content of antioxidant compounds and other nutritional properties of fruits obtained from different geographic areas.

Although different apricot varieties have been investigated by many researchers in the world (Sass-Kiss et al., 2005; Ruiz et al., 2005; Akin et al., 2008; Drogoudi et al., 2008), a research on the chemical compositions of Portuguese apricots, has not yet been investigated in detail. Considering that climacteric conditions, soil properties and type of apricot cultivars carrys great influences in their chemical composition and antioxidant activity of each fruit, this research aimed to determine other important properties (dry matter, soluble solid content, pH, color, water activity, sugars, total phenolics, carotenoids content, tritratable acidity, ascorbic acid content and their synergetic effect)

in apricot fruit, evaluation. This way is possible to assess their free radical scavenging capacity and also confirm the applicability of Portuguese apricot in consumption and promote an increased production, being an asset to the agronomic and economic resources of Portugal.

2. Experimental Part

2.1 Plant Material

Portuguese autochthonous apricot fruits (var. *Polida*) were collected at commercial harvest time, in 2010. During harvest season, 100 fruits were collected locally from 20 different apricot trees in the same plantation area from three different geographic regions situated in the north-eastern (Macedo de Cavaleiros), center (Guarda) and in the south (Portimão) of Portugal. On the day of purchase, apricot fruits were cleaned and prepared according to the requirements of the intended analysis and stored at 4ºC until the analysis, less than two weeks, to avoid significant changes in the secondary metabolites. Three replicates of each sample were selected and analyzed. The chemical analysis corresponds to different lots of apricot fruits collected in one season.

2.2 Standards and Reagents

All reagents and solvents used were obtained from Merck (Darmstadt, Germany) and were of HPLC or analytical grade. Folin-Ciocalteu phenol reagent, gallic acid standard (GA), 2,6-dichlorophenolindophenol (DIP), sodium carbonate, sodium hydroxide, oxalic acid; methanol, petroleum ether, β-carotene, 2,2-diphenyl-1-picrylhydrazyl (DPPH), 2,6-bis (1,1-dimethylethyl)-4-methyphenol (BHT) were purchased from Sigma (St. Louis, MO, USA). Sources of reference compounds were citric acid, ascorbic acid, sucrose, glucose, fructose and sorbitol (Sigma, St. Louis, MO, USA). All reagents and standard solutions were prepared using Milli Q deionised water (Millipore, Belford, USA).

2.3 Quality Parameters

Color (hº), titratable acidity (TA), pH, water activity (a_W), moisture, ash (%) and soluble solids content (SSC) were evaluated as quality fruit indices. Color values on the surface (ground skin color) were measured with a Minolta chroma meter (CR-2000, Minolta, Ramsey, NJ) tristimulus color analyzer calibrated to a white porcelain reference plate. The color space coordinates L^*, a^*, b^*, hue angle [($h°$) arctangent (b^*/a^*)], and chroma $(a^{*2} + b^{*2})^{1/2}$ were determined around the equatorial region in three different positions (with an average of six times for each apricot). TA was determined by titrating 5 mL of apricot aqueous extract with 0.05M NaOH and results were expressed as percentage of malic acid. Akin et al. [14] reported that malic acid was the predominant organic acid in apricot genotypes (*P. armeniaca* L.). The pH values were measured with a pH-meter (Hanna instruments 8417), for six times for each apricot sample. Water activity (a_w) was measured using a Rotronic Hygropalm 9 VCD at 25ºC±0.5ºC. Moisture was determined by AOAC methods [36] as well as ash content determined at 550ºC. The SSC were quantified using a hand digital refractmeter Leica Abbe Mark II (Leica, Buffalo, NY, USA) and expressed as ºBrix.

2.4 Bioactive Compounds Quantification

2.4.1 Extraction and Analysis of Ascorbic Acid

Apricot purees (5 g) were diluted with 200 mL of water, and 5 mL of metaphosphoric acid (30%) in glacial acetic acid was, after, added. The mixture was titrated with 2,6-dichlorophenol-indophenol (DIP). Ascorbic acid was quantified from a calibration curve built with a pure standard (Sigma,

Milan, Italy) and expressed as mg/mL (on a FW - fresh weight basis), analytical validated method published in a previously work (Vinha et al., 2012).

2.4.2 Total Carotenoids Assay

Total carotenoids were extracted according with Akin et al. (2008) with some modifications. Briefly, five grams of sample was extracted with 100 mL of methanol/petroleum ether (1:9, v/v) using a high-speed homogenizer, at 5000 rpm for 30 minutes (Heidolph, Diax 900, Germany) and the homogenized was transferred to a separating funnel. Petroleum ether layer was filtrated through sodium sulphate, transferred to volumetric flask and to a volume of 100 mL with petroleum ether. Finally, total carotenoid content was measured spectrophotometrically (Hitachi UV-2800 spectrophotometer) at 450 nm by using an extinction coefficient of 2500 and results were expressed as β-carotene equivalents (milligrams per 100 g of FW).

2.4.3 Total Antioxidant Capacity and Total Phenolic Assays

These analyses were carried out on the same fruits that had been previously subjected to the physical and chemical determinations. Frozen apricot cv. *Polida* (5 g) from the flesh of three replicate fruits were homogenized in 10 mL of 80% MeOH/H_2O (v/v). The extracts were centrifuged for 10 min, to avoid oxidation and the supernatant was recovered. Total antioxidant capacity was measured using the stable 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radical, previously prepared (methanolic solution containing 0.06 mM DPPH) which has an intense violet color but turns colorless as unpaired electrons are sequestered by antioxidants molecules. Absorbance was measured at 517 nm with a UV spectrophotometer and ascorbate equivalent antioxidant capacity (mM) was extrapolated from a standard curve and compared with BHT standard, a synthetic antioxidant usually used in food nutrition stability.

Total soluble phenolics were determined according to the improved Folin-Ciocalteu method (Toor and Savage, 2006). This assay provides a rapid and useful indication of the antioxidant status of the studied material, and has been widely applied to different food samples. Gallic acid (GA) was used as a standard compound for calibration curve. Total phenol content was calculated as milligrams of GA equivalent (GAE) per 100 grams of fresh fruit weight (mg GAE / 100 g^{-1} FW).

2.4.4 Sugars Analysis Using High-performance Liquid Chromatography (HPLC)

Methods were described by Erosy et al. (2003) and Bernardez et al. (2004) with some modifications. Sugars content were determined from 12 g of fresh apricot fruits in the combined extracts using high-performance liquid chromatography: HPLC (Knauer type model Wellchrom, Germany) with a universal evaporative lights scattering detector. In the mobile phase an acetonitrile solution at 80% (v/v) was used, previously filtered and degasified. The column used was Eurospher 100 NH_2. The detector was taken by a refract meter (RI Detectors K-2301). Working conditions were: flow rate of 1.0 ml/min, ambient temperature and 2 Mpa pressure. The quantity and quality of glucose, fructose, sucrose and sorbitol in all samples were determined. Standard solutions were injected into the column. With those standard solutions, calibration lines for each one of the sugars were made, which were later used for assessing the concentrations corresponding to the different peaks in the chromatograms. Areas of peaks were determined by the Euro chrome 2000 software. Concentrations were expressed as mg/100 g of fresh weight.

2.5 Statistical Analysis

Descriptive statistical analysis was performed using Microsoft Excel. Data of all analysis were expressed as mean ± standard deviation (SD) from three independent samples in duplicate. Analysis of variance (ANOVA) was applied to investigate the experimental results. Statistical differences

with P – values under 0.05 were considered significant and means were compared by 95%. Duncan multiple ranges test, using SPSS program, version 13.0.

3. Results and Discussion

Lately, there is an increased awareness to the need of having fruit with satisfactory state of ripeness and true organoleptic characteristics, as it is important in determining consumer purchase intention. Fruit quality is fundamental for the acceptance of apricot cultivars, especially due to high competition in markets. Fruit quality was defined as the conjunction of physical and chemical characteristics that give good appearance and acceptability to the consumable products. Some researches indicated that quality is a human concept, which includes sensory properties (appearance, texture, taste and aroma), nutritional values, chemical compounds, mechanical properties and functional properties (Abbot, 1999; Ruiz et al., 2005; Akin et al., 2008; Milošević et al., 2010).

All quality parameters of Portuguese apricot fruits *cv. Polida*, an autochthonous Portuguese fruit, collected in three different geographic areas of Portugal were studied. The differences between the present results were significantly different ($p < 0.05$) due to different eco-geographical and environmental conditions (Table 1).

Table 1. Quality Index (QI) from Portuguese apricot fruits cv. *Polida*, collected in different geographic areas from Portugal, North (Macedo de Cavaleiros), Center (Guarda), South (Portimão)

QI Measured in *Polida* apricot	Region	Mean Values
Dry matter (%)***	North	88.10±0.632
	Center	78.57±0.159
	South	75.16±0.416
pH*	North	3.84±0.022
	Center	5.51±0.066
	South	4.90±0.012
Soluble solids (ºBrix)**	North	10.86±0.191
	Center	19.52±0.493
	South	23.00±0.028
Color index (ºh)***	North	55.89±4.227
	Center	56.16±7.764
	South	64.06±5.609
a_W (%)***	North	99.00±0.001
	Center	98.10±0.000
	South	97.70±0.002
Titratable acidity (%)***	North	1.00±0.001
	Center	0.89±0.005
	South	0.88±0.007
Ash (%)**	North	0.73±0.008
	Center	0.74±0.009
	South	0.88±0.023

*Each value in the mean ± standard deviation of nine determinations. Statistical F and Significance (Sig) for each apricot sample related with geographic origin cv. *Polida* were calculated ($^{*}p < 0.005$, $^{**}p < 0.002$, $^{***}p < 0.001$).

Quality indices of Portuguese apricot fruit including water activity (a_W), soluble solids content (SSC), titratable acidity (TA), dry matter, ash and pH recognized the fruits used in this study as ready-to-eat apricots. Dry matter content is one of the most important parameters that show the fruit commercial value. Dry matter content ranged from 75.16% to 88.10% from south to north, respectively. In general, apricot varieties with high dry matter content are preferred for drying processes while the ones with low dry matter content are consumed freshly. Apricot fruit produced in the north is more suitable for drying. Titratable acidity values were lower and pH values were higher in apricot collected in the center, Guarda, where the weather is milder, with temperatures rounding 24ºC±1ºC. According to results, all fruits presented the same relation between these two parameters, but apricot fruit collected in the north of Portugal showed highest titratable acidity (1.0%), which is directly related to the concentration of organic acids present in fruits. Ruiz et al. (2005) reported that TA in the fruit of 37 apricot cultivars grown in Spain varied from 0.90 to 2.44%, which supports the present findings. However, present range values were lower than those obtained by Ruiz et al. (2005) probably due to the different eco-geographic group of cultivars studied. The North of Portugal is characterized by the coldest weather with lower sun exposure. In the beginning of the ripening process as sugar/acid ratio is low, the fruit taste sour. During the ripening process fruit acids are degraded, sugar content increases and the sugar/acid ratio achieves a higher value. Overripe fruits have very low levels of fruit acid and therefore lack its characteristic flavor. Portuguese apricot showed lower values when compared with others apricots varieties studied in Iran (Ghasemnezhad et al., 2010) but with similar concentrations with Turkey's apricot (Akin et al., 2008). Ash contents varied from 0.73% to 0.88% from north and south, respectively ($p < 0.002$). Regarding SSC, values ranged between 10.86±0.191ºBrix (north) and 23.00±0.028ºBrix (south). *Polida* cultivar, excepting "north" had a SSC >12.0ºBrix. Ruiz and Egea (2008) reported that SSC is a very important quality attributes influencing notably the sweetness and taste of fruits in general. In addition, Ishag et al. (2009) reported that SSC content of the fresh apricot cultivars was 11,8% significantly lower than ours. Soluble solids content/tritatable acidity ratio varied from 10.86 (north), 21.93 (center) and 26.14 (south). Fruit maturity controls the quality attributes, such as SSC, TA, firmness, and market life potential. Moreover, the relationship between SSC and TA has an important role in consumers' acceptance of some stone fruits such as apricot, peach, nectarine, and plum cultivars. Color is used as an index of apricot maturity. Hue angle (h^o) is expressed in degrees corresponding to: 0º (red color), 90º (yellow color), 180º (green color) and 270º (blue color). Hue angle was shown to be closely correlated (r=0.94) to total carotenoid content of apricot flesh (Ruiz et al., 2005) and hence this parameter was a suitable choice to monitor changes in carotenoid contents during ripening. The h^o values of apricot samples ranged from 55.89º (north), 56.16º (center) to 64.06º (south). In general, values were closer to 90º, corresponding to yellow color fruits, probably due to carotenoids concentration, naturally pigments synthesized by fruits and plants. According to Burns et al. (2009) there are evidences of geographic variation in fruit hues and results implies that fruit color may be different in temperate regions, namely in the south of Portugal (highest sun exposure and temperatures, 32ºC±1ºC). Normally, at apricot optimal ripeness, and ideal time of harvest, the average temperature of each geographical area studied varies significantly, namely from 20ºC±1ºC (north), 26ºC±1ºC (center) and 32ºC±1ºC (south). This temperature variation and our results are consistent with Burns et al. (2009).

There are many differences in antioxidant components concentration presented in plant tissues and it is relatively difficult to measure each antioxidant component separately. There is great interest in

evaluating changes in antioxidant status through agricultural and climatic factors, such as soil type, sun exposure and climacteric characteristics.

More than 5000 natural compounds with chemopreventive effect, especially phenolics and polyphenolics, have been identified in plants (Gazdik et al., 2008). Their synergic effects are well known, thus the total content of these substances is of interest and can reveal important information about the nutritional values of fruits. Determination of total polyphenols levels were calculated based on gallic acid. The highest value of total polyphenols were observed in apricot fruits collected in the south (7961.70 mg of GAE/100g FW) and the lowest in the north (4938.56 mg of GAE/100g FW) (Table 2). Even the lowest level still represent considerable amounts of polyphenols comparing with others investigations. Ruiz et al. (2005) reported that total phenolic amounts in Spanish apricot varieties ranged from 326 to 1600 mg/100 g of fresh weight, significantly lower than Portuguese apricot fruits. In comparison with previously reports, Portuguese apricot fruits may be considered as a good source of total phenolics content (Gill et al., 2002; Moyer et al., 2002; Ruiz et al., 2005; Ruiz et al., 2008; Sochor et al., 2010).

Table 2. Variations observed in total carotenoids, total phenolics, ascorbic acid content (mg /100g) of Portuguese apricot fruits cv. *Polida* collected in different Portugal geographic regions

Apricot fruits cv. *Polida*	**Carotenoids*****	**Phenolics*****	**Ascorbic acid*****
North	19.64±2.026	4938.65±19.95	30.38±1.358
Center	29.71±5.391	6010.61±0.867	20.47±1.160
South	89.33±4.585	7967.20±19.24	78.47±5.229

*Each value in the mean±standard deviation of triplicate determinations; Statistical F and Significance (Sig) for each apricot sample (related with geographic origin) ($^{***}p < 0.001$)

Total carotenoids were analyzed not only because Portuguese apricot have yellow-orange color but mainly because it was reported that the main carotenoids presented in apricot fruits are β-carotene, β-cryptoxanthin, γ-carotene, lutein and lycopene (Sass-Kiss et al., 2005). In fruits, carotenoids have the important antioxidant function of quenching (deactivating) singlet oxygen, an oxidant formed during photosynthesis. Although important to fruits the relevance of singlet oxygen quenching on human health in less clear. Total carotenoid contents in *Polida* cultivar planted in the south of Portugal presented 89.33 mg /100 g of fresh weight, 4.5 times higher than those planted in the north (19.64 mg /100 g of fresh weight) ($p < 0.001$). Ruiz et al. (2008) have reported that carotenoids content of Spanish apricot varieties ranged from 1.36 to 38.52 mg / 100 g of fresh weights. Is important to note that Portugal does not produce apricots in a large scale when compared with other Mediterranean countries, Spain, Turkey, Italy, therefore this study is interesting for ensuring the nutritional quality from apricot fruit in general and for nutrition benefits for human health.

Ascorbic acid (vitamin C) is known for its antioxidant power and for its presence in almost all fruits. Considering geographic areas as an important factor influencing antioxidant compounds in fruits, is interesting to refer that ascorbic acid contents in samples from the north are higher than those in the center of Portugal (30.38 and 20.47 mg/100g FW, respectively), verifying a positive correlation with titratable acidity observed in apricot fruits collected in north of Portugal (1.00%) which is directly related to the concentration of organic acids present in fruits. Comparing these values with Turkey apricots from Malatya region, our results were similar to those described by Akin et al. (2008) and in agreement with reported data (Thompson and Trenerry, 1995).

Some authors have correlated the presence of phenolics with antioxidant activity in apricots (Voi et al., 1995; Guclu et al., 2006; Sochor et al., 2010) and in other yellow/orange fruits (Kobayashi et al., 2008; Vieira et al., 2009; Rufino et al., 2010; Vinha et al., 2012). Free radical scavenging activity of

the methanolic fruit extracts of cv. *Polida* apricot were tested through DPPH method and results are presented in Fig 1. The peel presence in Portuguese apricot fruit *cv. Polida* was analyzed in this experimental analysis once colored pigments usually are in higher concentration in fruit peels.

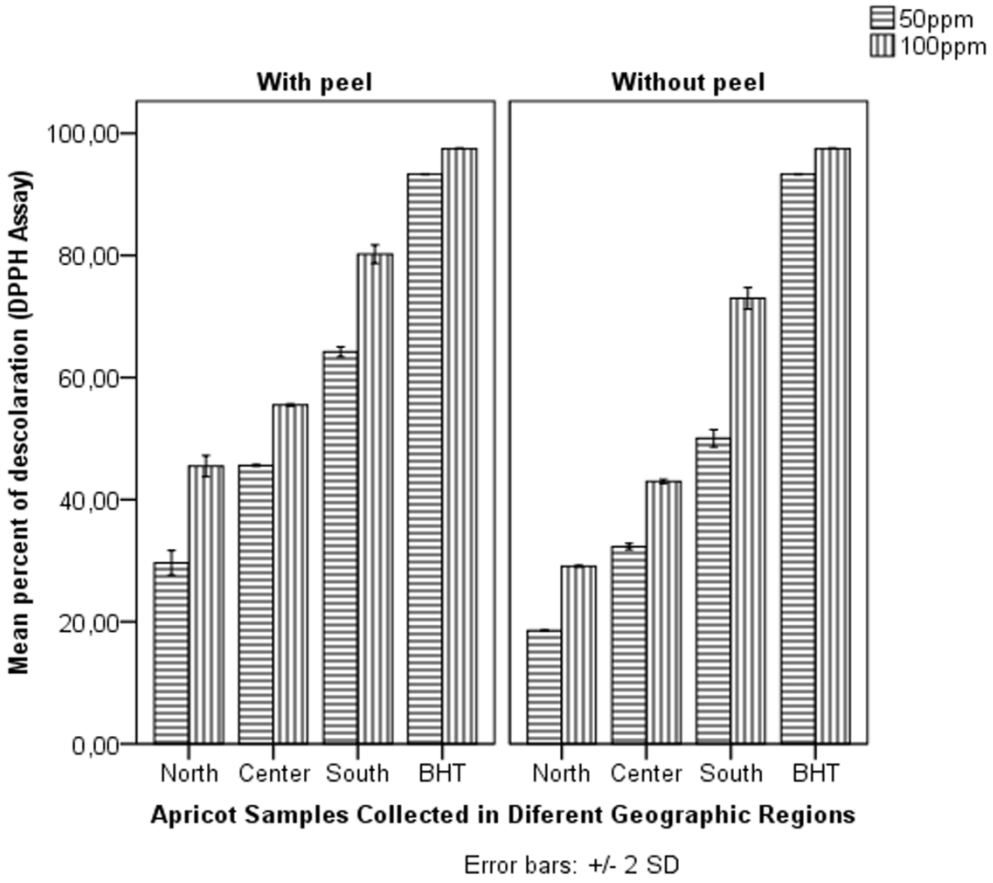

Fig 1. Radical scavenging activity of methanolic fruit extracts, with peel and without peel, by DPPH assay; Fruit methanolic extracts and standard BHT (butylhydroxytoluene, synthetic antioxidant) at 50 and 100 µg/ mL concentrations

The essence of DPPH method is that the antioxidants react with the stable free radical i.e., α,α-diphenyl-β-picryllhydrazyl (deep violet colour) and convert it to α,α-diphenyl-β-picryllhydrazine with discoloration. The degree of discoloration indicates the scavenging potentials of the sample antioxidant. In the present study considerable variations were found in all measured traits among the same apricot cultivar *Polida* collected in different geographic area from Portugal, with and without peel. Fruit skin removal was performed because this fruit is usually eaten raw. The skin of the fruit usually has a higher concentration of antioxidants such as phenolic compounds (flavonoids and anthocianins), since they are responsible for solar radiation protection and the characteristic fruit astringency during its maturation process (Toor and Savage, 2006). Methanol extracts obtained from apricot fruit with peel showed differences in antioxidant activity, namely 45.50% (north), 55.51% (center) and 80.23% (south). Antioxidant activity showed a direct correlation with the phenolic compounds concentration found in apricot fruit samples, collected in three distinct geographic areas different fruit samples studied. Fruit peel removal also affects the antioxidant

activity and our results showed lower values on apricot fruit without peel (29.08%, 42.99%, 72.98%, corresponding to north, center and south, respectively), ie, there was a percentage loss of 16.42% in north samples, 12.51% in center samples and a lowest loss in south apricot fruit samples (7.22%). Overall, results of the present study showed considerable amounts of bioactive compounds (vitamin C, carotenoids and phenolics) presenting a positive correlation with antioxidant activity.

Today, most breeding programs are focused on improvement of apricot flavor through determination of the roles played by acids and sugars in flavor expression. Large differences in sugars content were observed (Table 3).

Table 3. Evaluation of sugar contents of *Polida* cultivar apricot fruits, in mg /100g of fresh weight (FW)

	Sugars Content[a] (mg / 100g)			
Geographic regions	**Sucrose***	**Glucose***	**Fructose***	**Sorbitol***
North	45.16±1.007	6.49±0.539	14.00±1.864	14.39±1.616
Center	24.51±0.929	19.61±0.747	12.52±0.200	23.63±0.863
South	19.45±2.483	17.17±0.989	11.27±1.494	24.77±2.203

[a]Sugar contents expressed as miligrams per 100 g fresh weight. Each value is the mean±standard deviation of three determinations.
*Statistical significance (Sig.) for each apricot sample ($p < 0.05$), *cv. Polida* apricot fruit, by comparison different geographic areas.

During the analyses, particular attention was made to select apricot fruits, regarding maturation index. High sugar levels were attributing to advanced stages of fruit maturity. Sucrose was found as the predominant sugar present in all samples, ranged from 45.16 mg/ 100 g FW to 24.51 mg/ 100g FW in north to south cultivation, respectively. Many fresh fruits contain high levels of sucrose, including nectarines, mangoes, jackfruit, peaches, cantaloupe, apricots and bananas. *Polida* cultivar collected in the north showed higher percentage of sucrose ratio (56.4%) compared with *Polida* fruits collected in center and south (30.5% and 26.8%, respectively). Apricots from center showed the highest glucose content (19.6 g/100 g FW) followed by south samples (17.2 g/100 g FW) and the lowest in north apricot samples (6.49 g/100 g FW). Total sugar content ranged from 72.6 to 80.3 g/100 g FW in fruits collected in the south and in the center of Portugal. Sugar profile and specific sugars ratios have been suggested as an indicator for the determination of juice samples authenticity. An average glucose: fructose ratio of 2.3 ranging from 1.6 to 3.1 has been reported for eleven Italian apricot varieties (Forni et al., 1997). It was determined that *Polida* apricot cultivar contain considerable amounts of sorbitol, also known as glucitol a sugar alcohol that is slowly metabolizes in human body. Sorbitol concentration ranged from 14.4 g/100 g FW (north) and 24.8 g/100 g FW (south). These values are consistent with other published (Guclu et al., 2006; Akin et al., 2008). According to our knowledge, this is the first report showing sugars content in Portuguese apricots. It is important to note that sorbitol is one of alcohol sugars more beneficial with regard to nutrition diet control and dental health, reducing caloric intake and also improving the sweet taste and texture of fruits. However, sorbitol is poorly absorbed in small intestine and, studies have indicated that sorbitol intolerance is not uncommon, inducing abdominal symptoms.

From the agronomic point of view, for optimum production, apricot plants require environmental (temperature and light) conditions typical of temperate and semi-temperate regions, where irrigation water is usually limited. Portugal seems to have edaphic and climacteric conditions to provide good nutritional apricot fruit.

4. Conclusions

Apricots are cultivated worldwide for their high-quality fruit, which is consumed fresh, processed by food industry, or preserved by drying. Human health and nutrition are still one of the most studied and interesting topics directly related with fruits quality. Natural compounds, including those coming from plants and fruits are nowadays under detailed investigation due to their potentially beneficial effects. Results had shown that apricot fruits are good sources of antioxidants. Research studies comprising simultaneous detailed compositional and sensory aspects are necessary to complement and strengthen our understanding on flavor relationships. Information available about antioxidant compounds, namely, phenolic compounds are not complete, restricted to the few Portuguese apricot cultivars.

The present study revealed significant antioxidant activity of the extracts of both apricot samples (with peel and without peel), suggesting that there is a clear relationship between the antioxidant activity and total phenolic content. Although Portugal is a mediterranic country, apricots cultivation and its production in a large-scale is still low but these results shows that production should be increased given nutritional quality of Portuguese fruit. Due to the warmer weather in the south, *Polida* cultivar presents higher antioxidant molecules may be an agricultural production in expancion. The sugar levels, in particular, sorbitol content, Portuguese apricots showed apparently normal levels, with higher values in samples from south, highlighting that particular for patients with diabetes mellitus who should be consuming fruit apricots from the north or central of Portugal. Our results also showed that there is potential for promoting apricot fruit from specific geographical regions because they contained elevated concentrations of antioxidant polyphenolic compounds.

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