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Comparative Study of Fruit Bioactivity of *Spondias*

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Abstract**—** *Brazil has one of the biggest biodiversity of fruits of the world, with great potential to agricultural business. Among the fruits with agronomic potential the Spondias are evidenced by its characteristics of differentiated colors and flavors, besides being considered food rich in phytochemical compounds. This study aimed to evaluate the physicochemical characterization and bioactive compounds of Spondias fruit. The Cajá fruits, umbu-cajá, cajarana and seriguela were acquired in the local market of Campina Grande, PB. The fruits were selected, washed, sanitized and analyzed in the Food Engineering laboratory from the Federal University of Campina Grande. The analyzes performed were: water content, pH, soluble solids, ashes, redactor sugar, luminosity, yellow intensity, red intensity, water activity, anthocyanins, flavonoids and ascorbic acid. The bioactive compounds were extracted from the pulp in natura, using maceration with ethanol in the proportion of 1:10. The determination of the anthocyanins and flavonoids was based on the Francis (1982) method and the ascorbic acid according to Benassi e Antunes (1988). For the water content were found, pH, total soluble solids, ashes, redactor sugar, luminosity, yellow intensity, red intensity, aw, anthocyanins, flavonoids and ascorbic acid from cajá (87.56%, 1.99, 10.5 ºBrix, 0.79%, 4.00%, 55.45, 72.25, 15.78, 0.98, 0.15 mg.100g, 2.86 mg.100g and 36.75 mg.100g), umbu-cajá (90.43%, 1.50, 8.2 ºBrix, 0.28%, 2.46%, 47.35, 48.12, 4.05, 0.99, 0.28 mg.100g, 2.27 mg.100g and 15.83 mg.100g), cajarana (90.54%, 2.10, 8.5 ºBrix, 0.62%, 3.46%, 46.86, 77.54, 10.19, 0.14mg.100g, 3.13 mg.100g e 24.39 mg.100g) and seriguela (80.13%, 2.13, 17ºBrix, 0.63%, 3.75%, 55.77, 64.00, 8.79, 0.98, 3.45 mg.100g, 2.55 mg.100g and 22.67 mg.100g). The varieties of Spondias present reasonable values of soluble solids, pH, flavonoids, and ascorbic acid, characterizing itself as raw material with great potential to its commercial utilization which satisfies the market's current expectations.*

Keywords**— Spondias, characterization, bioactive compounds.**

I. INTRODUCTION

Brazil has the world's greatest biodiversity, making it possible to grow numerous fruit species. Many of them are virtually unknown and, for this reason, are very little exploited commercially. Among the fruits with high agroindustrial power, there are fruits of the *Spondias*, which have unique nutritional and organoleptic properties. The taste and the attractive aroma of these exotic fruits are responsible for the high acceptance, whose relation is related to its sensorial attributes.

According to Tiburski et al. (2011), in the Brazilian Northeast, there are several areas where the climate and soil characteristics are especially favorable for growing tropical fruits. Fruit production and processing in these areas represent important economic activities, not only due to the relevant regional marketing, but also due to the growing domestic and international market.

The growing demand for *Spondias* products confirms the potential socio-economic exploitation of this species. However, in the process of harvesting and marketing the fruit *in natura*, there is a great waste. After harvesting, the fruits are marketed in open fairs, greengrocers, supermarkets and on highways in buckets, sacks or sieves of unhygienic vine, totally ripe, with a softened physical structure caused by mechanical damages usually caused by improper handling, which may cause stains and abrasions and be an entryway of insects and microorganisms (MELO et al. 2010; SOUSA et al. 2016).

According to Huber et al. (2012), the use of natural antioxidants may add the beneficial effects of bioactives to the foods in which they are added, thus protecting the consumer from toxicity of synthetic antioxidants.

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This study aims to evaluate the physical-chemical characterization and bioactive compounds of *Spondias* fruits.

II. MATERIALS AND METHODS

The experiment was conducted at the Food Engineering Laboratory (LEA), belonging to the Academic Unit of Food Engineering of the Federal University of Campina Grande. The fruits were purchased in the local market of Campina Grande, PB, in a ripe maturation stage.

The fruits were selected in laboratory, washed under running water, sanitized in sodium hypochlorite solution at 50 ppm for 15 minutes, and then rinsed under running water to remove excess of solution. At selection, besides the ripening stage, the integrity of the fruits was verified. Pulp extraction was performed using a food multiprocessor, and stored in a freezer at -18ºC.

2.1. Chemical composition and physical-chemical properties

The physical-chemical properties of *Spondias* fruits were evaluated by the standard methods of the Adolfo Lutz Institute: water content was determined using the gravimetric method in a greenhouse at 105 ± 3ºC for 24 h until constant weight; water activity (Wa) was determined using Aqualab 3TE (Decagon) with the sample at room temperature (25°C).

Color was determined by instrumental measurement using the MiniScan HunterLab XE Plus spectrophotometer and the CieLab color system, obtaining the readings of L* (luminosity), a* (transition from green to -a* to red +a*) and b* (transition from blue -b* to yellow +b*).

Ashes (%) were determined by incinerating the sample in muffle at 550°C until the ash became white or slightly gray. Soluble solids (SS) content, expressed as °Brix, was determined by reading the refractive index on an ABBE bench refractometer (model Q767B). Reducing sugar was determined by reducing the copper present in Fehling's solution.

Titratable acidity (TA, % of citric acid) was determined using 1 g of pulp to which 50 ml of distilled water and three drops of 1% alcoholic phenolphthalein indicator were added; then, the sample was titrated with a solution of 0.1 N NaOH previously standardized. The pH was evaluated directly in the pulp using a digital potentiometer

The determination of anthocyanins and flavonoids was based on the method of Francis (1982). The determination of alkaloids followed the methodology described by Sreevidya & Mehrotra (2003) and ascorbic acid according to Benassi and Antunes (1988).

The data of chemical and physical-chemical characteristics of *Spondias* fruits were evaluated by Tukey test at 5% probability.

III. RESULTS AND DISCUSSION

3.1. Physical-chemical characterization of fruits

The mean values for physical-chemical characteristics of *Spondias* sp. fruits are shown in Table 1.

There was a significant difference in all analyzed parameters when the Tukey test was applied, except for water activity. Sousa et al. (2016) observed similar results for the fresh pulp of umbu-cajá at two stages of ripening. The observed water activity is characteristic of fruits with large amounts of water.

Table.1. Mean values of physical-chemical characteristics of the fruits of Spondias sp.

Characteristics evaluated	Fruits evaluated				
	Cajá	Umbu-cajá	Cajarana	Seriguela	Umbu
Water content (%)	87.56b	90.43a	90.54a	80.13c	89.75b
Water activity	0.98a	0.99a	0.98a	0.98a	0.99a
pH	1.99a	1.50c	2.10a	2.13a	2.3b
ºBrix	10.5b	8.5c	8.5c	17.00a	9.2b
Reducing sugar (%)	4.00a	2.46c	3.46b	3.75b	4.5a
Ash (%)	0.79a	0.28c	0.62b	0.63b	0.32c
Luminosity	55.45a	47.35b	46.86b	55.77a	42.54c
Intensity of Red	15.78a	4.05d	10.19b	8.79c	3.05e
Intensity of Yellow	72.25b	48.12c	77.54a	64.00b	28.87d

The analysis of the results obtained for water content showed a unique variation among the varieties analyzed, ranging from 80.13% to 90.54%, indicating that these fruits are highly perishable and favorable to the development of microorganisms. Sousa et al. (2016), evaluating the physical-chemical quality of the fresh pulp of umbu-cajá fruits at two ripening stages, reported a value of water content ranging from 86 to 91.1%.

Spondias pulps are mostly acidic. Regarding pH, the lowest value was reported for the fruit of the umbu-cajá. Silva et al. (2015), evaluating the quality of umbu-cajá fruits from different genotypes, found pH values ranging from 2.60 to 2.93. According to the Normative Instruction No. 01 of January 7, 2000, the minimum pH established for the commercial pulp of cajá is at least 2.2. The values found are close to those obtained by Carvalho et al. (2011), who reported values of 1.7 for cajá, and in disagreement with the values reported by Carvalho et al. (2008), who verified pH values ranging from 2.5 to 3.0 when analyzing the physical and chemical characteristics

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of the umbu-cajá of Bahia, considering its degree of ripening.

Regarding the total soluble solids content (ºBrix), the values were statistically the same, and there was no statistical difference between the fruits of cajá and umbu. The highest result for total soluble solids was found for seriguela, considering that it is a sweet fruit. Sugars make up the bulk of soluble solids and are mainly in the form of glucose, fructose and sucrose. The reducing sugars of the umbu-cajá differed statistically ($p \leq 0.05$) from the other evaluated fruits. The values found are in accordance with the results found by Jesus et al. (2016) for umbu *in natura*.

The average value found for ash ranged from 0.28 to 0.79%; cajá was statistically different. These results corroborate those found by Silva et al. (2017) upon analyzing the quality of the fresh pulp of umbu, presenting an average content of 0.37%.

The results obtained for colorimetric analysis (L*, a* and b*) (Table 1) showed that there was a predominance of yellow, and the pulp of cajá and cajarana fruits showed a more intense color, tending to orange. Similar results were observed by Zielinski et al. (2014) (L* = 55.97 ± 3.20) (a* = 13.81 ± 0.04) (b* = 49.18 ± 0.40).

In Table 2, the chemical data of the fruit pulp of five *Spondias* varieties are presented. The results show that no alkaloids were found in the *in natura* pulp of the fruits analyzed.

The results obtained for anthocyanins in the *in natura* pulp of the fruits analyzed are in accordance with Almeida et al. (2011) who, upon evaluating bioactive compounds and the antioxidant activity of exotic fruits in Northeast Brazil, reported contents of 1.35 mg/100 g for seriguela and 0.46 mg/100 g for umbu.

Table 2. Bioactive compounds in varieties of Spondias

Fruits evaluated	**Characteristics evaluated**			
	Alkaloids (mg/g)	Anthocyanins (mg/100 g)	Flavonoids (mg/100 g)	Ascorbic acid (mg/100 g)
Cajá	-	0.15c	2.86a	36.75a
Umbu-cajá	-	0.28b	2.27b	15.83c
Cajarana	-	0.14c	3.13a	24.39b
Seriguela	-	3.45a	2.55b	22.67b
Umbu	-	0.32b	2.45b	10.55d

The statistical analysis of the data concerning flavonoid values presented in Table 2 showed that the fruit of cajarana obtained the best result, followed by cajá. The other fruits did not differ statistically among themselves. Moreira et al. (2012) observed similar values by studying phytochemical compounds in umbu-cajá genotypes. They reported flavonoid values ranging from 1.95 to 2.37 g in catechin-equivalent/100 g of pulp**.**

In general, the varieties analyzed presented a significant difference in ascorbic acid content, providing a higher value for the fruits of cajá. The values found were higher than those found by Canuto et al. (2010) and Gregoris et al. (2013), who verified values of 0.3 mg/100 g of pulp of cajá, 4.7 mg/100 g of pulp of seriguela and 1.5 mg/100 g of pulp of umbu, respectively.

IV. CONCLUSION

The fruits of the five species of *Spondias* analyzed presented in general a high water content, predominance of yellow coloration and relevant values of bioactive compounds.

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