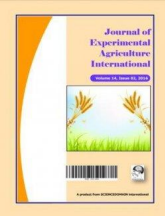

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# Ripening Banana (*Musa* spp.) under Different Conductions

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***Authors' contributions***

*This work was carried out in collaboration between all authors. Author DSM designed the study and wrote the protocol. Author JCC guided the research. Authors NCLJ and SRC performed the statistical analysis. All authors read and approved the final manuscript.*

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## ABSTRACT

The present work aims to evaluate the ripening of the banana under the effect of choking and calcium carbide. The experiment was carried out with banana fruits "Silver", harvested at the Production Unit of IFPE - Campus Vitória de Santo Antão. The experiment was conducted in a completely randomised design, containing 3 treatments (T1: Witness, T2: Use of calcium carbide, T3: Smothering) and 3 replicates. The analyses were carried out in the Laboratory of Physical and Chemical Analysis of the same institution, in February 2014. The fruits were subjected to titratable acidity and soluble solids analyses. Analyses were carried out at 1, 48 and 96 hours after application of the treatments. In the analysis of the soluble solid contents done in the first hour after the application of the experiment, only the control treatment and that of the bananas subjected to the carbide treatment were different from the others state values. The bananas conditioned to choking were the treatment that had the highest concentration of soluble solid state values, followed by the banana with carbide and the control. At 96 hours there was no significant difference

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between treatments. In the analysis of the soluble solid's contents done in the first hour after the application of the treatments, only the control treatment and that of bananas subjected to the carbide were different from the others. The banana undergoes several metabolic changes during the maturation process that can be observed by the parameters measured in the tests carried out in this experiment. In the treatment where the bananas were subjected to the action of the carbide, there was an increase in the rate of titratable acidity and an acceleration in its maturation. Meanwhile, in the treatment where the fruits were conditioned to choking at the end of their maturation, they had higher concentrations of soluble solid.

*Keywords: Soluble solids; suffocation; calcium carbide.*

## 1. INTRODUCTION

Banana (*Musa* spp.) is one of the most important fruits being grown in approximately 150 countries. Brazil has been raising its production and outstanding among the main global producers, occupying the fifth place in 2014 [1], with a production in 2016 around 6,962,134 tons in 516,980 hectares [2]. The banana (*Musa* spp.) is a plant of the family Musaceae, being that most of the species has as its center of origin in the southwest of Asia. The fruit produced is the banana, which originates from the flowers located in the female inflorescence. It is characterised by being the most consumed in natural fruit in the world and being exploited in most tropical countries [3]. The volume of banana exports worldwide in 2012 reached a record of 16.5 million tons and this increase is mainly explained by the growth of Latin American and Caribbean exports [4]. To meet the demands of the market and to obtain a longer useful life, the climacteric fruits must be harvested at the physiological maturity. However, the banana harvested in complete physiological development matures unevenly. The banana presents several chemical reactions during its ripening process, such as the variation of soluble solids content (Brix degree) and titratable acidity [5].

Maturity stage of fresh banana fruit is an important factor that affects the fruit quality during ripening and marketability after ripening. The ability to identify maturity of fresh banana fruit will be a great support for farmers to optimise harvesting phase which helps to avoid harvesting either under matured or over-matured banana. This study attempted to use image processing technique to detect the maturity stage of fresh banana fruit by its colour and size value of their images precisely. The cultivars and the maturation stage tended to influence the characteristics of the fruits but did not have great influence on the ripening of the fruits [6].

In semi-finished crops, transport to the beneficiation unit is carried out by haulers, and bunches are placed on the margins on banana leaves or on truck bodies or tractor trailers lined with banana or grass leaves. For crops that adopt more technology, the bunches are transported by aerial cables. In this system, fruit goes from the plant to the processing unit without having any contact with the soil, without being stacked, receiving pressure or friction from other bunches. Banana producers in Brazil face problems in handling the product from the harvest, involving transport, packaging, air conditioning, handling and logistics of the consumer market. The lack of care during post-harvest is also responsible for the devaluation of the banana in the domestic market and the loss of opportunities for exporting the fruit [7].

To meet the demands of the market, climacteric fruits, such as bananas, must be harvested at physiological maturity. However, the banana harvested with complete physiological development matures unevenly. Aiming at the homogenisation of the lots and the scheduled maturation of the fruits, it is possible to use the climatisation process. However, for all banana cultivars, there is no knowledge regarding the effect on quality, the time between harvesting and air conditioning, mainly regarding cultivars produced in Brazil [8].

Traditionally, the acceleration of banana maturation is carried out using calcium carbide, which releases the acetylene when moistened around the leaves, covering them with plastic canvas and in contact with the fruit acts as an enzymatic catalyst. Acetylene is analogous to ethylene and may cause a similar physiological effect on plant tissues. Another alternative is cooking that anticipates the respiratory peak of bananas during ripening [8]. Temperature is usually the most important58environmental factor that affects the post-harvest life of fruits and vegetables by slowing or accelerating breathing.

The low temperature is effective to maintain post-storage quality of vegetables [9].

The Brix and the Titratable Acidity are parameters that can be used to follow the changes in the banana fruits during ripening. In addition, the ability of both Brix and Titratable Acidity concentrations between different varieties of banana during ripening stages is presented. The bananas Silver presented in the green fruit values of 17.00 of ºBRiX. In the mature fruit, the values found to reach a maximum of 36.00. While for Titratable Acidity it can range from 0.96 when all green reaches 7.6 on the fifth day [10].

The present work aims to evaluate the ripening of the banana under the effect of choking and calcium carbide.

## 2. MATERIALS AND METHODS

The banana used in the experiment was of the Prate variety (Musa AAB), grown in the agriculture sector of the Institute of Education, Science and Technology of Pernambuco (IFPE) - Campus Vitória, in Vitória de Santo Antão, PE (08°05'59 "S and 35°17'25 "O) with an average elevation of 155 m. The climate of the region, according to the classification of Köppen, is classified as AS, the average temperature is 24.1°C with average annual rainfall of 1,014 mm.

The experiment was carried out with "Prata" banana fruit, in February 2014, collected at the IFPE - Vitória Campus of Santo Antão. The analyses were carried out in the Laboratory of Physical and Chemical Analysis of the same institution. The fruits were harvested on completion of 13 weeks after the removal of the flowers.

The bunches harvested were transported to the packing house of the IFPE - Vitória Campus of Santo Antão, where they went through pre-cleaning and elimination of the rachis. They were then cooled by tank immersion in water containing aluminium sulphate and 2% calcium chloride at 20 ± 2°C for 20 minutes, followed by division into bouquets. The fruits were then transported in plastic boxes of 20 kg to the Laboratory, where they were immersed in 2.5% sodium hypochlorite solution for 10 minutes.

The rinsing and drying were performed in air (22 ± 1°C and 75 ± 3% RH) for 30 minutes. The bouquets, with 3 to 5 fingers, after being selected and standardised for size and absence of visual damage / defects, were subjected to sampling.

The experiment was conducted in a completely randomized design (DIC) containing 3 treatments (T1: Control, T2: Use of calcium carbide, T3: choking) and 3 replicates. In all analyses, three replicates were used with five fruits as experimental unit. For the treatment made with suffocation the fruits were wrapped in low density polyethylene plastic bags.

Freshly harvested bunches of green. For T1 the plants were not submitted to any treatment, T2 and T3 are submitted for 24 hours the conditions of each treatment. The analyses were performed 1 hour, 48 hours and 96 hours after the application of the treatments. The fruits were subjected to titratable acidity and soluble solids analyses.

After application of the treatments, the bouquets packaged in low density polyethylene were stored in a refrigerator at 12 ± 1°C and 93 ± 2% RH for up to 30 days. The low density polyethylene film was 0.010 mm thick, permeability area of 805 $cm^{3,}$ oxygen permeability) of 11.234 $cm^{3}$ $m^{-2}$ $d^{-1}$ and carbonaceous gas permeability 05 $cm^{3}$ $m^{-2}d^{-1}$.

The analyses were evaluated according to the methodology proposed by the Adolf Lutz Institute. The titratable acidity (TA) contents were determined by the titration of 10 g of comminuted pulp, homogenised and diluted to 100 mL in distilled water, with 0.1 M NaOH solution, and a turning point at pH 8.2. The results were expressed as% of malic acid, 100 $g^{-1}$ of pulp. [11]. Data were submitted to analysis of variance through Genes [12]. Then the means were separated by the Turkey test ($p < 0.05$).

## 3. RESULTS AND DISCUSSION

Regarding the titratable acidity, in the analysis done in the first hour after the application of the treatments, the result of the control treatment and the banana conditioned to the suffocation did not differ statistically among themselves. Table 1 shows the results obtained. Only the result of the banana with carbide differed from the others. The action of the acetylene causing the acceleration of ripening in the banana. The higher production and, consequently, the increase of the ethylene concentration in the packages, possibly potentiated the rapid maturation in the bananas with carbide [12].

Ripening is the result of complex changes occurring in the fruit. The main changes that can

**Table 1. Acidity and Briz in bananas submitted to different maturation conditions**

| Hours | Titratable acidity | | | °Brix | | |
|---|---|---|---|---|---|---|
| | 0 | 48 | 96 | 0 | 48 | 96 |
| Witness | 2.47Cb | 12.20Aa | 7.53Ba | 4.86Cb | 24.00Bc | 25.9Ab |
| Bananas with carbide | 8.40Ba | 11.10 Aa | 9.27ABa | 16.00Ca | 25.00Bb | 26.00Ab |
| Conditioned banana | 2.60Cb | 12.13Aa | 9.03Ba | 4.96Cb | 25.96Ba | 27.00Aa |

*Means followed by the same capital letters in HORIZONTAL do not differ statistically from each other; Means followed by the same lowercase letters in VERTICAL do not differ statistically from one another*

be observed are: respiratory rate increase, increase in ethylene production, increase in sugar concentration, solubilisation of pectic substances, pigment degradation, increase in the concentration of phenolics and acids, production of volatiles, variations in the contents of enzymes, vitamins, minerals and changes in the permeability of tissues [6].

According to the result of total titratable acidity in Table 1. In relation to the behaviour of total titratable acidity, there was a tendency to decrease during forty-eight and ninety-six hours after storage and may be associated to the increase of values pH in the same period. The titratable total acidity was not influenced by the different climatisation seasons and the values found in this experiment were within the range of levels found by other authors [13].

Means followed by the same capital letters in HORIZONTAL do not differ statistically from each other; Means followed by the same lowercase letters in VERTICAL do not differ statistically from one another. In the second analysis performed after 48 hours, the treatments were not statistically different, this may have occurred due to the acceleration of the maturation provided by the carbide. The analysis may also have coincided with the natural climacteric peak of the banana. For the analysis done at 96 hours, there was no significant difference between the treatments, since the bananas had already reached their final maturation stage. After climacteric maximum, the process of senescence begins where growth slows, and biochemical processes of ageing prevail in transformations that tend towards degradation [14].

In relation to the results of the analysis of the soluble solids contents done in the first hour after the application of the experiment, the control treatment and that of the banana conditioned to the choking were not statistically different from each other. Unlike the result of the banana with carbide that differed from the others state result. Possibly this result is related to the transformation of starch into simple sugars as already explained [15]. In the second analysis, performed after 48 hours, all treatments were statistically different state results.

With maturation, the titratable acidity of the bananas increased, with relatively constant increases, which may be the effect of the solubilisation of pectic substances because of the enzymatic activity. The bananas conditioned to choking were the treatment that obtained the highest concentration of soluble solids, followed by the banana with carbide and the control. In this case the divergences are due to the different metabolic rates (respiration), ethylene production and relation with other hormones [16].

In the third analysis done at 96 hours the treatment of the banana conditioned to the suffocation was significantly different from the other treatments if it maintained with the highest content of soluble solids, this characteristic can be expressed due to the mode of storage. After reaching the peak of maturation are detected reductions in the soluble solid contents of banana silver fruits [17].

Where it is concerned with the handling of storage conditions can significantly alter the levels of reducing sugars. The contents of sugars vary according to the temperature of exposure and the stage of maturity of the fruits [18].

The fruits matured by choking also did not present problems in the staining and this is a positive point. The factors that affect fruit quality are related much more to appearance and distribution than to internal characteristics. To obtain good quality, you need properly developed fruits, uniform in size, without spots, bruises and rot, light yellow peel colouring and adequate shelf life.

Soluble solids are used as indicators of banana maturity that increase because of the hydrolysis of the starch, precursor of sugars and, determine the quality of the fruit, exerting an important role

in the flavour [19]. In the present work, with carbide action, the maximum value was (26.0º Brix), in Witness (25.9º Brix) and choking banana (27.0 ºBrix). Thus, the highest concentration of soluble solids was obtained in choking this process is the most suitable for acclimatisation conditions in organic production systems. The farmer in small areas does not need to have the resources to buy carbide and not prey to use agrochemicals to obtain the rapid maturation of bananas.

## 4. CONCLUSION

The banana undergoes several metabolic changes during the maturation process that can be observed by the parameters measured in the tests carried out in this experiment. In the treatment where the bananas were subjected to the action of the carbide, there was an increase in the rate of titratable acidity and an acceleration in its maturation. Meanwhile, in the treatment where the fruits were conditioned to choking at the end of their maturation, they had higher concentrations of soluble solids. In this way the most recommended for organic agriculture is p choking.

## COMPETING INTERESTS

All authors disclose any financial and personal relationships with other people or organizations that could inappropriately influence (bias) their work.

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