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Original Research Article

Use of Calcium Chloride in post-harvest conservation in atmosphere modified through refrigeration, respiratory rate and physicochemical characteristics of Umbu (Spondias tuberosa Arr. Cam.)

JC de Sales Silva[1*], CLC de Lima[2], LC Caetano[3], A Atroshenko[4]

[1]State University of Alagoas, Animal Science Department, Brazil
[2]Federal University of Alagoas, Center for Agrarian Sciences, Brazil
[3]Federal University of Alagoas, Institute of Chemistry and Biotechnology, Brazil
[4]London School of Economics and Political Science, United Kingdom

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The umbu (Spondias tuberosa Arr. Cam.), Tropical plant native to the Northeast of Brazil, has great potential as exotic fruit in both internal and external markets, which motivated this study undertaken with fruits purchased in the market Santana do Ipanema, picked one day before analysis in a physiologically ripe condition, which were then immersed for one hour in calcium chloride solution at concentrations of T1 (0% CaCl 2), T2 (3% CaCl2), T3 (6% CaCl 2), T4 (9% CaCl2) and T5 (12% CaCl2). After soaking, the fruits were subjected to respiration, were weighed before and after respiration, immediately after which the fruits were placed in a plastic tray and under a PVC film and stored for seven days under refrigeration (15 ° C + 1 ° C and 52%). After seven days, the respiration process was repeated. The following characteristics of the fruits were evaluated: respiratory activity, humidity, Total Soluble Solids TSS, Total Titratable Acidity TTA, TSS / TTA, pH. Ca did not affect the respiratory activity of umbu, but influenced significantly the storage period. The characterization analysis obtained the following results: sample mean humidity of the fruits 88.62%; sample mean TSS 10.58 ° Brix with a significant difference between the means for T1 (a), T2 (a) and T3 (b), T4 (b) and T5 (b); sample mean TAT of 0.30 g citric acid / 100 g of pulp; sample mean TSS / TTA of 2.34 and the mean pH of the fruits under all treatments of 2.75.

Key words: Brazil, Umbu, Fruits and Respiration.

INTRODUCTION

Despite Brazil being the second largest producer of fruits globally, with millions of tons exported every year, it is estimated that only 0.8% of the total exports are represented by native tropical fruits, which remain economically underexplored (IBGE, 1996). World production of tropical fruits continues to grow considerably, with new markets being conquered every day, a phenomenon attributed by Schottler and Hamatschek (1994) to the appearance and the exotic taste of the fruits. At 2001, the IBGE estimated the production of umbu in the northeastern region, excluding Maranhao and Alagoas, at approximately 9919 tons.

The umbu (Spondias tuberosa Arr. Cam.), a species of trees of the Anacardiaceae family, is a tropical fruit plant from the semi-arid plains of northeastern Brazil; the plant found good conditions for growth in the regions of Agreste (Piauí), Cariris (Paraíba), Caatinga (Pernambuco, Alagoas and Bahia) and especially in the region of Cariris Velhas. It vegetates from Piauí in the south to the north of Minas Gerais. In colonial Brazil, it was called ambu, imbu, ombu, all variations of the Tupi-Guarani word "y-mb-u," which means "the-tree-that-gives-a-drink". Due to the importance of its roots, Euclid da Cunha called the plant "the sacred tree of the Wild" (Ritzinger et al. 2001).

Ritzinger et al. (2001), affirms that umbu has significant potential both in domestic and foreign markets of exotic fruits, especially if marketed in the forms of the pulp, in soft drinks, as juice or as umbuzada – umbu cooked with water and subsequently mixed with milk and sugar into a paste that can be made into an ice cream. The fruit has a bittersweet taste and, when ripe, the pulp is almost liquid. The fruit can be manufactured into bottled juices, sweets, jams, wine, vinegar, acetone, concentrate for ice cream, pulp for juice, prune (if

Corresponding Author: josecrigot@hotmail.com

dried under the sun). Moreover, fresh fruit also serves as fodder for animals.

In this study, we investigated the use of calcium in the post-harvest conservation of umbu (Spondias tuberosa Arr. Cam.) Using Calcium Chloride in four concentrations under atmosphere modified using a plastic tray and PVC film to maintain a temperature of 15 ° C ± 1 ° C and 52% humidity, the following variables were evaluated: respiration of the fruits before and after storage, physical and chemical characteristics of the fruits.

2. Materials and Methods

This experiment was conducted in the Food Technology Laboratory of the Center of Agricultural Sciences, Federal University of Alagoas, Rio Largo municipality in Alagoas in April 2007. The study was undertaken on physiologically mature fruits collected in the semi-arid region of the municipality of Santana do Ipanema, Alagoas.

The experiment consisted of 05 treatments of the umbu fruits immersed for one hour in an aqueous solution of calcium chloride CaCl2 in the following concentrations: 3%, 6%, 9% and 12%. For seven days, the fruits were placed in plastic trays and covered with PVC film. A temperature of 15 ° C + 1 ° C and 52% humidity were maintained throughout the experiment.

2.1 Variable Review

2.1.1 Determinations of The Respiration Curve of The Umbu Fruit

The measurements of the respiration rate of the umbu fruits were undertaken twice • at two and nine days post-harvest, respectively, before and after storage under refrigeration at 15 ° C ± 1 ° C and 52% RH in 4 different solutions of CaCl2. The measurement of the respiration rate of the fruits was made indirectly by measuring the CO2 content in the fruits under 05 treatments, using the methodology adapted from BLEINROTH et al (1976) and cited by OLIVEIRA (1996).

A compressor delivered air to the respiration chambers. Air, driven by the aquarium compressor passed through the first transparent glass flask, sealed with 250 ml inside (1st bottle) that only had one input and one output. This flask contained 100 ml of a concentrated solution of (Ba(OH)2), through which the inlet air bubbled in and out. To ensure a greater degree of confidence in the results of the assessment of the respiration rate, 3 Erlenmeyer flasks were used in a sequence, ensuring that the air that reaches the respiratory rate measurement chamber was CO2-free. This way, the atmospheric air containing approximately 0.3% CO2 was trapped in the solution, in accordance with equation 1 below:

Equation 1: $Ba(OH)_2 + CO_2 = CO_3 + H_2O$ Ba

The clear glass respiratory rate measurement chamber of 1000 ml capacity was securely sealed with only one input and one output. 5 fruits were placed in this chamber, each after different treatment in order to take the measurements of the respiration rate. Downstream, the air reached the final flask, also securely sealed and containing 100 ml of 0.1N KOH solution, where the bubbling air was released into the atmosphere.

This degree of care assured that the CO2 that came into contact with the KOH solution originated from the respiration of the umbu fruits and was retained in the form of (K2CO3) in 0.1N KOH solution according to Equation 2:

Equation 2: $2KOH + K_2CO_3 + H_2O = CO_2 + KOH$

At each respiration rate measurement, an aliquot of 10ml of the KOH solution was taken, which then underwent titration using a standardized 0.1N HCl solution with phenolphthalein used as an indicator. By analyzing differences in the amount of 0.1N HCl solution required to titrate the stock solution and to titrate the reacted solution, the volume of CO2 was calculated according to the equation 3.

Equation 3: $KOH + HCl = KCl + H_2O$

$$TCO2 = \frac{2.2.\ (B-T)\ .V1}{P.T.V2}$$

Where,

TCO2 = respiration rate in g CO2 / kg of fruit hour;
B = volume in ml of standardized HCl required for titration of the standard potassium hydroxide before the absorption of CO2;
T = volume in ml of standardized HCl required for titration of the standard potassium hydroxide after the absorption of CO2 from respiration;
V1 = volume of KOH used to absorb CO_2 (ml);
V2 = volume of potassium hydroxide used for titration (ml);
P = fruit weight (kg);
T = time of metabolic reactions (hours);

2.2 = Considered to be equivalent to CO_2 = 44/2 multiplied by the concentration of 0.1N hydrochloric acid.

2.1.2 Physical and Chemical Characteristics of Post-Harvest Umbu

The chemical characterization of each treatment was performed using every fruit under treatment, whereby the fruits were pulped and mashed in a household blender. The characteristics of the fruits that were measured after storage and cooling were: pH using a Digital Digimed pH meter; the titratable acidity (TA) measured according to the analytical standards of the Institution Adolfo Lutz (1985) and the results were expressed in grams of citric acid / 100 g of pulp; total soluble solids (TSS) determined through refractometry, with the results in ° Brix and the relationship between TSS and TTA.

The physical characteristic of the fruits that was studied was their humidity, expressed in %, as measured by digital semi-analytical scales BEL, obtained after drying the fruit in an oven at 65 ° C for 24 hours. The measurement of the respiration rate of the fruits before and after storage under refrigeration was conducted in a split plot, since the physical and chemical characterization was performed in a randomized experiment. Statistical analyses were performed by the 7.4 beta (2007) version of Assistant computer program for the Windows operating system. The Tukey's test of mean comparison at a 5% significance level was undertaken to analyze the mean measurements.

Table 1: Analysis of the umbu respiration rate (Spondias tuberosa Arr. Cam.), 2007

Source of variation	Degrees of freedom	Sum of squares	Mean of sum squares	F-statistic
Treatment-a(Ta)	4	1.66565	0.41641	2.5663 ns
Residual-a	20	3.24528	0.16226	
Parcelas	24	4.91093		
Treatment-b(Tb)	1	38.17632	38.17632	246.3052 **
Interaction effect (Ta*Tb)	4	3.01131	0.75283	4.8571 **
Residual-b	20	3.09992	0.15500	
Total	49	49.19848		

** Significant at a 1% significance level (p<.01)

Table 2: Analysis of the pH measurements

S.V.	D.F.	S.S.	M.S.S.	F-Stat
Treatment	4	0,02640	0,00660	2,3571 si
Residual	20	0,05600	0,00280	
Total	24	0,08240		

si – statistically insignificant (p >= 0,05)

Table 3: Analysis of the Total Titratable Acidity – TTA

S.V.	D.F.	S.S.	M.S.S.	F-Stat
Treatment	4	0,00494	0,00123	0,8327 si
Residual	20	0,02964	0,00148	
Total	24	0,03458		

si - statistically insignificant (p >= 0,05)

Table 4: Analysis of Total Soluble Solids TSS found in umbu

S.V.	D.F.	S.S.	M.S.S.	F-Stat
Treatment	4	13,27360	3,31840	25,1394 **
Residual	20	2,64000	0,13200	
Total	24	15,91360		

** statistically significant at a 1% significance level (p< 0,01)

Table 5: Analysis of TSS / TTA

S.V.	D.F.	S.S.	M.S.S.	F-Stat
Treatment	4	0,47200	0,11800	1,2115 si
Residual	20	1,94800	0,09740	
Total	24	2,42000		

si statistically insignificant (p >= 0,05)

Table 6: Analysis of Humidity in the Fruits

S.V.	D.F.	S.S.	M.S.S.	F-Stat
Treatment	4	22,16986	5,54247	0,5974 si
Residual	20	185,53776	9,27689	
Total	24	207,70762		

si – statistically insignificant (p >= 0,05)

3. Results and Discussion

3.1 Determination of The Umbu Fruit Breathing Curve

As the data contained in Table 01 demonstrates, Ca did not affect the respiratory activity of umbu in the concentrations used during the study period. As for the storage period, the result of the Tukey's test at a 5% significance level support the hypothesis of statistically significant differences.

There were statistically significant differences between treatments in the periods evaluated, with the respiratory activity greater in the initial measurement. This phenomenon can probably be attributed to the role of Ca2 + in maintaining the cell membrane integrity of the fruit. According to Chitarra (1990), the effect of calcium on the cell membrane or on the fruit is manifested in the final aging, when the substrates may have been exhausted (carbohydrates, organic acids).

3.2 Physical And Chemical Characteristics OF Umbu Post-Storage

The characterization analysis produced the following results:

3.2.1 **pH measurement**

The mean pH of the sample was 2.75 with a statistically insignificant difference between the means of treatments at a 5% significance level. In his study of the umbu-hog plum (Spondias sp), Noronha (2000) found a mean pH between 3.15 and 3.27, which is slightly less acidic than was found in this study.

Folegatti (2003) found a mean pH of 2.82 in umbu pulp, which indicates that one the umbu of the semi-arid Alagoas has a more acidic pulp than was studied by these authors.

3.2.2 Measurement of Total Titratable Acidity (TTA)

The mean TTA was 0.30 g citric acid / 100 g pulp, indicating that the calcium did not influence the treatments in terms of reducing the acidity of the fruit. Noronha (2000) found mean values between 18.04 and 16.83 mmol (H +) / 100.g in umbu-cajá (Spondias sp). Folegatti (2003) found a concentration of 1.56% citric acid in the umbu fruit, a result similar to the one found in this study.

3.2.3 Measurement of Total Soluble Solids (TSS)

The mean measurement of the Total Soluble Solids TSS found in the sample was 10.58 ° Brix. The result indicated a statistically significant difference between the averages of different treatments, with an average of 9.48 ° Brix for the T1 (a) treatment, 9.96 ° Brix for the T2 (a) treatment, 11.00 ° Brix for the T3 (b), 11.16 ° Brix for the T4 (b) treatment and 11.32 ° Brix for the T5 (b) treatment.

Noronha (2000) found means of 11.04 and 12.88% in his study, which is similar to the mean measurements taken for T3 (b) with 11.00 ° Brix and T4 medium (b) with a mean 11.16 ° Brix. In another study of the umbu pulp, Folegatti (2003) found a mean level of 10.0 ° Brix.

3.2.4 TSS / TTA

The mean measurement of TSS / TTA obtained was 2.34, without a statistically significant difference between the means.

3.2.5 Fruit Humidity

The sample mean humidity of the fruits was 88.62%, with no significant difference between the means of different treatments. Noronha (2000), found mean levels of humidity of 86.02 and 86.62%, which is similar to the results of this study.

4. Conclusion

The Ca+2 did not influence the respiratory activity of the umbu, but had a significant influence on the storage period.
The characteristics analysis gave the following results: mean humidity of the fruits of 88, 62%; mean SST 10,58°Brix, with a significant difference between the means of treatments T1 (a), T2 (a) e T3 (b), T4 (b) e T5 (b); mean ATT of 0.30 g of citric acid /100g of pulp; mean SST/ATT 2.34 and mean pH for all treatments of 2.75.

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