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Physico-chemical and antioxidant properties of jujube fruit (Ziziphus jujuba) grown in Albania

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Abstract

Fruits and vegetables are well known to be health supporters, and it is why the interest for their investigation has increased significantly in recent years. Nowadays is getting popular jujube fruit, especially for its high phenolic content and antioxidant activity. The aim of this paper is to study the physico-chemical properties of Albanian jujube fruit, collected at full maturity stage in Tirana, Durres, and Elbasan region, and their total content of polyphenols, flavonoids, anthocyanins and antioxidant activity in terms of ABTS (2,2-azino-bis-(3-ethylbenzothiazoline-6-sulfonic acid), both in peel and pulp extracted with 80% methanol. The results revealed that the physico-chemical parameters ranged for TSS 23-27 ^{o}Brix, total acidity 0.91-1.02 %, pH 4.5-4.7, and ash 0.88-0.92 %. The antioxidant activity ranged 123.80 to 152.81 ascorbic acid equivalent/100 g for the peel and pulp of jujube fruit, the total polyphenolic and flavonoid content ranged 219.57 to 274.20 mg gallic acid equivalent/100 g and 79.05 to 146 mg catechin equivalent/ 100 g, while anthocyanins were not detected. From these findings may be suggested that Albanian jujube varieties may benefiting intake of health promoting natural antioxidants, also this study may serve as basis for selecting potential jujube varieties and further applications in food industry.

Keywords: Ziziphus jujuba; jujube; antioxidant; polyphenols.

1. Introduction

Several studies have shown that fruits and vegetables are good sources of phytochemicals and contain various antioxidants. Their intake has been demonstrated to have a positive effect on reducing risk of diseases caused by oxidative stress [1-3], of certain types of cancers, of cardiovascular diseases and other non-communicable diseases [4-8]. It is why the interest in the investigation of bioactive compounds of fruits and vegetables has increased significantly in recent years [9-10].

One of the fruits that has been known for its medicinal properties [11] and have long been used for human consumption fresh, or processed products [12-13], is jujube fruit. Jujubes (Ziziphus jujuba Mill.) are grown in tropical and subtropical areas of Asia, America and the Mediterranean, with various characteristics and taste. Studies on biological activities and bioactive compositions of jujube grown in China, Vietnam, Italy, India and Turkey have been reported [12-17] showing that nutritional value of jujube comes from its rich content of bioactive nutrients, as well as vitamin C, carbohydrates, minerals etc. Beside the long history of usage of jujube as a fruit and remedy nowadays, phytochemical studies of jujube fruits have shed some light on their anticancer, anti-inflammatory, anti-obesity, immune-stimulating, antioxidant, hepatoprotective, and gastrointestinal protective activities and inhibition of foam cell formation in macrophages [18-21].

In Albania many jujube varieties have found appropriate natural conditions for growing and can be found to local market mainly sold as fresh fruit. In this paper, physico-chemical and antioxidant were investigated during the full maturity stages of jujube fruits grown in Albania. The results may serve filling the gap of literature resources for Albanian jujube, also this study may serve as basis for selecting jujube varieties and suggesting their intake as a good source of health promoting natural antioxidants. Future

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studies may be focused on possible application of jujube for food processing.

2. Material and Methods

2.1. Samples

Jujube (Ziziphus jujuba) fresh fruits were collected in Tirana (T), Durres (D) and Elbasan (E) during 2020. Fruits were manually harvested and picked up randomly from different parts of several trees at full maturity stage, and free from defects. Fruit were placed in plastic bags, labeled, and transferred immediately to the laboratory for further analysis. For sample preparation were manually separated peel, pulp and seed (30 fruits random selected in 3 repetitions), weight measurement was done for each fruit fraction, using the balance with a accuracy of 0.001 g. Fruit tissue from each variety T, D and E were finely chopped and then homogenized using blender and analyzed in triplicate for moisture, TSS, titratable acidity, pH, ash content. For analyzation of total polyphenols (TP), total flavonoids (TF), total anthocyanin (TA) and antioxidant activity in terms of ABTS extracts were prepared in 80% aqueous methanol. For extracts preparation 1 g of homogenized sample was weighted in a test tube, adding 10 ml of 80% aqueous methanol, then the mixture was vortexed for five minutes, kept for 15 minutes at a temperature of 30 °C under ultrasounds action, after were centrifuged at 3500 rpm for 15 min and supernatants were collected, according Velioglu, et al.,(1998) [22], with modification. All measurements were done in triplicate.

2.2. Determination of physico-chemical parameters

Length and width (mm) of fruit were measured using digital caliper gauge (± 0.01 mm), holding the caliper perpendicular to the direction of the dimension was measured. The color was determined by reflection on the two opposite faces of each fruit using a portable colorimeter (model NH310) with the CIE L*, a*, b*. The moisture was measured using MB120 OHAUS moister analyzer at 105 °C, and the result were expresses as g/100 g fresh weight (FW). Total soluble solids were measured using ABBE refractometer in the juice pressed and filtered and the results were expressed in oBrix. Total titratable acidity (TTA) was estimated by titration with 0.1 N NaOH of aqueous extracts and expressed as g citric acid per 100 g FW. The pH measurements were done using pH Meter Lab 855, calibrated prior with standard buffer solution at pH 4 and 7. Ash content was estimated as the difference in mass before and after incinerating at 525 °C in a muffle furnace [23], and the result were expresses as g/100 g FW.

2.3. Determination of total phenolic (TP) content

Total phenolic content of jujube fruits was determined using Folin–Ciocalteu's reagent, according to [24-26] with modification. An aliquot (100 µL) of sample was mixed with Folin-Ciocalteu's reagent (Folin/water; 1:8). After that, 1 mL of sodium carbonate 10% (w/v) was added to the former mixture and kept for 30 min at room temperature in the dark place. The solution was mixed completely and the absorbance level was measured spectrophotometrically versus prepared reagent blank at 765 nm using UV/Vis spectrophotometer Libra S22. A standard curve of the gallic acid (50 – 500 mg/L) was constructed (y = 0.0345x-0.0705), and the results for TP were expressed as mg gallic acid equivalent (GAE)/100 g FW of sample.

2.4. Determination of total flavonoid (TF) content

Total flavonoid content was determined using aluminum chloride colorimetric assay, as described by Abu Bakar, et al., (2009) [27] with modification. An aliquot (500 µL) of sample was added to 10 mL volumetric flask containing 5 mL distilled water, followed by addition of 0.3 mL 5% NaNO2. After 5 min, 0.3 mL of 10% AlCl3 solution was added and allowed to stand for another 6 min before 2.0 mL of 1 M NaOH was added, and the total volume was made up to 10 mL with distilled water. The solution was mixed completely and the absorbance level was measured spectrophotometrically versus prepared reagent blank at 510 nm using UV/Vis spectrophotometer Libra S22. A standard curve of the of catechin was constructed (y=0.0036x+0.0007) and the results for TF were expressed as mg catechin equivalent (CE)/100 g FW.

2.5. Determination of total anthocyanin (TA) content

Anthocyanin's content was measured according to the pH differential method [28]. Absorbance of an aliquot

of 1ml was diluted 1:5 with solution pH 1.0 and pH 4.5. The absorbance of the mixtures was then measured at 520 nm and 700 nm. Calculation of the anthocyanins concentration was based on a cyanidin-3-O-glucoside and results were expressed as mg cyanidin-3-glucoside equivalents (C3G)/100 g FW.

2.6. Evaluation of antioxidant activity, in terms of ABTS assay

Antioxidant activity was determined using ABTS radical scavenging assay [29]. ABTS and potassium persulfate mixture was kept in the dark at room temperature for 16 h before use. For the analysis, the stock solution was diluted in aqueous methanol 80% (v/v) until the absorption at 734 nm reached 0.7± 0.02. An aliquot (25µl) of sample was mixed with 975 µl of ABTS reagent. A standard curve of the of ascorbic acid was constructed (y =-0.1641x + 0.7139) and the results were expressed as mg ascorbic acid equivalents (AAE)/100 g FW.

3. Results and Discussion

3.1 Physico-chemical parameters

Jujube fruit analyzed in this study (figure 1) had dry matter ranged between 64.81 to 82.58 %. From the results in Table 1, it is noted that jujube grown in Albania showed to have little variation among varieties T, D and E. The variety D, showed greater fruit weight (6.68±5.32 g), width (22.12±0.77 mm) and length (27.40±1.04 mm), stone weight (0.70±0.08 g) and flesh/stone ratio (9.54±1.32 %). Whereas variety E, a small fruit showed to have greater values for TSS 27.00±0.02 oBrix, and lower acidity values 0.922±0.022 g citric acid/100 g FW of sample. Variety A, showed intermediate values for fruit size compared to other varieties, but lower values for TSS (23.00±0.01), and greater values for acidity (1.011±0.018). Total ash content jujube fruits showed smaller amount (0.88-0.91%) compared to the investigations conducted by Li et al. (2007) [30]. Albanian jujubes are small (2.82-6.68 g fruit weight), sweet (23-27 oBrix), with an acidity 0.922-10.11 g citric acid/100g FW of sample) and pH 4.5-.47, which make them suitable for food processing as dried products, jam etc., beside the fresh consumption. These values are within the range of other studies [31,34].

The color of the jujube of the E variety is more reddish, with a value of the redness parameter a* was 21.65, whereas variety T has higher brightness as corresponds to a value of L* of 41.01, and blueness parameter b* was 25.31 (table 2).

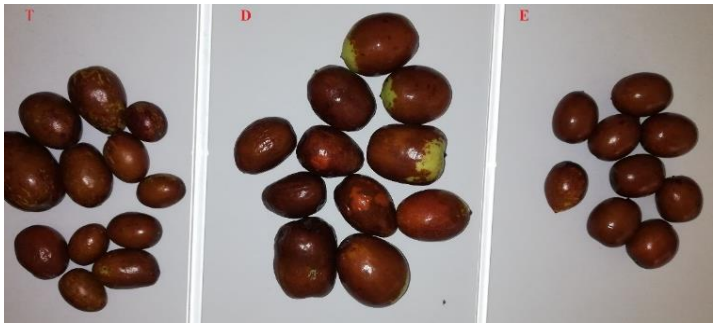

Figure 1. Jujube fruits studied, collected from Tirana (T), Durres (D) and Elbasan (E).

Table 1. Means values (±SD) of jujube fruits characteristics

Sample	Fruit weight (g)	Fruit length (mm)	Fruit width (mm)	Stone weight (g)	Flesh/stone ratio (%)	Soluble solid (^{o}Brix)	Acidity (citric acid/100 g FW)
T	4.25±6.54	24.94±2.21	18.45±2.07	0.59±0.03	7.20±0.71	23.00±0.01	1.011±0.018
D	6.68±5.32	27.40±1.04	22.12±0.77	0.70±0.08	9.54±1.32	25.00±0.018	0.982±0.018
E	2.82±1.62	20.93±0.67	16.65±0.63	0.36±0.02	7.74±0.56	27.00±0.02	0.922±0.022

Table 2. Means values (±SD) of jujube fruits CIE L*, a*, b*

	T	D	E
L*	41.01±1.52	35.02±2.05	37.74±1.95
a*	20.82±0.68	18.54±1.82	21.65±0.33
b*	25.31±2.93	15.27±2.37	19.81±2.46

Jujubes are characterized by turning from a green color when they are immature to a reddish color when they are mature [32]. The color values may be influenced by many factors such as genotype, harvest time, cultural practices, crop load, etc. [33,35].

The content of total phenolic (TP), total flavonoid (TF), total anthocyanins, and antioxidant activity of whole fruit and peel in each sample T, D, and E of jujube are expressed as mean values in mg equivalents/100 g FW of sample.

3.2. Antioxidant properties

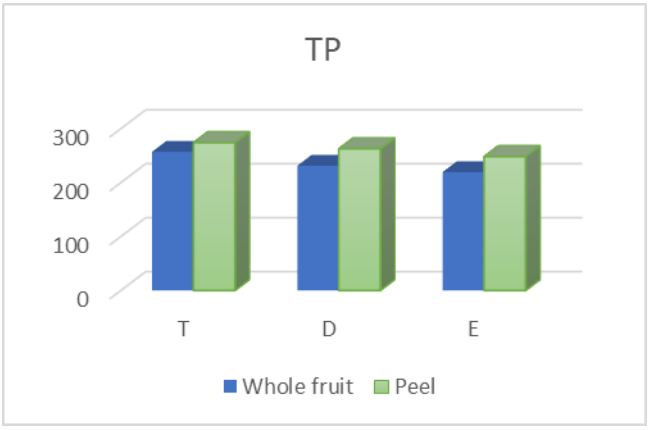

Figure 2. Total polyphenolic content in jujube fruits studied, collected from Tirana (T), Durres (D) and Elbasan (E).

TP ranged for the whole fruit 257.10-219.57 mg GAE/100 g FW, greater amounts were noted in the peel (248.26-274.20), and among varieties sample T had greater amount, following the order T> D> E. From the other studies it is found that TP are greater in the green tissue than for the ripe material. If we consider other physico-chemical parameters evaluated in correlation with TP may be concluded as more reddish get the fruit (sample E) smaller content of TP can be detected. This finding was evident for flavonoid content, which ranged 79.06 to 101 mg CE/100 g FW of the sample, greater amount was detected in peel of the fruit (134.06-146).

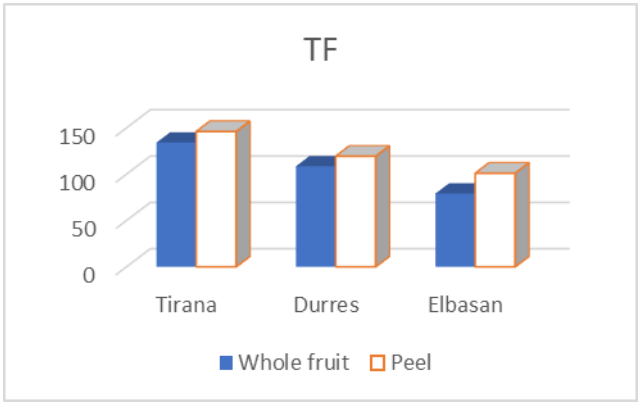

Figure 3. Total flavonoid content in jujube fruits studied, collected from Tirana (T), Durres (D) and Elbasan (E).

After evaluation of total anthocyanins content, it was revealed that weren't detected at all in jujube fruits. The antioxidant activity was evaluated in terms of ABTS radical scavenging activity, and expressed as ascorbic acid equivalent (AAE) in mg/100 g FW of sample. The results ranged for the whole fruit 123.80 to 135.02 and for the peel 133.07 to 152.81 mg AAE/100 g FW.

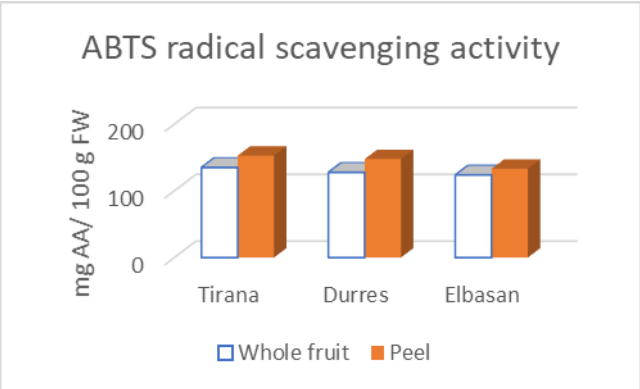

Figure 4. ABTS radical scavenging activity in jujube fruits studied, collected from Tirana (T), Durres (D) and Elbasan (E).

The correlation between TP, TF and antioxidant activity are in figure 5, where is noted that variety T have greater values of phenolic content and a correlation, followed by D and E samples.

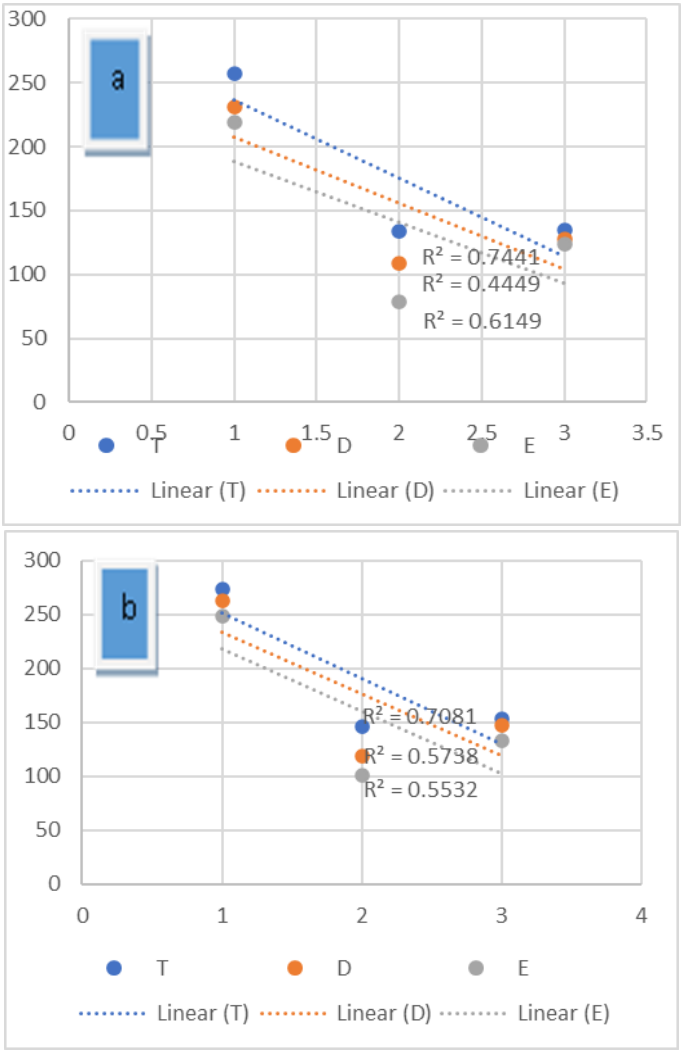

Figure 5. Correlation between TP, TF and antioxidant activity of jujube whole fruit (a) and peel (b) for samples collected in Tirana (T), Durres (D) and Elbasan (E).

Many external factors may influence the change of the phenol content [36]. Although fruits such as strawberry, grapes, black mulberry, grapefruits, cherry [37-41], contain high phenol, jujube is superior as contains more phenol and a high antioxidant activity compared to these fruit species. Previous studies report that phenolic compounds, as potent hydrogen donors, would indicate high ABTS radical scavenging

activity [42-43]. These findings suggested that jujube fruits with high content of phenolic compounds may play an important role in scavenging of free radicals. What can be noted is that not only varietal differences in phenolic and flavonoid contents exist, as well as their distribution in the fruit differ and the peel is the main contributor. Although comparison is difficult, the phenolic contents, flavonoid contents and antioxidant activity of our samples is within the range of the literature [13,30]. The significant differences in phenolic and flavonoid contents between the cultivars are presumably due to a combination of genetic factors (between cultivars) and growth environment factors, thus influencing the biosynthesis of phenolic compounds [44-45]. Furthermore, the evaluation of differences of these parameters that could be found between degrees of maturity, between tissues and between varieties take importance when bioactive value of jujubes is the study interest.

4. Conclusions

This investigation clearly shows the potential value of the Albanian jujube, which have found appropriate natural conditions for growing. Based on the parameters evaluated in this study, Albanian jujubes resulted to be a small fruit with a good source of nutrients. Varietal differences in phenolic, flavonoid contents and antioxidant activity were noted, whereas anthocyanins were not detected. Furthermore, the differences were seen in the distribution of these components in the fruit, where the peel resulted to be the main contributor of these health promoting natural antioxidants. Albanian jujube provides a good source of polyphenols, and it is why may benefiting intake these fruits. In the near future may be suggested that studies to be focused on possible utilization of jujube for food processing as dried products, jam etc., which may give more value to this fruit, playing a role in economy diversification and creation new opportunities for the jujube growers and cultivators. The extraction of jujube natural antioxidants may be also benefiting for cosmetic industry, and medicine, giving thus an adequate attention to its values, and a high rank among other valuable fruits.

5. Acknowledgements

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