

## PROTOCOL FOR HARVESTING 'BRS PRINCESS' BANANA FRUITS<sup>1</sup>

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**ABSTRACT-** The aim of this study was to develop a protocol to determine the ideal harvest time for 'BRS Princess' banana, using the number of aborted bracts. The bananas were selected according to the number of aborted bracts since the flowering until the time of harvest, yield clusters with 90, 95, 100 and 105 aborted bracts. The physical and chemical analyzes were performed every 3 days on fruits: soluble solids, titratable acidity, weight loss, length and diameter, pH, firmness, skin color (CIELab) and pectin enzyme activity. The statistical design was completely randomized in a 4x5 factorial, with 4 points and 5 periods of harvest analysis and data were evaluated using analysis of variance and regression. For all parameters, fruits harvested at 90 and 105 aborted bracts had unwanted changes in its metabolism when compared to the other treatments, while fruits harvested at 95 and 100 aborted bracts had the best post-harvest characteristics. This method was effective in determining the point of harvest in 'BRS Princess' banana fruits, since it allows to obtain fruit quality after storage, and is a simple and objective method.

**Index terms:** aborted bracts, maturation, *Musa paradisiaca*

## PROTOCOLO DE COLHEIRA PARA BANANAS 'BRS PRINCESA'

**RESUMO-** O objetivo deste trabalho foi de desenvolver um protocolo para determinar o ponto de colheita ideal para a banana variedade Princesa utilizando o número de brácteas abortadas. Os cachos de bananas foram selecionados de acordo com o número de brácteas abortadas desde a emissão da inflorescência até o momento da colheita, obtendo-se cachos com 90, 95, 100 e 105 brácteas abortadas. As análises físicas e químicas foram realizadas a cada 3 dias nos frutos: sólidos solúveis, acidez titulável, perda de massa, comprimento e diâmetro dos frutos, pH, firmeza, coloração da casca (CIELab) e atividade da enzima pectinametilsterase. O delineamento estatístico utilizado foi o inteiramente casualizado em esquema fatorial 4x5, sendo 4 pontos de colheita e 5 períodos de análise, os dados foram avaliados por meio da análise de variância e regressão. Para todos os parâmetros analisados, os frutos colhidos com 90 e 105 brácteas abortadas apresentaram alterações indesejadas em seu metabolismo quando comparado os demais tratamentos, enquanto que os frutos colhidos com 95 e 100 brácteas abortadas apresentaram as melhores características pós-colheita. Este método é eficaz na determinação do ponto de colheita para banana variedade BRS Princesa, pois possibilita obter frutos de qualidade após o armazenamento, além de ser um método simples e objetivo.

**Termos para indexação:** brácteas abortadas, maturação, *Musa paradisiaca*.

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## INTRODUCTION

The banana has been considered an important food in the world due to its chemical composition and levels of vitamins and minerals, especially potassium. Among the tropical fruit banana is the most consumed, both for its versatility in terms of consumption patterns as per their taste characteristics, hygiene and ease of use *in natura* (DONATO et al. 2006).

Brazil is the fourth largest producer of banana in the world, with 7.12 million tons. Ranking third in the world market for fruit consumption, with 5.5 million tons, which is equivalent to 9.7% of the bananas consumed in the world (FAO 2013). The State of Sergipe has emerged as a major producer of this fruit, with a production of 47,845 tons (IBGE 2011). This shows a growing interest in this sector of the state production, justifying the deployment of new investment in that culture.

The most widespread cultivars of banana in Brazil are: 'Prata', 'Pacovan', 'Prata Anã', 'Dwarf', 'Silk', 'Mysore', 'Plaintain' and 'D Angola', (AAB group), used solely for internal market, and 'Nanica', 'Nanicão' and 'Grand Naine' (AAA group), used mainly for export. Of these cultivars, Prata Anã and Pacovan are responsible for approximately 60% of the cultivated area with banana in Brazil (SILVA et al. 2008). Among the cultivars, 'Silk' banana presents pleasant sensory qualities, and perhaps the tastiest of all cultivars for fresh consumption (PINHEIRO et al. 2007).

There are different parameters to determine the best time to harvest the fruits of banana, as such as skin color, angularity of corners and fruit diameter. The determination of the optimal harvest time is an important factor, since the fruits must be harvested at physiological maturity, thereby avoiding early or late harvest in order to avoid losses, because sooner or later harvest lower consumption of life (ALVES et al., 2004).

Another method used is the number of bracts aborted, which is based on the age of the bunch and corresponding to the number of days since the emergence of the inflorescence until the time of harvest. This method is used counting the markings left on the stalk from the inflorescence to the bunch. This method is a simple and objective way to measure time to harvest (Sarmiento, 2012).

The bracts are sometimes called wrappers protect the placenta, which in turn is a species of the terminal tangs that emerges from the center of the leaf sheaths (Ram et al., 1962). When blooming occurs, the apex expands and produces the inflorescence

bracts, which are mass produced and distributed by spirally rachis. Each branch has an axillary mass concave shape that is the beginning of the bunch, where they differentiate of the flowers, arranged alternately in two parallel rows, with simultaneous development. The number of hands varies with cultivar and plant vegetation conditions and can reach 13-14 (Ram et al., 1962).

Therefore, this cultivars as any other newly launched, requires studies to characterize its maximum as determining the optimal time to harvest, an extremely important factor enabling fruit to have a good quality and long shelf-life. Thus this study aimed to develop a simple and precise protocol to determine the harvest point of 'BRS Princess' banana fruits.

## MATERIAL AND METHODS

The banana 'BRS Princess' fruits were obtained from the Experimental Field Jorge Prado Sobral of Embrapa Tabuleiros Costeiros in Nossa Senhora das Dores-SE. Fruits were selected according to the number of aborted bracts, getting bunches with 90, 95, 100 and 105 aborted bracts. Then it were separated from the bunch with 6 fruits composing the sample. The plants were labeled at flowering, when started counting the number of aborted bracts by banana stem markings left on the plant until the formation of clusters. After harvest fruits were brought to the Ecophysiology and Postharvest (ECOPOC) laboratory at the Federal University of Sergipe, and sanitized with mild detergent, dried naturally and stored at  $25 \pm 2^\circ\text{C}$  and  $85 \pm 5\%$  relative humidity (RH), evaluated every 3 days, always using fruits of 2nd and 3rd bunch of their selected bunches. It were analyzed the soluble solids content, titratable acidity, pH, weight loss, firmness, diameter and length, skin color and pectinmetilesterase enzyme activity.

The soluble solids (SS) were determined by direct readout in digital refractometer RTD-45, Instrutherm and results expressed as  $^\circ\text{Brix}$ ; titratable acidity (TA) according to AOAC (1992) in which 5.0 mL of juice pulp were homogenized in 50 mL of distilled water. To the sample was added three drops of 1% phenolphthalein indicator, then proceeding titration, under stirring, with NaOH 0.1N for neutralization of organic acids, with results expressed as an acid malic percentage. Firmness was determined with digital penetrometer (Turoni), probe with 8 mm diameter and flat tip, were made two readings per fruit on opposite sides of its middle region, after removing the skin surface and the results

expressed in Newton (N).

Weight loss was determined by difference between the weight of the fruit at harvest and after the storage period and expressed in percentage based on the sampling unit (bunch with 6 bananas). The fruit length was measured using a measuring tape and diameter was measured on the median of the fruit with a caliper. Both results were expressed in centimeters.

The skin color was measured with a Minolta Colorimeter, model CR-400, according to the scale  $L^* a^* b^*$ . In addition, it were made two color readings per fruit on opposite sides of its median region, and the results were expressed as hue angle (H), chromaticity (C) and Luminosity ( $L^*$ ). Pectinmethylesterase E.C 3,1,1,11 (PME) activity was determined by Hultin et al. (1966). Enzyme extract was prepared with a sample containing 5 grams of fruit macerated with 20mL of cold 0.2 N NaCl. Five mililiter was filtered added 30 mL of citrus pectin in 1% NaCl 0.2 N. Finally the pH of the solution was kept around 7.0, for ten minutes, by titration with NaOH 0.01 N. One unit of PME was defined by the amount of enzyme capable of catalyzing the demethylation of pectin corresponding to the consumption of NaOH  $1 \mu\text{mol min}^{-1}\text{g}^{-1}$  fresh weight, under the test conditions. Results were expressed in U.E. formed  $\text{min}^{-1}\text{g}^{-1}$ . Statistical design using was completely randomized in a  $4 \times 5$  factorial with 4 harvest points (90, 95, 100 and 105 bracts aborted) and 5 analysis periods (0, 3, 6, 9 and 12 days). The data were submitted to variance analysis and qualitative factor levels were compared by Tukey test. Quantitative factor was realized with the adjustment of regression models. In all analyzes, were adopted the nominal level of significance of 5% probability using the statistical program SISVAR (FERREIRA, 2000).

## RESULTS AND DISCUSSION

Soluble solids increased (Figure 1A) in all treatments over time evaluation primarily due to the conversion of starch into sugars, which with the progress of ripening, is hydrolysed to glucose, responsible for the increase in the degree of sweetness of the fruit. No reduction was observed in soluble solids throughout the experiment, suggesting that the preferred substrate for respiration is not the sugars but organic acids as noted by Carvalho et al. (1989), which the drop in acidity occurred when the bananas were very ripe or senescent due to consumption of organic acids after respiration. Poor presentation of Bananas harvested at 90 and 105 aborted bracts showed values of soluble solids

higher than other fruits probably because these fruits were not harvested at the optimum time. However, in work, the most appropriate time were 95 and 100 bracts aborted. Fruit harvested at 95 and 100 bracts aborted showed an increase in soluble solids over the 12 days of storage, while fruit harvested at 90 and 105 bracts aborted had higher increment followed by decreasing trend suggesting that fruits harvested at 90 and 105 aborted bracts were harvested in inappropriate period.

It was also found that the levels shown by all the fruits were larger than 25 °Brix, at the end of 12 days of storage.

Titrateable acidity in bananas has increased for all fruits (Figure 1B) until the 6<sup>th</sup> day, with highest values between 6 and 9 days for the fruits with 90 and 105 aborted bracts then decrease. Regarding the fruits with 95 and 100 aborted bracts, the highest acidity values were between the 9th and 12th day, and not decreased, showing lower values in fruits with 90 and 105 aborted bracts. These results indicate that fruits with 95 and 100 aborted bracts had synthesis and degradation of organic acids delayed by three days with increasing acidity that is directly proportional to fruit ripening (XISTO et al. 2004).

The conversion of these acids or consumption after the peak of acidity was probably due to the breathing process (CARVALHO et al. 1989; DAMATTO et al. 2005). The authors demonstrated that the acidity increases with banana for your maturity and decreases when the fruit is very ripe or senescent. This is because the consumption of organic acids characteristic fruit senescence stage. In this work, it was verified, less consumption of organic acids and slowing the metabolism of fruits harvested at 95 and 100 bracts aborted when compared to 90 and 105 fruits with aborted bracts.

Fruits harvested at 90 and 105 aborted bracts were those with the most rapid loss of firmness and high (Figure 1C) whereas for fruit 95 and 100 aborted bracts firmness reduction was less intense, initially observed between the 3<sup>rd</sup> and 6<sup>th</sup> day of analysis with falling 55,33N and 51,16N for fruits with 90 and 105 bracts aborted. Thus, the fruits of treatment with 95 and 100 aborted bracts were those who had late and slower loss of firmness, with higher values during the entire storage period. The reduction of the firmness is related to the loss of integrity of the cell wall, which was observed in all fruit during the experiment. Probably fruit harvest with 90 aborted bracts was very early and the fruit harvested with 105 aborted bracts were harvested late, which caused greater loss of firmness and consequently greater increase in acidity in the initial periods of analysis (Figure 1B). This relationship was also observed by Leite et al. (2010), working with post-harvest quality

of 'Pacovan' banana.

The pectin methyl esterase is an enzyme that acts on the degradation of pectic cell wall structures of the fruit, causing the fruit softening and consequently the loss of firmness thereof. Thus, fruits with 95 and 100 aborted bracts showed tendency to had enzyme activity increase (Figure 1D) less intense than the fruits with 90 and 105 aborted bracts. The maximum values of the enzymatic activity of the fruits of 90 and 105 aborted bracts of 100 and 80 U<sub>E</sub>min<sup>-1</sup>g<sup>-1</sup> while were that of 90 and 100 aborted bracts 66 and 70 U<sub>E</sub>min<sup>-1</sup>g<sup>-1</sup>. This tendency can be related to the loss of firmness of the fruit (Figure 1C), PME activity more intense induced greater loss of firmness (fruits with 90 and 105 aborted bracts) while the PME activity induced less intense lower loss of firmness (fruits with 95 and 100 aborted bracts). Increased acidity may also be associated with increased enzyme activity (Figure 1B) in fruits with 95 and 105 aborted bracts because there was increased in galacturonic acid production PME activity.

The pH values were higher than 5 in the initial period of the experiment (Figure 1E) with a strong decrease for the fruits with 90 and 105 aborted bracts until the sixth day, coinciding with the increase in acidity (Figure 1B). After 6 days initiated the pH increased the same way as the acidity decreases started. In fruits with 95 and 100 aborted bracts, the pH decrease was less abrupt and later than fruits with 90 and 105 bracts, checking up on the same period also increased acidity. This trend of smaller decrease in pH for fruit with 95 and 100 bracts suggests lower cell wall degradation and consequently slower ripening. Similar results were observed in Prata-Anã cultivar and the PA 42-44 hybrid in works done by Pimentel et al. (2010).

The decrease in pH during the ripening is a natural tendency to be associated with the accumulation of sugar and acid constituents during fruit ripening. As the soluble sugars are precursors of organic acids, with predominance of malic acid in bananas, accumulation leads to a pH decrease during the ripening (NASCIMENTO JUNIOR et al. 2008). The increase in pH at the end of the experiment refers to the consumption of organic acids by respiration, characteristic of fruits senescence stage.

Regarding the mass loss of bananas was due to perspiration checked for all fruits throughout the experiment, but it was noted that the fruits with 90 bracts aborted suffered further loss, reaching 27.43% mass loss at the end the storage period and was statistically different from the other fruits (Figure 1F). This trend is possibly due to the fruits are not fully mature physiologically. The maximum observed for further treatments was less than 15%.

Viviane and Leal (2004), studying post-harvest banana genotypes under modified atmosphere,

observed mass loss of 28.11% within 8 days of storage in genotypes unpacked and stored at 25 °C. Damatto et al. (2005), working in the production and characterization of 'Prata-Anã' and 'Prata-Zulu' banana fruits without acclimatized conditioning, found mass loss of 11.13% in Prata-Anã cultivar within 12 days after harvest. These results show that the weight loss may be related to the genotype and the harvesting point while kept under the same storage condition.

The lengths of the bananas were 11.5, 11.7, 12.9 and 12.3 cm for the treatments with 90, 95, 100 and 105 aborted bracts, respectively (Table 1). Sales et al. (2004), working with 'Prata-Anã' banana fruits found length with 12 cm, very close to that found in this work. Gomes (2004), studying the growth and yield of banana Silver-Anah and Apple fertigated with potassium, found in the 1st cycle of production of its control plants (without application of potassium) a length of 12 cm for banana fruits Silver-Anah and 10.7 cm for the fruits of apple variety.

As the diameter was found average values of 3.2, 3.3, 3.4 and 3.4 cm for the fruits of 90, 95, 100 and 105 respectively bracts aborted (Table 1). The diameter values range between 3.13 and 3.6cm along the experiment, which is confirmed by Donato et al. (2006), analyzing the behavior of varieties and hybrids of banana (*Musa* spp) in two production cycles in southwest Bahia, found values of approximately 3.5 to Silver-dwarf variety. Already Gomes (2004) found values of 3.04 and 3.21 cm for the dwarf varieties Silver and Apple respectively.

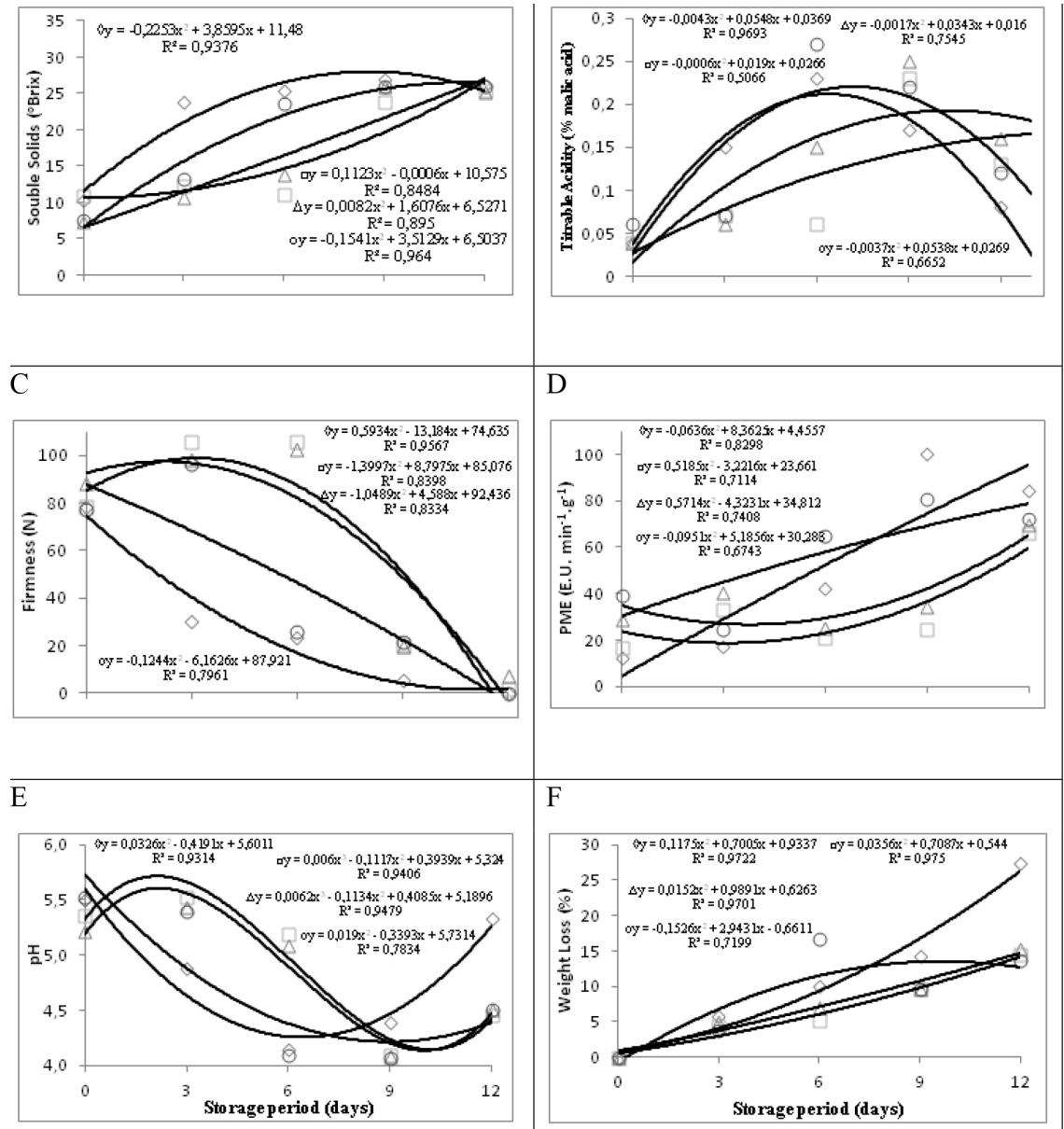
Regarding the color shown in the skin, the coordinate L\* represents the luminosity and the scale ranges from 0 (dark fruit) to 100 (bright fruit). The fruits of 90 aborted bracts showed increased luminosity long before other fruits (Figure 2A) and from the 6th day showed a strong decrease (up from 66.08 to 22.24). This trend displayed by these fruits may be related to changes in metabolism suffered by the fruit due to the early harvest. It may be related to metabolism changes suffered by the fruit due to the early harvest with greater weight loss (Figure 1F). Fruits of the other treatments showed values between 55 and 60.23 on day 1 of analysis and between 70 and 72 on the last day of examination, during which presented its highest values. Pinheiro et al. (2005) and Alvarez et al. (2003) studied the post-harvest of 'Tropical' and 'Prata' banana found similar trend observed in this work that is coordinated increase in L, reaching maximum values of 68.1 and 68.43, respectively.

The parameter H (hue angle) was used to check the change of skin color from green to yellow. It was due by the synthesis of carotenoids and, or, chlorophyll degradation, thus giving visibility to

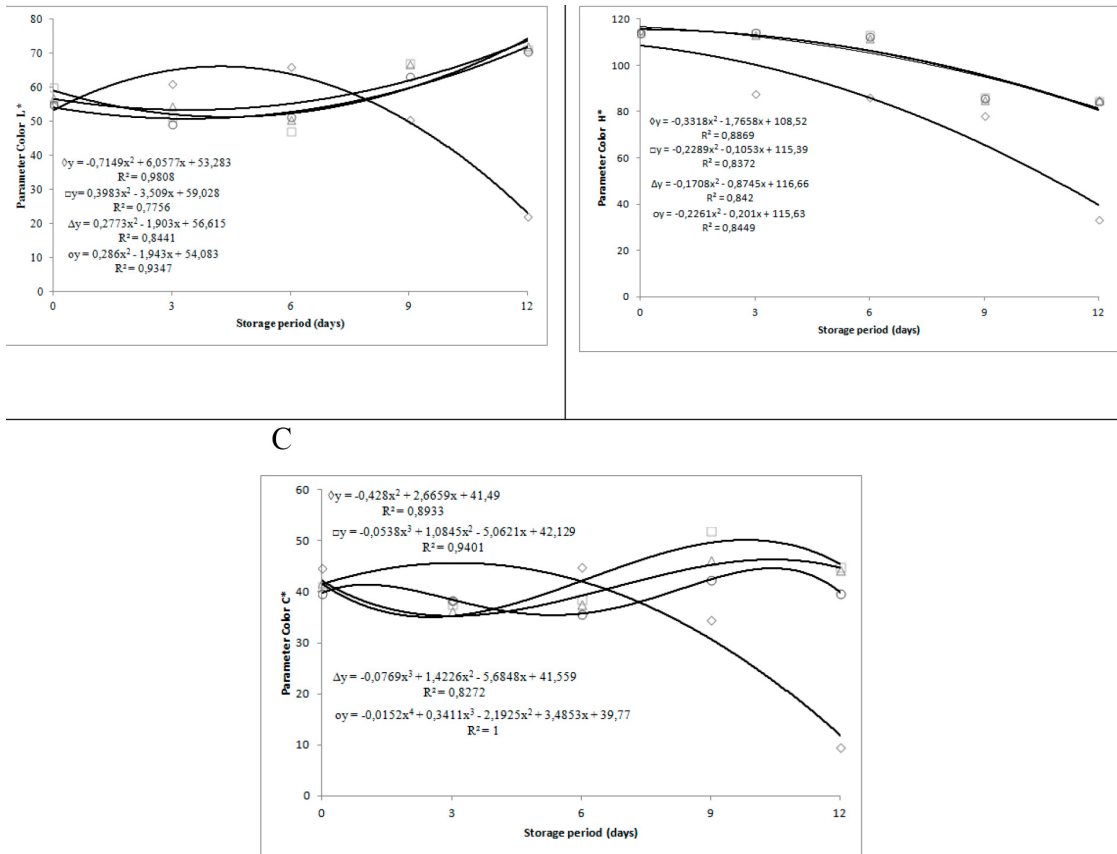


carotenoids. The results of this parameter (Figure 2B), showed no significant difference between fruit on the first day of the experiment, with values around 113° to 115°. According to the check data it was possible that during the ripening of fruit with 90 aborted bracts always showed lower values than others, or less fruits and more yellowish green, suggesting that changes in metabolism caused greater synthesis of carotenoids and chlorophyll degradation. Pinheiro et al. (2005), also found in Tropical cultivar variation in hue angle of 105.35° to 77.33° consistent with values found for fruit harvested at 95, 100 and 105 aborted bracts.

The values of C\* represent the saturation of the color between red and green (a\*) and yellow and blue (b\*). One more time, it was possible to see that the fruits with 90 aborted bracts had different tendency related to other fruits, while the fruits with 95, 100 and 105 aborted bracts tended to increase and fruits with 90 aborted bracts showed decreases for color saturation. Thus, as in most analyzes the fruits with 90 and 105 aborted bracts showed trends of lower quality, while the 95 and 100 aborted bracts were those with the highest quality and trend storage.



**FIGURE 1-** Influence of harvest time in physical and chemical transformations on 'BRS Princess' banana fruits with 90(◇), 95(□), 100(△) e 105(o) aborted bracts, until 12 days after harvest under storage at 25o C e 80% RU.



**FIGURE 2-** Influence of harvest time in colorimetric values parameters for 'BRS Princess' banana fruits with 90( $\diamond$ ), 95( $\square$ ), 100( $\Delta$ ) e 105( $\circ$ ) aborted bracts, until 12 days after harvest under storage at 25o C e 80% RU.

**TABLE 1-** Average length and diameter in centimeters Princess variety of bananas harvested at 90, 95, 100 and 105 aborted bracts at 12 days of storage at room temperature.

Treatments	Length (cm)	Diameter (cm)
90 bracts	11,5	3,2
95 bracts	11,7	3,3
100 bracts	12,9	3,4
105 bracts	12,3	3,4

## CONCLUSIONS

The fruits harvested with 90 and 105 aborted bracts had unwanted change in metabolism interfering and quality of fruits.

The method using the number of aborted bracts is efficient and practical to determine the ideal harvest for 'BRS Princess' banana fruits.

The harvest of banana BRS Princess cultivar should be held in bunches with 95-100 aborted bracts.

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