PHYSIOLOGY AND POSTHARVEST QUALITY OF PALM SPROUTS HARVESTED AT DIFFERENT TIMES

ABSTRACT

Objective: The objective of this work was to study the physiological and postharvest quality characteristics of the palm sprouts harvested at different times.
Experimental design: experiment was carried out in a completely randomized design, consisting of three palm cultivars (Gigante, Clone IPA 20 and Redonda), eight harvest times (3, 6, 9, 12, 15, 18, 21 and 24hours).
Place and duration of the study: experiment was carried out in the experimental area of the Agri - Food Science and Technology Center of the Federal University of Campina Grande, Pombal, Paraíba, from November to January 2016.
Methodology: The experimental design was in a completely randomized design (ICD), in a factorial scheme 8x3x3, having 8 harvest times (3, 6, 9, 12, 15, 18, 21 and 24 hours), 3 cactus cultivars ("Gigante", "Clone IPA 20 "and" Redonda ") and 3 replicates, belonging to the family Opuntia.
Results: Palm sprouts showed high values of titratable acidity, ascorbic acid, chlorophyll and phenolic compounds. Were observed for TA for BRG and BPR, presenting mean values of 0,63 and 0,60 (% malic acid).
Conclusion: 'Gigante' cultivar presented the best results for the evaluated parameters. Palm sprouts showed high values of titratable acidity, ascorbic acid, chlorophyll and phenolic compounds. Harvest schedules influenced the quality of this plant. The best harvest dates were 3, 6 and 9 hours, based on the physiological characteristics evaluated.

Key words: acidity, ascorbic acid, cactus, *Opuntia ficus-indica*.

1. INTRODUCTION

Palm (*Opuntia ficus-indica*) is a widely used crop in the world, with emphasis on the use of bases for the production of cosmetics and pharmaceuticals.
Palm sprout (young cladodes) is seen as a herb of desert and several recipes are made with this herb, both sweety or salty dishes. The palm sprouts are composed of 92% water, 4% total carbohydrates, 4% fiber, 1% protein, minerals such as calcium (1%) and potassium (166 mg 100 g^{-1}), 10 to 15 mg 100 g $^{-1}$ of vitamin C and 30 mg 100 g^{-1} of carotenoids [1]. The sprouts also present, in their constitution, flavonoids such as kaempferol, isoramino and quercetin that are in the form of aglycones,i.e., in the form of molecules without sugars [2] [3].
In the use of the sprout in the composition of the dishes must be taken into account its physiology, considering that, because the plant has a characteristic cactaceae metabolismo. Crassulacean Acid Metabolism (CAM), gives it besides the rusticity and resistance to water stress, characteristics special that directly interfere in the taste as the acidity and its pH, leading to variation throughout the day, besides its high productivity when compared with species C3 and C4. [4]. The knowledge of the time of harvest of the palm shoot would allow to know its quality throughout the day.
The palm sprout is shown as potential alternative in Brazilian Northeastern cuisine, coming to the composition of several sophisticated dishes attracting several consumers. Many species are used for these purposes, among the most common in the northeast region of the country we can highlight the cultivars 'Gigante', 'Clone IPA 20' and 'Redonda'. The objective of this study was to evaluate the post-harvest physiological quality of palm sprout (Gigante, Clone IPA20 and Redonda) harvested at different times.

2. METHODOLOGY

2.1 Plant Material

Sprouts of "Gigante" (BPG), "Clone IPA 20" (BPI) and "Redonda" (BPR) cultivars from the experimental area, belonging to the Center of Science and Technology of the UFCG, Câmpus

Pombal, located in Pombal-PB, Brazil (Latitude: 06º 46' 13" S and Longitude: 37º 48' 06" W), classified as BSh (hot semi-arid climate) [5].

2.2 Methodology

Sprouts were harvested 10-15 cm long, every 3 hours, starting at 3 o'clock in the morning and ending at 24 o'clock the next day, totaling 8 harvests with three replicates each. After the harvest the shoots were transported to the Food Analysis Laboratory where they were washed and dried, and the following analyzes were carried out.

2.3 Analytical Determinations

Soluble solids (SS): The cell juice was extracted from 100 g of palm sprouts, crushed with the aid of a cell juice extractor. The soluble solids content was read in a digital refractometer with automatic temperature compensation.

H^+ ion content: Hydrogen ionic potential was determined in the juice according to the number of repetitions using a digital bench potentiometer to estimate the H + ion content.

Titratable Acidity (TA): The acidity was measured in 5 mL of juice, homogenized in 45 mL of distilled water. The solution containing the sample was titrated with 0,1 N NaOH until reaching the turning point of the phenolphthalein indicator, confirmed by the indicator pH range of 8,2 [6].

Ascorbic Acid (AA): Was estimated by titration using 5 mL of palm juice juice plus 45 mL of 0,5% oxalic acid and titrated with Tillmans solution until reaching pink staining according to the method (365/IV) [7].

Pigments: Chlorophyll contents were estimated, with adaptations [8]. The chlorophyll and carotenoid contents were defined from the equations:
Chlorophyll a (mg $100g^{-1}$ Fresh mass) = $12.25\ A_{663.2} - 02.79\ A_{646.8}$
Chlorophyll b (mg $100g^{-1}$ fresh weight) = $21.5\ A_{646.8} - 05.1\ A^{663.2}$
Total Chlorophyll (mg $100g^{-1}$ Fresh Mass) = $07.15\ A_{663.2} + 18.71\ A^{646.8}$
Carotenoids (mg $100g^{-1}$ Fresh Pasta) = $(1000\ A^{470} - 1.82\ C_a - 85.02\ C_b)/198$

Total sugars: About 0.5 g of palm sprout was macerated in 10 mL of distilled water and the volume was made up to 50 mL; an aliquot of 400 mL of the diluted extract plus 1000 mL of distilled water and 1000 mL of Antrone were used for reaction in boiling water for 10 minutes followed by cooling in ice water to room temperature. The determination of soluble sugars were performed at 620nm, in SP-1105 spectrum [9].

Phenolic compounds: Phenolic compounds were estimated from the method of Folin and Ciocalteau with modifications [10]. An aliquot of 500 µL of the extract was transferred to a test tube and mixed with 1625 µL of water and 125 µL of the Folin-Ciocalteau reagent. The mixture was allowed to stand for 5 minutes, and then we added 250 µl of 20% sodium carbonate, followed by stirring and standing in a water bath at 40 °C for 30 minutes. The results were shown as mg of gallic acid 100 g^{-1} FM.

2.4 Statistical analysis

The experimental design was in a completely randomized design (ICD), in a factorial scheme 8x3x3, having 8 harvest times (3, 6, 9, 12, 15, 18, 21 and 24 hours), 3 cultivars ("Gigante", "Clone IPA 20 "and" Redonda ") and 3 replicates.
The results were submitted to analysis of variance (ANOVA), using AgroEstat software, version 2014 [11]. The means were compared by the Tukey test with 95% probability ($P \leq 0.05$). When significant differences were found, regression analysis was performed.

3. RESULTS AND DISCUSSION

3.1 Soluble solids (SS)

No statistical differences ($P > 0.05$) were observed in the soluble solids content in the palm sprouts (Fig 1).

SS values varied from 4.4 to 7.5% for BPG, from 3.8 to 5.8% for BPI and from 3.8 to 5.2 for BPR. These values can be explained as response to plant metabolism to the environment and harvest time. Several authors confirm the variation of SS content in the palm sprouts, finding values around 2 to 8% [12] [13]. These variations found in the SS content of shoots can be linked to the energy consumption of the plant during the photosynthetic process [14].

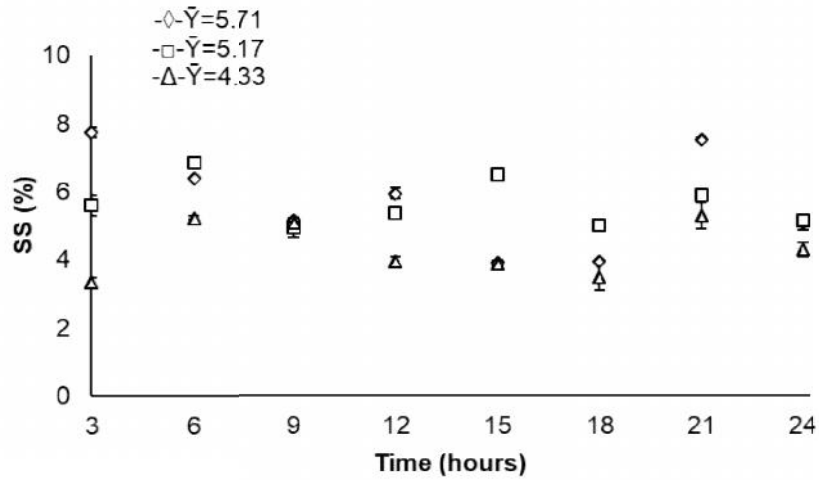

Fig. 1. Soluble solids in palm sprouts 'Gigante' (-◊-), 'Clone IPA 20' (-□-) and 'Redonda' (-Δ-). The vertical bar represents the standard deviation of the mean.

3.2 Concentration of H^+

It was possible to establish a functional relationship between the H^+ ion content in BPG and BPI (Fig. 2). With a progressive decrease until 15 hours. No statistical differences (P> 0.05) were observed for the H^+ ion content for BPR, presenting an average value of 10.22.

These values are consistent with the synthesis and consumption of acids throughout the day, as can be seen in Fig. 3, where the highest and lowest TA peaks are at the same harvest times. [15] found values ranging from 25.8 to 209.8 µM for 'Gigante' cultivar and from 19.61 to 95.86 µM in the 'Redonda' cultivar, working with shoots at different stages of development, harvested around 9 am.

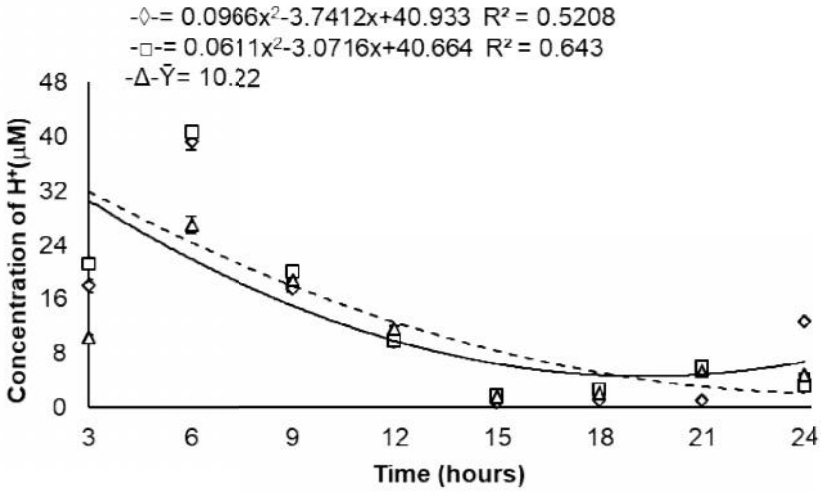

Fig. 2. Concentration of H^+ in palm sprouts 'Gigante' (-◊-), 'Clone IPA 20' (-□-) and 'Redonda' (-Δ-). The vertical bar represents the standard deviation of the mean.

3.3 Titratable Acidity (TA)

It was possible to establish a functional relationship between the titratable acidity content only in the BPI (Fig 3). However, all cultivars showed a progressive decrease in titratable acidity values up to the 6 harvest (18 hours). No statistical differences (P> 0.05) were observed for TA for

BRG and BPR, presenting mean values of 0.63 and 0.60 (% malic acid). [16] which studied 10 cultivars of palm, found acid contents varying from 0.28 to 0.76% in shoots with 30 days of age and 20 cm of length, collected at 6 hours.
The acid behavior described in this study can be attributed to plant age and management, as well as the acidic metabolism of this cactus. Found that the acid content in the palm (*Opuntia fícus-indica*) in natura varies according to the size of the cladodes, management conditions, stage of development [17]. The variation of the acidity during the day is a typical characteristic of CAM plants, that must be taken into account to determine the time of harvest [18].

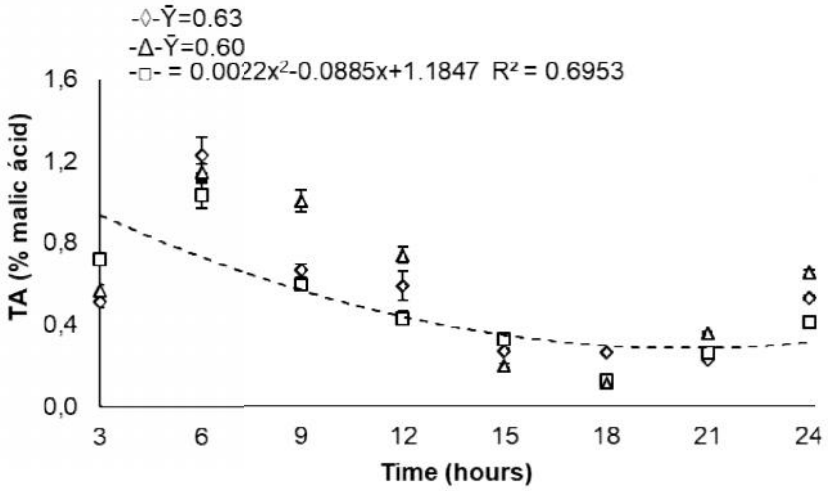

Fig. 3. Titratable Acidity in palm sprouts 'Gigante' (-◊-), 'Clone IPA 20' (-□-) and 'Redonda' (-Δ-). The vertical bar represents the standard deviation of the mean.

3.4 Ascorbic Acid (AA)

There was a significant effect (P> 0.05) for ascorbic acid in BPG and BPR, with the best fit for the quadratic equation, with values ranging from 0.9 to 12.5 and from 2.5 to 9.1 mg 100^{-1} fresh mass, for BPG and BPR, respectively (Fig 4). For BPI, no significant effect (P> 0.05) was observed, with a mean value of 3 mg 100^{-1}g of fresh mass.
The variations of the ascorbic acid levels found during the harvest times can be attributed to the consumption of this antioxidant in synthesis of biochemical reactions [15]. Was observed vitamin C content in 'Redonda' and 'Gigante' palm sprouts, ranging from 10 to 18.1 mg and $100g^{-1}$ mg. found vitamin C values in a 10mg $100g^{-1}$ palm sprouts [1].

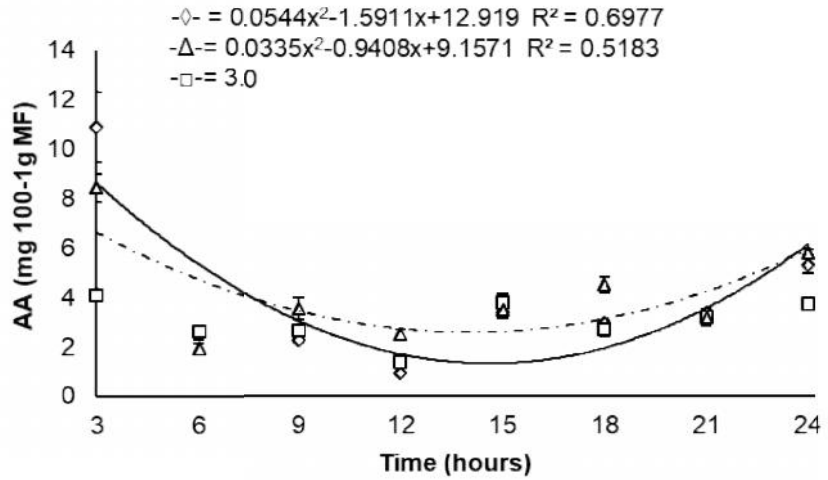

Fig. 4. Ascorbic Acid in palm sprouts 'Gigante' (-◊-), 'Clone IPA 20' (-□-) and 'Redonda' (-Δ-). The vertical bar represents the standard deviation of the mean.

3.5 Pigments

No significant effects were observed (P>0.05) for chlorophyll total (CT) content in BPG, BPI and BPR, with mean values of 1320.8, 1296.9 and 1333.3 μg 100^{-1}g fresh mass (Fig 5).

It was observed a significant effect (P> 0.05) for the carotenoid content in BPG, ranging from 721.4 to 1754.16 μg 100^{-1}g in fresh mass, in the palm sprouts of varieties IPA 20 and Round was not observed with a mean value of 208.7 and 211.1 μg 100^{-1}g of fresh mass for BPI and BPR, respectively (Fig 6).

The pigments assist in the photosynthetic process besides presenting anticarcinogenic and antioxidant action. The high values of chlorophyll found in this study prove the beneficial action of this desert vegetable in the human diet. [15], [18], found values consistent with this work evaluating the quality of young and fresh palm sprouts.

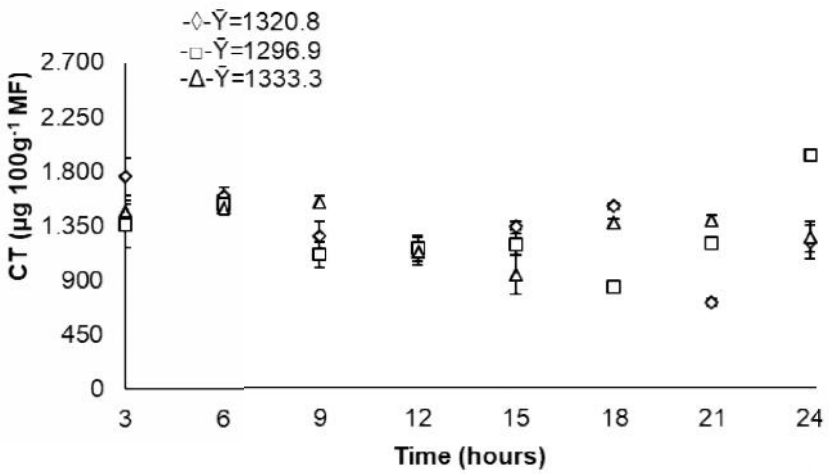

Fig. 5. Chlorophyll total in palm sprouts 'Gigante' (-◊-), 'Clone IPA 20' (-□-) and 'Redonda' (-Δ-). The vertical bar represents the standard deviation of the mean.

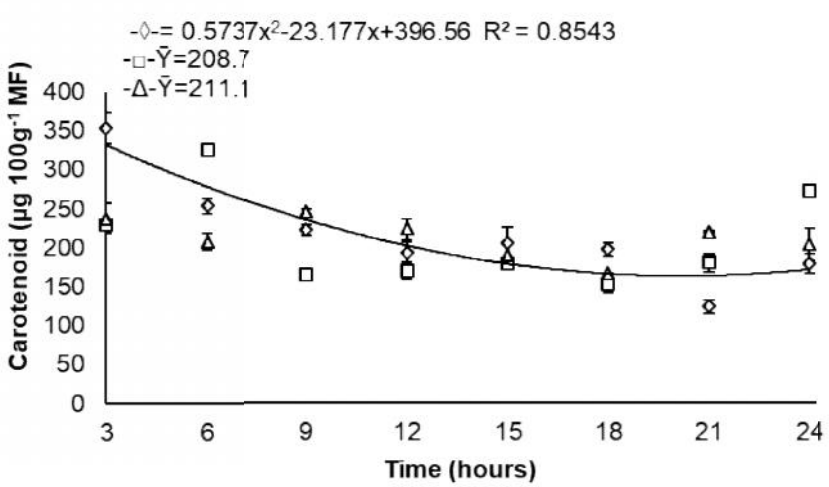

Fig. 6. Carotenoid total in palm sprouts 'Gigante' (-◊-), 'Clone IPA 20' (-□-) and 'Redonda' (-Δ-). The vertical bar represents the standard deviation of the mean.

3.6 Soluble sugar

No significant effects (P>0.05) were observed for the soluble sugars content in BPG, BPI and BPR, with mean values of 1.29, 1.34 and 0.86 g 100^{-1} g fresh mass, respectively (Fig 7).
The values of soluble sugars found in this study, presented the highest levels (12 hours), this behavior can be attributed to a physiological response as a function of the time, since the 4th harvest corresponds to the highest temperature schedule of the day. Corroborating with this work [19] found total sugar values for 'Giant' palm sprouts with 1.28 and 2.16 mg $100g^{-1}$ and 1.53 and 2.90 mg $100g^{-1}$ in 'Round' palm.

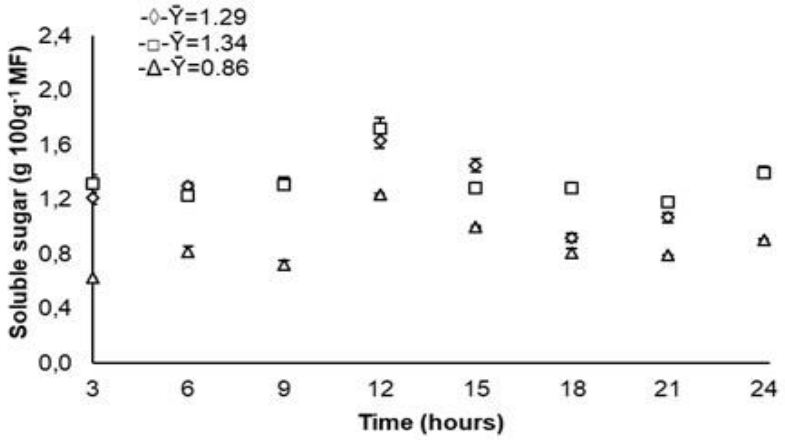

Fig. 7. Soluble sugar in palm sprouts 'Gigante' (-◊-), 'Clone IPA 20' (-□-) and 'Redonda' (-Δ-). The vertical bar represents the standard deviation of the mean.

3.7 Phenolic compounds (PC)

No significant effects (P> 0.05) were observed for the content of phenolic compounds in BPG, BPI and BPR, with mean values of 139.8, 142.8 and 101.4 mg of gallic acid 100^{-1}g of fresh mass (Fig 8).
The phenolic compounds are reported to be stable during processing under high temperature conditions so that for increased phenolic compounds increased levels may occur due to the breakdown of cellular constituents [20]. This variation of phenolic compounds can be attributed to enzymatic reactions of synthesis and degradation during the acid metabolism of this desert vegetable.
Found levels of 910 mg 100 g^{-1} in crisp lettuce and 900 mg 100 g^{-1} in arugula when grown under conventional production system [21]. This distinction of PC values can be attributed to climate and species differences when compared to palm sprouts.

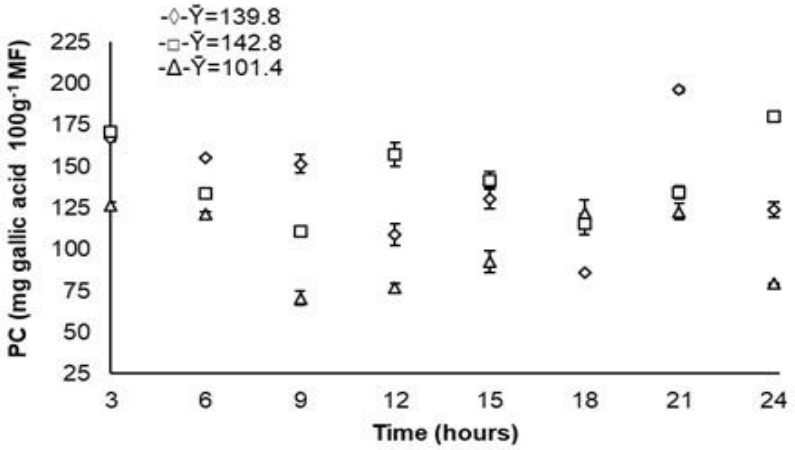

Fig. 8. Phenolic compounds in palm sprouts 'Gigante' (-◊-), 'Clone IPA 20' (-□-) and 'Redonda' (-Δ-). The vertical bar represents the standard deviation of the mean.

4. CONCLUSION

'Gigante' cultivar presented the best results for the evaluated parameters. Palm sprouts showed high values of titratable acidity, ascorbic acid, chlorophyll and phenolic compounds. Harvest schedules influenced the quality of this plant. The best harvest dates were 3, 6 and 9 hours, based on the physiological characteristics evaluated.

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