

1 Original research article

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3 Ripening banana (Musa spp.) under 4 different conductions

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The present work aims to evaluate the ripening of the banana under the effect of smothering and calcium carbide. The experiment was carried out with banana fruits "Prata", harvested at the Production Unit of IFPE - Campus Vitória de Santo Antão. The experiment was conducted in a completely randomized design, containing 3 treatments (T1: Witness, T2: Use of calcium carbide, T3: Smothering) and 3 replicates. **Men** The analy~~zes~~es were carried out in the Laboratory of Physical and Chemical Analysis of the same institution, in February 2014. The fruits were **submitted subjected** to titratable

acidity and soluble solids analy~~zes~~es, **and Analyses**a were carried out **atanalyzed** 1, 48 and 96 hours after application of the

treatments. **The fruits were submitted to titratable acidity and soluble solids analyzes and analyzed 1,**

48 and 96 hours after application of the treatments. In the analysis of the soluble solids contents done in the first hour after the application of the experiment, only the control treatment and that of the bananas **submitted subjected** to the carbide **treatment** were different from the others **state values**. The bananas conditioned to **choking??**

were the treatment that **obtained had** the highest concentration of soluble solids **state values**, followed by the banana

with carbide and the control. At 96 hours there was no significant difference between treatments. In the analysis of the soluble solids contents done in the first hour after the application of the **experimenttreatments**,

only the control treatment and that of bananas **a submitted subjected** to the carbide were different from the

others. In the treatment where the bananas were **submitted subjected** to the action of the carbide had an increase in the rates of titratable acidity and an acceleration in its maturation. However, in the treatment where the fruits were conditioned to the suffocation~~???~~, at the end of their higher soluble solids concentrations~~???~~.

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Keywords: Soluble solids; suffocation; Calcium Carbide. 89

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12 1. INTRODUCTION

13

14 Banana **tree** (Musa spp.) is one of the most important fruits being grown in approximately 150
15 countries. Brazil has been raising its production and outstanding among the main global producers,
16 occupying the fifth place in 2014 [1], with a production in 2016 around 6,962,134 tons in 516,980
17 hectares [2]. The banana **tree** (Musa spp.) **is** a plant of the family Musaceae, being that the majority of
18 the species has as its center of origin **in** the southwest of Asia. The fruit produced is the banana, which
19 originates from the flowers located in the female inflorescence. It is characterized by being the most
20 consumed in natural fruit in the world and being exploited in most tropical countries [3].

21

22 The volume of banana exports worldwide in 2012 reached a record of 16.5 million tons and
23 this increase is mainly explained by the growth of Latin American and Caribbean exports [4]. To meet
24 the demands of the market and to obtain a longer useful life, the climacteric fruits must be harvested
25 at the physiological maturity. However, the banana harvested in complete physiological development
26 matures unevenly. The banana presents several chemical reactions during its ripening process, such
27 as the variation of soluble solids content (Brix degree) and titratable acidity [5].

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29 Maturity stage of fresh banana fruit is an important factor that affects the fruit quality during

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30 ripening and marketability after ripening. The ability to identify maturity of fresh banana fruit will be a
31 great support for farmers to optimize harvesting phase which helps to avoid harvesting either under
32
33 matured or over-matured banana. This study attempted to use image processing technique to detect
34 the maturity stage of fresh banana fruit by its color and size value of their images precisely. The
35 [cultivar](#) and the maturation stage tended to influence the characteristics of the fruits, but did
36 not have
37 great influence on the ripening of the fruits [6].

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In semi-finished crops, transport to the beneficiation unit is [37](#) carried out by [hauliers](#) and
38 bunches are placed on the margins on banana leaves or on truck bodies or tractor trailers lined with
39 banana or grass leaves. For crops that adopt more technology, the bunches are transported by aerial
40 cables. In this system, fruit goes from the plant to the processing unit without having any contact with
41 the soil, without being stacked, receiving pressure or friction from other bunches. Banana producers
42 in Brazil face problems in handling the product from the harvest, involving transport, packaging, air
43 conditioning, handling and logistics of the consumer market. The lack of care during post-harvest is
44 also responsible for the devaluation of the banana in the domestic market and the loss of
45 opportunities for exporting the fruit [7].

46

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

53

54

55 Traditionally, the acceleration of banana maturation is carried out using calcium carbide,
56 which releases the acetylene when moistened around the leaves, covering them with plastic canvas
57 and in contact with the fruit acts as an enzymatic catalyst. Temperature is usually the most important
58 environmental factor that affects the post-harvest life of fruits and vegetables by slowing or
59 accelerating breathing. The low temperature is effective to maintain post-storage quality of vegetables
60 [9].

61

62

63 2. MATERIAL AND METHODS

64

65 The banana used in the experiment was of the Prata variety (Musa AAB), grown in the
66 agriculture sector of the Institute of Education, Science and Technology of Pernambuco (IFPE) -
67 Campus Vitória, in Vitória de Santo Antão, PE (08°05'59 "S and 35°17'25 "O) in red-yellow argisol
68 ([SANTOS et al., 2006](#) [replace with number](#)), with an average elevation of 155 m. The climate of the
69 region, according to
70 the classification of Köppen, is classified as As, the average temperature is 24.1 ° C with average
71 annual rainfall of 1,014 mm.

71 The experiment was carried out with "Prata" banana fruit, in February 2014, collected at the

72 IFPE - Vitória Campus of Santo Antão. The [analyses](#) were carried out in the Laboratory of Physical
73 and Chemical Analysis of the same institution. The fruits were harvested on completion of 13 weeks
74 after the removal of the flowers.

75 The bunches harvested were transported to the packing house of the IFPE - Vitória Campus

76 of Santo Antão, where they went through pre-cleaning and elimination of the rachis. They were then

77 cooled by tank immersion in water [containing](#), aluminum sulphate and 2% calcium chloride at 20 ± 2 °
C for 20

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78 minutes, followed by division into bouquets. The fruits were then transported in plastic boxes of 20 kg
79 to the Laboratory, where they were immersed in 2.5% sodium hypochlorite solution for 10 minutes.
80 The rinsing and drying were performed in air (22 ± 1 °C and $75 \pm 3\%$ RH) for 30 minutes. The
81 bouquets, with 3 to 5 fingers, after being selected and standardized for size and absence of visual
82 damage / defects, were subjected to sampling.
83 The experiment was conducted in a completely randomized design (DIC) containing 3
84 treatments (T1: Witness, T2: Use of calcium carbide, T3: Smothering) and 3 replicates. In all analyses,
85 three replicates were used with five fruits as experimental unit. For the treatment made with
86 suffocation the fruits were wrapped in low density polyethylene plastic bags. The analyses were
performed 1 hour, 48 hours
87 and 96 hours after the application of the treatments. The fruits were submitted subjected to titratable
acidity and
88 soluble solids analyzesanalyses.

89
90 After application of the treatments, the bouquets packaged in low density polyethylene were
91 stored in a refrigerator at 12 ± 1 °C and $93 \pm 2\%$ RH for up to 30 days. The low density polyethylene
92 film was 0.010 mm thick, permeability area of $805 \text{ cm}^3 \cdot \text{m}^{-2} \cdot \text{d}^{-1}$ oxygen permeability of $11.234 \text{ cm}^3 \cdot \text{m}^{-2} \cdot \text{d}^{-1}$
93 and carbonaceous gas permeability $05 \text{ cm}^3 \cdot \text{m}^{-2} \cdot \text{d}^{-1}$.
94 The analyses were evaluated according to the methodology proposed by the Adolf Lutz
95 Institute. The titratable acidity (TA) contents were determined by the titration of 10 g of comminuted
96 pulp, homogenized and diluted to 100 mL in distilled water, with 0.1 M NaOH solution, and a turning

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point at pH 8.2. The results were expressed as% of malic acid, 97 100 g^{-1} of pulp. [10]. Data were
98 submitted to analysis of variance through Genes [11]. Then the means were separated by the
TukeyTurkey
99 test ($p < 0.05$).

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101

102 3. RESULTS AND DISCUSSION

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104

105 Regarding the titratable acidity, in the analysis done in the first hour after the application of
106 the treatments the result of the control treatment and the banana conditioned to the suffocation did
107 not differ statistically among themselves. Table 1 shows the results obtained. Only the result of the
108 banana with carbide differed from the others. This can be expressed²²² due to the action of the
109 acetylene causing the acceleration of ripening in the banana. The higher production and,
110 consequently, the increase of the ethylene concentration in the packages, possibly potentiated the
111 rapid maturation in the bananas with carbide [11].

112 Ripening is the result of complex changes occurring in the fruit. The main changes that can
113 be observed are: respiratory rate increase, increase in ethylene production, increase in sugar
114 concentration, solubilization of pectic substances, pigment degradation, increase in the concentration
115 of phenolics and acids, production of volatiles, variations in the contents of enzymes, vitamins,
116 minerals and changes in the permeability of tissues [6].

117 According to the data result of total titratable acidity are described in Tables 1. In relation to the
118 behavior of total titratable acidity there was a tendency to decrease during forty eight and ninety six
119 hours after storage and may be associated to the increase of values pH in the same period. The
120 titratable total acidity was not influenced by the different climatization seasons and the values found
in

121 this experiment were within the range of levels found by other authors [12].

122
123

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

Titratable Acidity °Brix

hours 0 48 96 0 48 96

Witness 2.47Cb 12.20Aa 7.53Ba 4.86Cb 24.00Bc 25.9Ab

Bananas with

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carbide

8.40Ba 11.10 Aa 9.27AB

a

16.00Ca 25.00Bb 26.00Ab

Conditioned

banana

2.60Cb 12.13Aa 9.03Ba 4.96Cb 25.96Ba 27.00Aa

125 Means followed by the same capital letters in HORIZONTAL do not differ statistically from each other; Means

126 followed by the same lowercase letters in VERTICAL do not differ statistically from one another.

127

128 In the second analysis performed after 48 hours, the treatments were not statistically different,

129 this may have occurred due to the acceleration of the maturation provided by the carbide. [SaidThe](#)

130 analysis may also have coincided with the natural climacteric peak of the banana. For the analysis

131 done at 96 hours there was no significant difference between the treatments, since the bananas had

132 already reached their final maturation stage. After climacteric maximum, the process of senescence

133 begins where growth slows, and biochemical processes of aging prevail in transformations that tend

134 towards degradation [13].

135

136 In relation to the results of the analysis of the soluble solids contents done in the first hour

137 after the application of the experiment, the control treatment and that of the banana conditioned to

the

138 suffocation[???](#) were not statistically different from each other. Unlike the result of the banana with

139 that differed from the others [state result](#). Possibly this result is related to the transformation of starch

into simple

140 sugars as already explained [14]. In the second analysis, performed after 48 hours, all treatments

141 were statistically different [state results](#).

142

143 With maturation, the titratable acidity of the bananas increased, with relatively constant

144 increases, which may be the effect of the solubilization of pectic substances because of the enzymatic

145 activity. The bananas conditioned to choking[????](#) were the treatment that obtained the highest

146 concentration of soluble solids, followed by the banana with carbide and the control. In this case the

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divergences are due to the different metabolic rates (respiration), 147 ethylene production and relation

148 with other hormones [15].

149

150 In the third analysis done at 96 hours the treatment of the banana conditioned to the

151 suffocation was significantly different from the other treatments if it maintained with the highest

152 content of soluble solids, this characteristic can be expressed due to the mode of storage. After

153 reaching the peak of maturation are detected reductions in the soluble solids contents of banana

154 silver fruits [16].

155

156 Where it is concerned with the handling of storage conditions can significantly alter the levels

157 of reducing sugars. The contents of sugars vary according to the temperature of exposure and the

158 stage of maturity of the fruits [17].

159

160 The fruits matured by suffocation[???](#) also did not present problems in the staining and this is a

161 positive point. The factors that affect fruit quality are related much more to appearance and

162 distribution than to internal characteristics. To obtain good quality, you need properly developed

fruits,

163 uniform in size, without spots, bruises and rot, light yellow peel coloring and adequate shelf life.

164

165 Soluble solids are used as indicators of banana maturity that increase because of the

166 hydrolysis of the starch, precursor of sugars and, determine the quality of the fruit, exerting an

167 important role in the flavor [18]. In the present work, with carbide action the maximum value was

(26.0

168 °Brix), in Witness (25.9 °Brix) and Conditioned banana (27.0 °Brix). Thus, the highest concentration
of
169 soluble solids was obtained in Conditioned banana^{???} this process is the most suitable for
170 acclimatization conditions in organic production systems. The farmer in small areas does not need to
171 have the resources to buy carbide and not prey to use agrochemicals to obtain the rapid maturation of
172 bananas. and the **s** results show up to °Brix paw^{???} Conditioned banana.

174 4. CONCLUSION

175
176 The banana undergoes several metabolic changes during the maturation process that can be
177 observed by the parameters measured in the tests carried out in this experiment. In the treatment
178 where the bananas were **submitted subjected** to the action of the carbide, **there was had** an increase
in the rates of
179 titratable acidity and an acceleration in its maturation. Meanwhile in the treatment where the fruits
180 were conditioned to drowning^{???} at the end of their maturation they **obtained had** higher
concentrations of
181 soluble solids.

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229 DEFINITIONS, ACRONYMS, ABBREVIATIONS
230 Here is the Definitions section. This is an optional section.
231 Term: Definition for the term
232
233 APPENDIX
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