

Postharvest changes and respiratory pattern of bacuri fruit (*Platonia insignis* Mart.) at different maturity stages during ambient storage.

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ABSTRACT

Bacuri (*Platonia insignis*, Mart.) is one of the most important among Amazonian fruits. However, little is known about its postharvest physiology, such as maturity stages, changes during ambient storage, and respiratory pattern. Fruits were harvested at three maturity stages based on epicarp colour: dark green, light green, and turning (50% yellow), in order to determine colour modification and respiratory pattern during ambient storage (25.2 °C, 75.1 % RH). Fruit of all maturity stages showed, after three days of harvest, a non-climacteric respiratory pattern, with turning fruit presenting the highest CO₂ production rate until the fourth storage day (177.63 mg.CO₂.kg⁻¹.h⁻¹). Yellowing increased throughout storage as related to lightness, chromaticity, and hue angle reductions. Turning fruit can be stored at ambient conditions for up to 10 days without any loss in marketability.

KEY WORDS

Guttiferae, Tropical fruit, Non-climacteric, postharvest.

Mudanças pós-colheita e padrão respiratório de frutos de bacuri (Platonia insignis Mart.) em diferentes estádios de maturação durante o armazenamento no ambiente.

RESUMO

O bacuri (*Platonia insignis*, Mart.) é um dos mais importantes entre os frutos da Amazônia. Todavia, pouco se sabe sobre sua fisiologia pós-colheita, bem como, estágio de maturação, mudanças durante o armazenamento sob condições ambientais e padrão respiratório. Os frutos foram colhidos em três estádios de maturação baseados na coloração do epicarpo: verde-escuro, verde-claro e “de vez” (50% amarelo), com o objetivo de se determinar as modificações de coloração e padrão respiratório durante armazenamento sob condições de ambiente (25,2 °C, 75,1 % UR). Os frutos de todos os estádios de maturação apresentaram, a partir do terceiro dia de colheita, comportamento respiratório não climatérico, com os frutos “de vez” apresentando maior taxa de produção de CO₂ até o quarto dia de armazenamento (177,63 mg CO₂.kg⁻¹.h⁻¹). O amarelecimento aumentou durante o armazenamento e foi relacionado com a diminuição da luminosidade (L), cromaticidade e ângulo hue. Os frutos “de vez” podem ser armazenados sob condições de ambiente por até 10 dias sem nenhuma perda da qualidade comercial.

PALAVRAS-CHAVE

Guttiferae, fruta tropical, não climatérico, pós-colheita.

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INTRODUCTION

The bacuri (*Platonia insignis* Mart.) is one of the most important among Amazonian fruits (Ferreira *et al.*, 1987). This species is popular because of the creamy whitish pulp that envelops the seed and which has a distinct, strong, acid-sweet, agreeable flavour. Bacuri is increasing in popularity but demand has not yet exceeded supply. The fruit is obtained almost exclusively from wild or managed plants maintained on farms (Clement & Venturieri, 1990).

Its natural distribution is found along the forest-savanna transitional zone south of the Amazon forest, from the Atlantic to Paraguay (Clement & Venturieri, 1990). Fouqué (1974) reported its origin as the rain forest of Guyana and the northern rain forest of Brazil. It occurs at low frequency (0.5 to 1 individual/ha) throughout this region, with occasional stands of 50-100 individuals per hectare, possibly due to Amerindian management.

The mature bacuri tree may attain 20 plus meters in height and 50 to 120 cm in diameter and is an element of the mid to upper canopy in these traditional forests (Calzavara, 1970). The cultivated plant, grown in a more open area, may attain 15-20 m in height, with a crown of 10-15 cm in diameter. The fruit is ovoid to subglobose, 7-15 cm long and 5-15 cm in diameter, weighting between 200 and 1000 g. The rind is thick (1-3 cm), pale yellow to brownish yellow in colour, tough and somewhat elastic, and exudes a yellow latex when bruised (Fouqué, 1974; Calzavara, 1970).

Bacuri harvest season occurs from January to May, however the largest fruit production occurs between February and March. The fruit is collected 4 to 4.5 months after flowering, and a vigorous mature seedling tree will produce about 500 fruits per season (Calzavara, 1970), although some have been observed to produce up to 1000.

With shorter trees obtained by grafting, studies are needed to establish the best maturity stage for bacuri harvest (Villachica *et al.*, 1996). On the other hand, the best maturity stage can be based on colour modification during maturation and ripening, as colour changes have been used as a subjective harvest index (Pantastico *et al.*, 1979a; Chitarra & Chitarra, 1990).

In addition to maturity stage, respiratory pattern has great importance on determining fruit shelf life. Fruits which present high respiratory rates, such as bananas and avocados, tend to ripen faster, thus are more perishable (Tucker, 1993). On the other hand, among non-climacteric fruits, correlation exists between higher respiratory rates and shorter post harvest shelf life.

The objective of this work was to evaluate colour modification of bacuri fruit during ambient storage, as well as determine the respiratory pattern of this Amazonian fruit.

MATERIAL AND METHODS

Fruit material

Bacuri fruits were accessed from native trees in Matões, Maranhão State, Brazil. Fruit was harvested in three maturity

stages based on epicarp colour; dark green (totally green), light green (25% yellow) and turning (50% yellow). Fruit was sent by express mail to Laboratório de Tecnologia dos Produtos Agrícolas of FCAV/UNESP, and was received in three days. Whereupon the fruit was immediately washed with tap water, dipped in sodium hypochloride solution at 100 mL.L⁻¹ for 5 minutes, and stored at room condition (25±2 °C and 75±1 % RH), ambient condition, for eight days.

Quality and colour evaluation

Fresh mass loss was measured daily, weighing the fruit in a semi-analytic scale with 0.01 grams precision. Subjective visual appearance and colour evolution were evaluated using scores according to Teixeira (2000). For appearance: 1, absence of browning symptoms; 2, some brown spots; 3, brown spots and light shrinkage; 4, brown spots, severe shrinkage and rots, and 5, fruit totally brown and shrivelled. For colour: 1, fruit totally green; 2, light green; 3, beginning yellow colour; 4, predominantly yellow and 5, totally yellow. Colour was also determined using a Chromameter Minolta CR-200b, according to the system proposed by the Commission Internationale de l'Eclairage (CIE). Two points were marked on the equatorial region of the fruit, using three specimens per treatment, with three replications. The colour was expressed in lightness (L), chromaticity, and hue angle (McGuire, 1992).

Chemical analysis

Pulp was extracted and frozen at -10 °C at the end of storage. Then it was homogenized and used for total soluble solids (TSS), titratable acidity (TA), and pH determination (A.O.A.C. 1995 - proc. 932-12, 942-15, 945-27, respectively), and ratio (TSS/TTA) as well.

Respiration and gas analysis

Respiration was determined daily using the groups of 3 fruit per each maturity stage, with 3 replications. The fruit was kept during one hour in a recipient hermetically closed (plastic jars - 2.0 L) followed by determination of CO₂ production into the recipient in mg of CO₂.kg⁻¹.h⁻¹. The atmosphere composition inside the plastic jars was measured by injecting 0.3 mL gas samples in a gas chromatograph (Finningan 9001) equipped with Porapack-N and molecular sieve (5A) columns, a thermal conductivity detector (150 °C), and flame ionization detector (150°C), using nitrogen as the carrier gas (30 mL.min⁻¹). The data were integrated using a Borwin software.

Statistical analysis

The trial was conducted according to a split-plot design, with three treatments (main plot; maturity stages), eight withdraws (sub-plot; time) with three replications. The data were subjected to analysis of variance (ANOVA) using SISVAR statistical package.

RESULTS AND DISCUSSION

During ambient storage, fresh mass loss increased and was affected by the maturity stage. Dark green fruit lost more moisture, followed by light green and turning fruit (Figure 1). A loss in weight up to 5% may be sufficient to promote wilt or shrinkage, affecting fruit and vegetable quality (Pantastico *et al.*, 1979b). For bacuri, severe shrinkage was only observed for light green and dark green fruits at the end of the storage period, when they presented mass losses of 23.76% and 26.22%, respectively. Higher weight losses for bacuri fruit at immature stages were also reported by Teixeira *et al.* (2001). This trend can be related to thick wax deposition on the exocarp, which provides good protection against excessive moisture loss (Mourão & Beltrati, 1995).

Visual appearance was significantly affected by moisture loss (Figure 2b). Shrinkage was the main factor affecting appearance, however epicarp browning also contributed. Browning was the result of mechanical damage lesions occurring during harvest, which became worse throughout the storage. Light green and dark green fruits obtained the highest scores (worst appearance) following fresh mass loss trend. The appearance of turning fruit was significantly better after eight days of storage, obtaining the lowest scores.

Epicarp colour scores were higher ($P < 0.05$) for the turning fruit group, which presented a colour completely yellow since the beginning of storage, three days after harvest (Figure 2a). Dark and light green fruit showed colour evolution, which from the sixth day did not differ from each other until the end of storage.

When CIE was used to measure fruit colour, it was observed that fruit became less bright and more yellow during storage (Figures 3a, b, c). Bright reduction was confirmed by lightness (L) reduction in turning and light green fruit, which presented values significantly higher than dark green (Figure 3a). Chromaticity was reduced during storage (Figure 3b), except for the dark green group, probably due to dehydration and lesions that occurred at harvest. These lesions browned the

epicarp and also could have contributed to lightness reduction. Turning and light green fruit did not differ in chromaticity, however light green presented higher saturation than dark green, which was less colourful until the ninth storage day. Hue angle reduction confirms fruit yellowing during storage (Figure 3c). Turning fruits did not present modification in this angle, thus, they were already yellow and therefore did not change colour during storage, which was in agreement with the observed epicarp colour scores (Figure 2a). The other two stages presented reduction in hue angle during storage, showing the transition from predominately green to predominately yellow by the tenth day of storage, when no statistical differences were observed.

No difference in the TSS content was observed, but observed differences were for TA, TSS/TA ratio, and pH between the maturity stages evaluated at the end of storage period (Table 1). Turning fruit was more mature, which was indicated by the lowest TA, highest ratio TSS/TA and pH ($P < 0.05$). These results showed a good relation with epicarp colour scores at the end of storage (Figure 2a), where the fruits harvested in the turning stage presented the highest scores, with colour considered totally yellow, and therefore ripe. Besides the differences among maturity stages, the parameters evaluated were in agreement with values reported by Clement & Venturieri (1990), Villachica *et al.* (1996), and Teixeira *et al.* (2001).

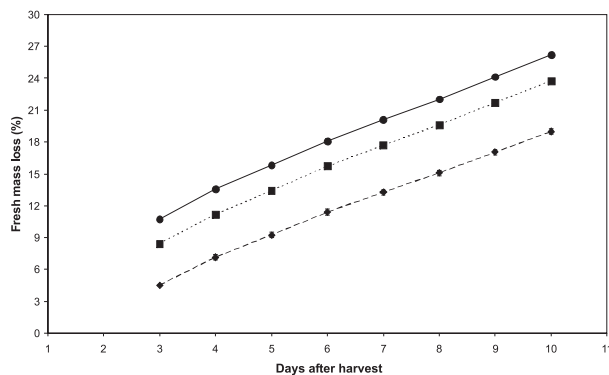


Figure 1 - Fresh mass loss (%) of bacuri fruit stored under ambient conditions (25.2°C, 75.1 % RH), in three stages of maturity, dark green (●), light green (■), and turning (◆). Vertical bars denote SDs for means of 3 separate measurements.

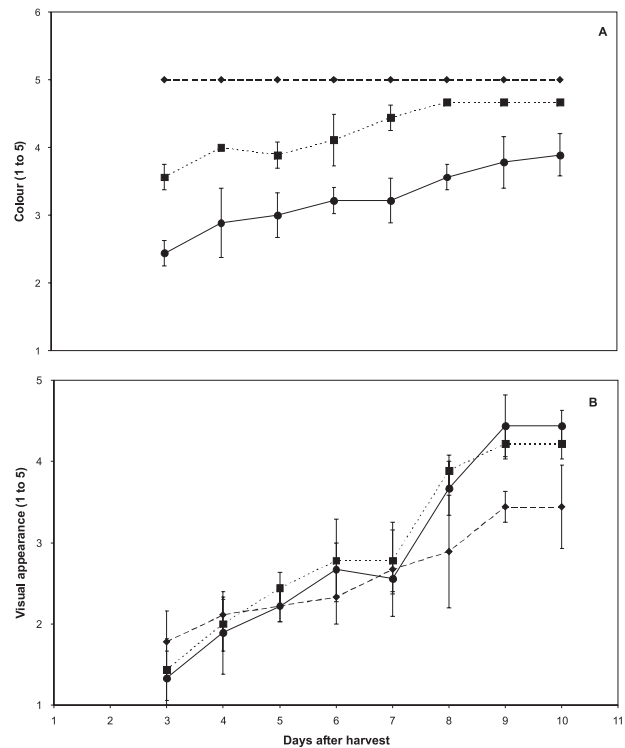


Figure 2 - Visual appearance (a) and epicarp colour (b) of bacuri fruit stored under ambient conditions (25.2°C, 75.1 % RH), in three stages of maturity, dark green (●), light green (■), and turning (◆). Vertical bars denote SDs for means of 3 separate measurements.

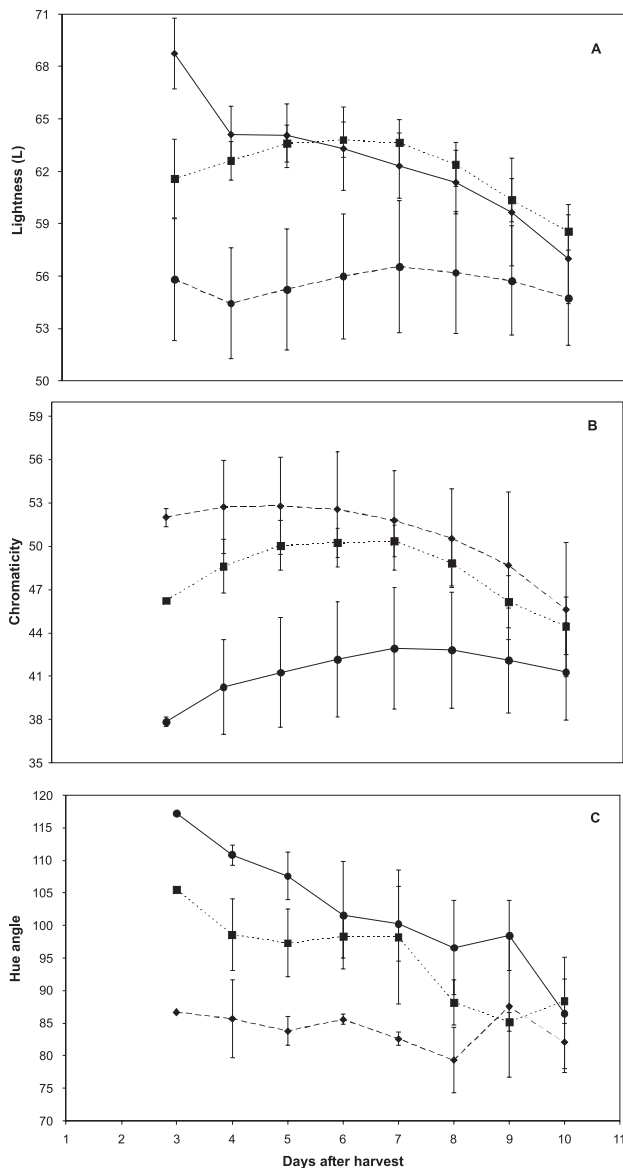


Figure 3 - Epicarp lightness - L* (a), chromaticity (b) and hue angle (c) by bacuri fruit stored under ambient conditions (25.2°C, 75.1 % RH), in three stages of maturity, dark green (●), light green (■), and turning (◆). Vertical bars denote SDs for means of 3 separate measurements.

Table 1 - Physical-chemical characteristics of bacuri fruit stored under ambient conditions (25.2°C, 75.1 % RH), in three stages of maturity, after 10 days of storage.

Maturity stage	TSS ^A	TA ^B	TSS/TA	pH
Turning	20.22 a	0.35 b	58.98 a	3.25 a
Light green	19.08 a	0.50 ab	37.84 b	3.02 b
Dark green	18.81 a	0.64 a	29.87 b	2.93 b
F test	2.28 ns	15.13 **	21.03 **	13.01 **

^ATSS=total soluble solids (°Brix); ^BTA=titratable acidity (grams citric acid.100g⁻¹fresh pulp). Means followed by the same letter within the columns are not significant (P<0.01).

The respiratory rate of bacuri at three maturity stages is shown in Figure 4. Fruit respiration measured from the third day after harvest until the tenth day of ambient storage, followed the pattern attributed to non-climacteric fruit (Biale, 1964; Chitarra & Chitarra, 1990; Tucker, 1993), showing a slow drift downwards after detachment from the parent plant. The respiratory rates, as measured three days after harvest, were considered as high as the strawberry which presents a very high metabolic activity (Biale, 1964; Kader, 1992). Turning fruit presented the highest respiratory rate (P<0.05) up to the fourth day of storage and did not differ between maturity stages after that, with the respiratory intensity decreasing significantly during storage.

According to Rhodes (1970) and Tucker (1993), fruit considered non-climacteric present gradual decline in the respiration rate, which is in agreement with the results found herein (Figure 4). On the other hand, the orange, lemon, and grapefruit which are “tree-ripened” fruits, as is bacuri (Calzavara, 1970; Villachica *et al.*, 1996), when they are detached their respiration continues at a slowly declining rate. However, as the fruits arrived after three days of harvest, the climacteric rise in respiration might have occurred during this period. Biale & Barcus (1970) studying some Amazonian fruits reported a climacteric rise in respiration for breadfruit from 40 to 180 mL O₂.kg⁻¹.h⁻¹ in tow days period. Fruit from the Guttiferae botanic family, such as mangosteen (*Garcinia mangustana* L.), presented the climacteric peak by the tenth day of storage, although (Taylor, 1993).

Dull *et al.* (1967) have investigated the pattern of respiration in pineapple fruit picked at six stages and subsequently stored. They reported the fruit picked at the most immature stage presenting a rapid fall in respiration followed by a small rise and then a further rapid fall. The measurement of respiratory activity of bacuri fruit in this study was done at different maturity stages as indicated by colour differences. Thus, if the bacuri were a climacteric fruit, the characteristic upsurges in respiration rate would have been detected during the storage.

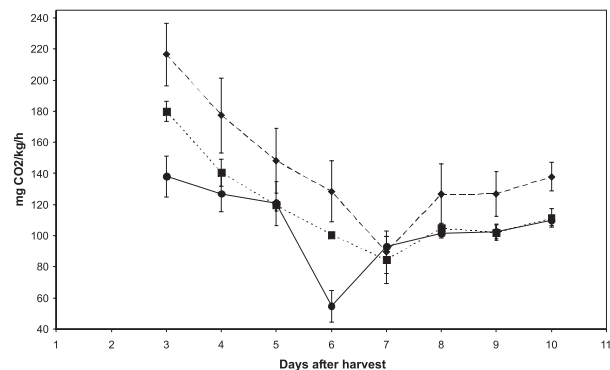


Figure 4 - Respiration rate of bacuri fruit (mg CO₂.kg⁻¹.h⁻¹) stored under ambient conditions (25.2°C, 75.1 % RH), in three stages of maturity, dark green (●), light green (■), and turning (◆). Vertical bars denote SDs for means of 3 separate measurements.

CONCLUSIONS

- 1) Colour was one important parameter when maturity stage was established based on bacuri epicarp colour.
- 2) Colour change was related to lightness (L), chromaticity and hue angle reduction.
- 3) Fruit of the maturity stages evaluated, from the third day after harvest, presented a gradual decline in CO₂ rate production, indicating a non-climacteric respiratory pattern.
- 4) Turning fruit (50% yellow) can be stored at ambient conditions for up to 10 days without any loss in marketability.

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