

Postharvest quality of banana 'Prata Anã' treated with microalgae coating

ABSTRACT

Biodegradable technologies that maintain the quality of food without causing harm to the health of the consumer or the environment will be an innovative tool applied in post-harvesting of fruits. The objective of this study was to test the efficiency of microalgae in the coating of bananas, of the variety: 'Prata Anã' stored under ambient temperature. The treatments were 0%, without coating; 2% Chlorella sp.; 2% of Scenedesmus sp.; 2% Spirulina platensis. After application of the treatments, the fruits were stored at 25 ± 2 °C and $65 \pm 5\%$ RH and analyzed periodically every two days for 10 days. The microalgae Spirulina platensis, Chlorella sp. and Scenedesmus sp., used at 2% in the coating of 'Prata Anã' bananas, offer reduction of ripening, maintenance of pulp firmness and fresh mass loss, potentiating fruit conservation for up to eight days, stored at room temperature (25 ± 2 °C and $65 \pm 5\%$ RH). Untreated fruits had accelerated ripening, high fresh weight loss and low pulp firmness, limiting post-harvest shelf life within six days of storage.

Keywords: *Musa acuminata*; conservation; edible films; alimentary safety.

1. INTRODUCTION

The banana (*Musa spp.*) it constitutes one of the main ones fruitful produced in all the continents, being one of the more important tropical fruits commercially, due to special flavor and nutritional properties, as well as world readiness along the year (Alali et al., 2018). The bananas are considered the second more important fruit in Brazil, just the oranges overcame production. The year of 2016, in agreement with [10], the total Brazilian production was of 6,7 million tons. In Brazil it prevails to cultivate Prata an evidence of good acceptance for the consumer.

Recently, a form quite studied to try to increase the life powder-crop of the fruits is the use of eatable coverings capable to delay the metabolism of the fruit and consequently to increase his/her useful life. The eatable coverings are being studied thoroughly in function of potential in increasing the useful life of the vegetables, they can be used to inhibit the migration of the humidity, oxygen and carbon dioxide, improving like this the characteristics of the covered products [5].

To improve the results of the coatings, the choice of the matter type excels to be used is of extreme importance. Among the several researched materials they stand out the microalgae, that can be an alternative for the coatings elaboration with the objective of prolonging the useful life of fruits and others vegetate.

Among the species of microalgae that they can be used for the fruit coating, stands out the use of the *Spirulina platensis*, which is interesting, because it presents in constitution great amount of proteins (64 to 74%), vitamins (A, B, B2, B6, B12, E and D), minerals, carbohydrates, carotenoids, beta-carotene, xanthophyll, γ -linolenic acid, antioxidant activity, among other properties [14, 2, 22]. Onias et al. [17] it detaches positive results when used as matter excels for the making of eatable coatings in the concentration of 3% associated to 3% of corn starch, it was what provided increase in the soluble solids around 30%, pulp firmness 15 N and loss of inferior fresh mass to 4%, and the largest vitamin content C to the 11 days of storage in mangos 'Tommy Atkins' stored 10 °C and 63% UR, shelf life of one day to 21,2 °C and 51% UR, being considered by the authors as better coating among tested them in the study.

Besides to *S. platensis*, the *Chlorella sp.* it also presents a rich constitution in proteins, substances as fatty acids, starch, mineral salts, phycocyanin, chlorophyll, beta-carotene, astaxanthin, vitamins, lipids, enzymes and essential amino acids [24].

Ursu et al. [23], they affirm that the proteins of the *Chlorella sp.* they possess a high emulsifying capacity compared with other ingredients overcoming them in this requirement. Besides rich composition that brings several benefits the human and animal health, the *Chlorella sp.* proved to have higher preservative activity than obtained them synthetically, such as, the compositions butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) [20]. Its rich composition does a promising matter of her excels for the use in fruits as a bio-organic coating, could join value to the products for their numerous nutritional properties.

The *Scenedesmus sp.* is one of the microalgae more thoroughly used in many studies for industrial application, such as for the production of biodiesel, bioethanol, polymeric and addictive alimentary because it is relatively easy to cultivate in culture and has the capacity to survive in extreme atmospheres. The microalgae of the gender *Scenedesmus* depending on cultivation possesses in constitution lipids (up to 60%), proteins (up to 60%), polysaccharides (up to 50%) and composed of high value, including, for instance, astaxanthin and lutein, besides containing all of the essential amino acids and good amounts of macro and microelements [1, 7].

In this sense, the objective of this work was to study the potential of the microalgae *Spirulina platensis*, *Chlorella sp.* and *Scenedesmus sp.*, for the use as coating in bananas 'Prata Anã' analyzed periodically under storage conditions in room temperature.

2. MATERIAL AND METHODS

The bananas 'Prata Anã' they were obtained in Petrolina-PE, the bunches were picked at stadium of maturation 2 (green peel with yellow lines), according to Norms of Classification of Banana [19]. They were conditioned in only layer, in containers previously covered with paper pricked to minimize the impact and the attrition among them and transported to the Postharvest Technology Laboratory of Fruits of the Federal University of Campina Grande (UFCG), Pombal-PB campus. In the laboratory selection was accomplished as for the size uniformity and color, discarding those with defects or offenses due to the transport. The fruits were washed with solution of neutral detergent to 1% and, after rinsing, sanitized with sodium hypochlorite solution to 100 mg L⁻¹ of chlorine, for 15 minutes and dry outdoors.

The experimental design was the completely randomized (DIC), in the outline of portions subdivided in the time, is tended in the portions the treatments (T), and in the subplots, the samplings along the time, with four repetitions and three fruits for portion. The samplings in the time happened periodically every other day, during 10 days of storage in atmosphere temperature (25 °C and 65% UR). The treatments (T) they were the following ones: T1: 0% control, without coating; T2: 2% of *Chlorella sp.*; T3: 2% of *Scenedesmus sp.*; T4: 2% *Spirulina platensis*, whose concentration was established previously with base in results of researches obtained for [15, 16].

The microalgae used in this study were produced according to [11], in tanks of organic production, in Fazenda Tamanduá, located in the city of Patos-PB. After the obtaining of the biomasses, the same ones were diluted in 2 L of distilled water, under constant agitation until the complete homogenization of the solution. The treatments were applied through the immersion of the fruits in referred them solutions. The analyzed variables were: Coloration of the peel through two readings in the equatorial area of the fruit and of the pulp through traverse cut and two readings for fruit, being used colorimeter (Konica Minolta, model Chroma to put CR-400), color space L * a * b *, for reflectance, whose calibration was accomplished with plate white pattern, following the manufacturer's instructions. The measured color parameters regarding to plate-pattern they were: Starting from the values L*, a*, b*, the angle hue was made calculations ($h^{\circ} = \arctang(a^*/b^*) \cdot (-1) + 90$), for a* negative and ($h^{\circ} = 90 - \arctang(a^*/b^*)$), for a* positive, and the saturation index or chromaticity, C * ($C^* = [(a^*)^2 + (b^*)^2]^{1/2}$); Firmness of the pulp (N): certain with aid of digital penetrometer, (Instrutherm, model PTR-300), being made measurements in two opposed points, in the equatorial area of the fruit with peel, accomplished with ferrule of 6 mm, according to [4]; Fresh mass loss (%): obtained by difference among the mass of the fruits checked in electronic scale, in the day of the installation of the experiment and every other day of the beginning of the storage. The homogenized pulp used in the evaluations was obtained after

it peels of the fruits and processing in domestic blender, being analyzed the following variables later: Titratable acidity (AT,% malic acid): certain through the titrating of 5 g of pulp of the banana diluted to 50 mL of distilled water and increasing 2 drops of phenolphthalein to 1%, proceeding the titration, under constant agitation, with solution of hydroxide of sodium NaOH to 0,1 M, according to [9]; pH: certain for direct reading in the pulp homogenized through digital peg of bench (Digimed DM-22), [9]; soluble Solids (SS,%): certain in the pulp through direct reading in digital refractometer (Instrutherm) [4]; SS/AT ratio: made calculations by the quotient among the two variables; Total soluble sugars (%): certain for the anthrone method, second procedure described by [26] with modifications. 0,5 g of the sample was diluted for 100 mL of distilled water, soon later it was taken brackets of 0,5 μ L for fruits up to four days also adding 0,5 μ L of distilled water totaling 1 mL, and brackets of 0,3 μ L for fruits starting from six days also adding 0,7 μ L of distilled water totaling 1 mL, to which 2 mL of anthrone was added in one tube under agitation, being put in bath Maria to 100 °C for 5 minutes, after cooling, the samples were taken to the spectrophotometer for reading, the a wavelength of 620 nm.

The results were submitted to variance analyses and polynomial regression starting from the obtained averages of the samples of each treatment, compared by the significance of R^2 of the equation and for the test t of Student, to 5% of probability being used the software SISVAR version 5.6 [8].

3. RESULTS AND DISCUSSION

In the day of the installation of the experiment, analyses were accomplished in the bananas for the characterization of the fruits in the moment of the crop, presenting the following values, according to the Table 1.

Table 1 - Initial Characterization of bananas 'Prata Anã', for occasion of the crop. Pombal-PB, 2018. (n=12)

Characteristics Initials	Averages $\pm$ DP
Fresh mass loss (g)	140,00 $\pm$ 11,05
Brightness in the peel (L^*)	57,07 $\pm$ 2,45
Chromaticity in the peel (C^*)	40,79 $\pm$ 1,08
Hue angle (h°) in the peel	116,58 $\pm$ 0,52
Brightness in the pulp (L^*)	86,4 $\pm$ 0,34
Chromaticity in the pulp (C^*)	21,43 $\pm$ 1,35
Hue angle (h°) in the pulp	92,08 $\pm$ 0,77
Pulp firmness (N)	63,65 $\pm$ 5,82
Titrateable acidity (% malic acid)	0,33 $\pm$ 0,65
pH	5,73 $\pm$ 0,07
Soluble solids (%)	4,55 $\pm$ 0,63
SS/TA ratio	14,66 $\pm$ 0,52
Total soluble sugars (%)	3,80 $\pm$ 0,29

The isolated effect of the factor was verified time of storage for the characteristics of brightness and chromaticity of the peel, and interaction between the coatings and the time of storage, for the other studied characteristics. Quadratic behavior is observed along the storage period, evidencing that the coatings didn't interfere in a negative way in the process of evolution of the coloration of the bananas, that happened slowly when compared the values of the fruits in the moment of the installation of the experiment, with the following values: for brightness and chromaticity of the peel, 57,07 and 40,79, respectively, and after 10 days of storage, they presented average of 57,27 for brightness and 41,09 for chromaticity, Figure 1(A and B). During ripening, the banana presents a change of coloration of green peel for yellow, resulting in increase in the values of the parameters of color of the brightness and of the it chromes, reflecting the yellowing of the peel [25]. [13] evaluating the effect of films formed by pectin, egg albumen, carrageenan, gelatin, potato starch, xanthan and corn starch in the conservation of banana cv. Caturra (*Musa paradisíaca* L.) it observed a yellowish coloration in all of the treatments, during every storage period.

133 The color angle (h°) of the peel it presented tendency to decrease along the time of storage, the fruits
 134 began with average of $116,58^\circ$ characterizing a green coloration with yellow lines, and the fruits
 135 control presented the smallest values, fact that it can be observed to the 6 days in that the fruits
 136 without coating presented values of (h°) of $103,30^\circ$ and the largest value among the coatings was
 137 verified in 2% of *Scenedesmus* sp. of $111,43^\circ$, the other coatings stayed same. Already to the 8 days
 138 the largest value of (h°) it was verified for 2% of *S. platensis* of $105,88^\circ$, and again the smallest value
 139 was verified for the fruits control of $95,21^\circ$. This reduction in the color angle coincides with the
 140 ripening of the fruit, in which happens the change of green coloration in the peel of the bananas for
 141 yellow, indicating that the fruits no covered to the 8 days of storage they presented coloration of the
 142 yellowish peel and the covered fruits presented peel with coloration yellow greenish (Figure 1C).

143 It is verified for the brightness of the pulp tendency to decrease along the storage period, us which the
 144 fruits with coatings didn't present great variations, presenting same behavior until the 6 of storage,
 145 and differing to the 8 days in that the fruits control presented the smallest value $75,09$. The coating to
 146 2% of *S. platensis* was the second smallest value, $80,24$, characterizing a darker pulp, indicating
 147 retard in the process of ripening of the pulp of the bananas (Figure 1D).

148 For the pulp the (h°) there was little variation along the time, already among the coatings it happened
 149 larger variation to the 8 days of storage, in that the control presented the largest value of $91,56^\circ$ and
 150 the smallest value for 2% of *S. platensis* ($87,95^\circ$). The fruits of the control presented characteristic
 151 pulp of banana ripens with coloration of cream-colored color. The covered fruits presented pulp of
 152 yellow coloration, with greenish lines, indicating retard in the ripening (Figure 1E).

153 Oliveira et al. [15] they also verified that with the increase in the concentrations of the coating of
 154 *Chlorella* sp. it happens larger pulp firmness and smaller transformations in the color of the peel of the
 155 mangos "Tommy Atkins". And that the use of the coating of *Chlorella* sp. in the concentration of 1%
 156 and 2%, it provides ripening without damage in the attributes of quality of the fruits analyzed to the 28
 157 days of storage (21 days to 10°C and 42% UR, more seven days to 25°C).

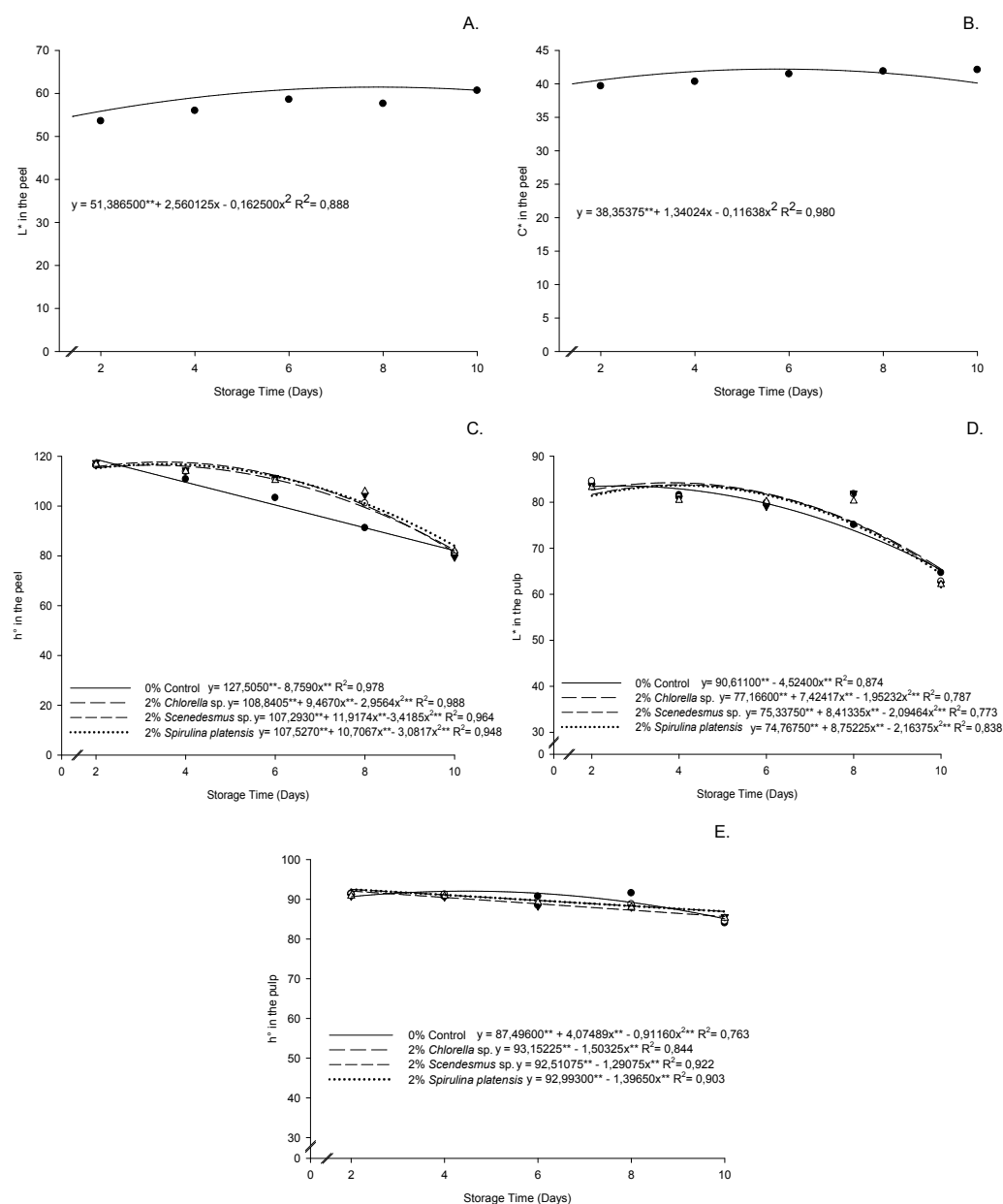
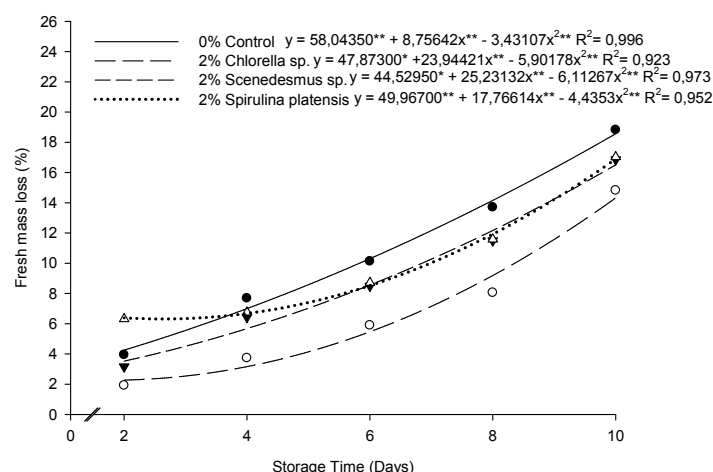


Figure 1. Brightness of the peel (L^*), hue angle in the peel (h°), chromaticity in the peel (C^*), brightness in the pulp (L^*), hue angle in the pulp (h°), respectively (A, B, C, D and E) in bananas 'Prata Anã' submitted the different coatings the microalgae base during the storage under $25 \pm 2^\circ\text{C}$ and $65 \pm 5\%$ UR, after 10 days.

The fresh mass loss of the bananas increased for all of the treatments studied along the storage, and the fruits of the control presented larger mass loss. To the 6 days of storage, the fruits control lost 10,12% of mass, following for the concentration 2% of *Chlorella* sp. with 5,89%, being this to smallest mass loss. In this way, the fruits covered with 2% of *Chlorella* sp. they maintained turgidity until the 8 days of packaging. At the end of the experiment larger mass loss was verified for the fruits controls of 18,82%, following by 2% of *Spirulina platensis* and 2% of *Scenedesmus* sp. 17,02 and 16,85%, respectively, and smaller mass loss for the bananas covered with 2% of *Chlorella* sp. 14,81% (Figure 2).

Oliveira et al. [16] they verified that the best indicative physical-chemical of maintenance of the quality mango 'Tomy Atkins' they were observed in the fruits that received the coating to the 1% of *Chlorella*

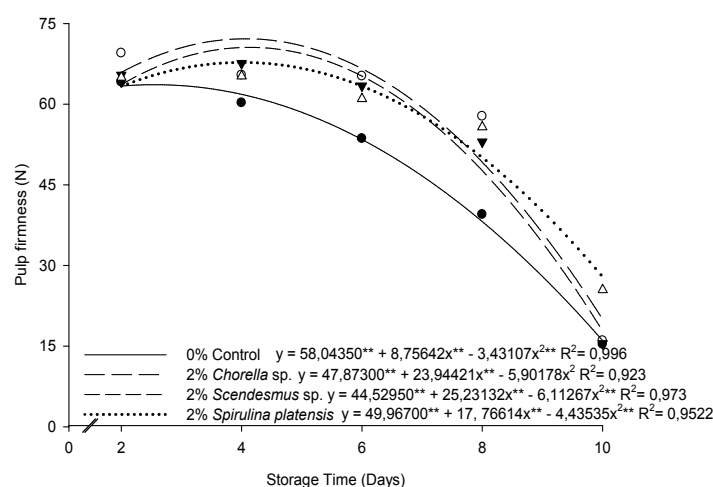
173 *sp.*, as reflex in the good appearance, **loss of inferior fresh mass to 5,5%** and total sugars above 12%,
 174 in storage conditions refrigerated to 10 °C and **atmosphere to 23 °C.**



175

176 Figure 2. Fresh mass loss (%) in bananas 'Prata Anã' submitted the different coatings the microalgae
 177 base during the storage under 25 ± 2 °C and 65 ± 5% UR, after 10 days.

178 The results for the **firmness of the pulp** had quadratic behavior, with significant reduction at the end of
 179 the storage. To the 6 days; the behavior was similar to it of loss of fresh mass, with prominence for
 180 the fruits covered with 2% of *Chlorella sp.*, which presented the largest pulp firmness, 65,24 N, while
 181 the control obtained the value of 53,61 N. To the 10 days, to smallest pulp firmness it continued in the
 182 fruits no covered of 15,35 N, following for 2% of *Scenedesmus sp.* and 2% of *Chlorella sp.* with 15,49
 183 and 16,01 N, respectively. The largest firmness was observed for 2% of *S. platensis* presenting 25,46
 184 N (Figure 3). [13] evaluating effects of films of polymeric natural in the conservation of banana cv.
 185 'Caturra', it also observed reductions of the firmness in all of the treatments along the storage, the
 186 same indicates that were proportionate for the reactions so much of syntheses, as degradations of the
 187 components of the cellular wall and to the loss of turgidity of the cells in the fabric with the progress of
 188 the ripening of the fruit.



189

190 Figure 3. Pulp firmness (N) in bananas 'Prata Anã' submitted the different coatings the microalgae
 191 base during the storage under 25 ± 2 °C and 65 ± 5% UR, after 10 days.

192

The titratable acidity presented increase tendency in all of the studied treatments, along the storage period, among the coatings there was not significant difference until the 6 days of storage, in which the smallest values were observed to 2% of *Spirulina platensis* (0,45% of malic acid), following for 2% of *Chlorella* sp. (0,60% of malic acid), control and 2% of *Scenedesmus* sp. with medium values of 0,65% of malic acid. In the end of the storage, the control had the smallest values (0,72% of malic acid) and 2% of *S. platensis* with 1,33% of malic acid; however, all the results obtained starting from the 8 days of storage were superior to the moderated by other studies with banana of same variety (Figure 4A). [12] they obtained 0,22% to 0,36% of malic acid in study with study with bananas 'Prata Anã' stored by 35 days, under cooling. Sarmento et al. (2015) for banana Silver they told values among 0,2% to 0,5% of malic acid.

Due to the increase tendency in the acidity, reduction was verified accentuated in the pH values for all of the treatments tested along the time of storage, presenting significant difference to the 6 days and 8 days of storage, being the smallest values of the fruits control, 4,41 and 4,14, respectively, among the coatings it was not verified differentiates amongst themselves, being the largest values moderated by 2% of *S. platensis* of 5,13 in keeping with the results of acidity at the end of the storage (Figure 4B).

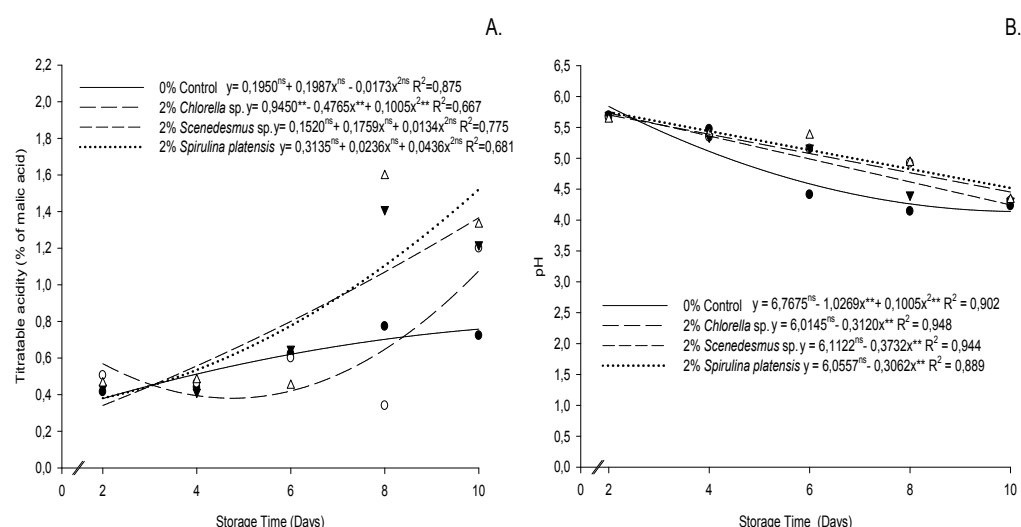
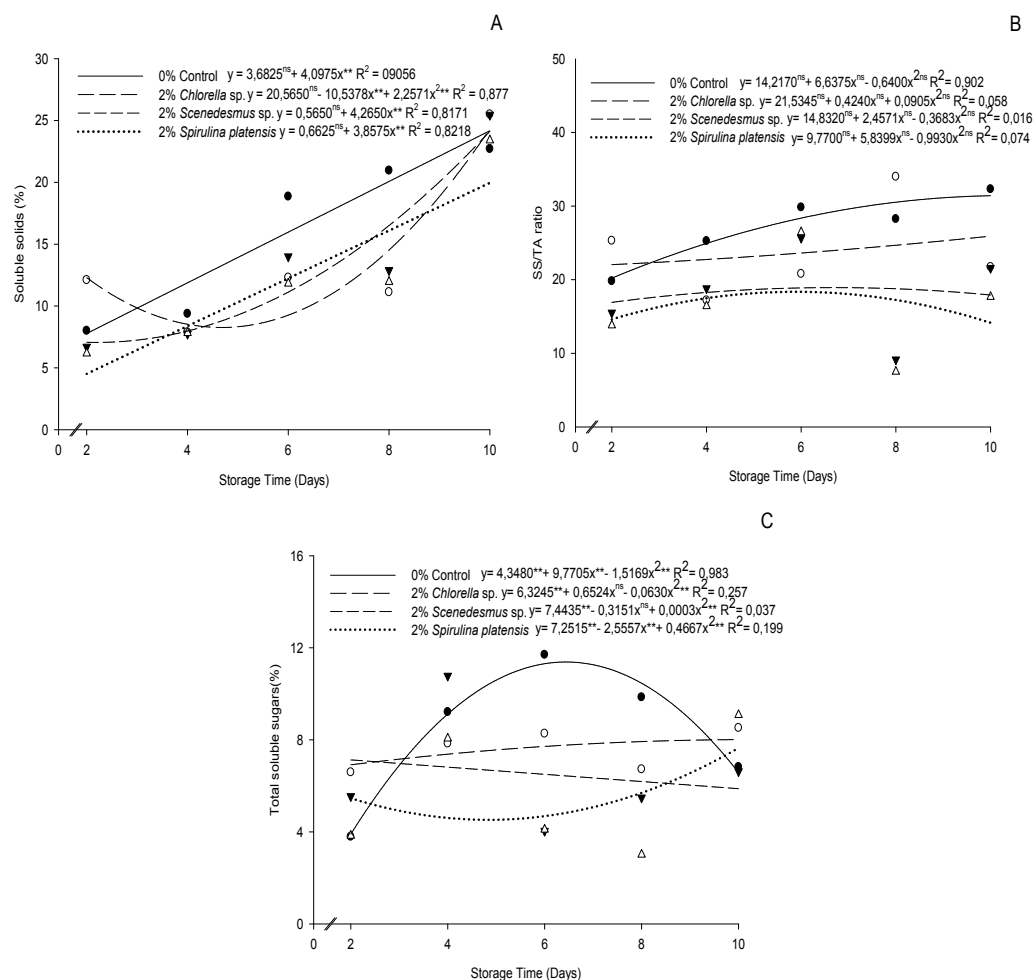


Figure 4. Titratable acidity (% of malic acid) (A), and pH (B), in bananas 'Prata Anã' submitted the different coatings the microalgae base during the storage under 25 ± 2 °C and 65 ± 5 % UR, after 10 days.

The soluble solids increased along the storage period, until the 8 days of storage the treatments that presented the largest values of soluble solids were the control with 20,95 following by 2% of *Scenedesmus* sp., however to the 10 days of storage the coating 2% of *Chlorella* sp. it presents the largest values with 25,50 and the fruits control presented the smallest values of 22,70 (Figure 5A). That behavior of SST indicates that the starch is hydrolyzed in sugars, through primary metabolism to supply breathing substrate for biological activities of the fruit, with consequent increase of the sweetness [18].

In agreement with the increase of the acidity and soluble solids along the storage, the ratio also presented tendency to growth along the packaging period, presenting variation among treatments, to the 10 days. The control had the largest value for the ratio of (32,30), following for 2% of *Chlorella* sp., 2% *Scenedesmus* sp. and 2% *S. platensis*, respectively, 21,73, 21,58 and 17,66 (Figure 5B). According to [6], the high ratio is very important and desirable in the fruits, being one in the ways more used for the evaluation of the flavor.

227 The total soluble sugars presented variations for all of the treatments along the storage period,
 228 beginning with value of 3,80%, and occurrence of the first variation to the 6 days of storage, in which
 229 the control presented the pick of synthesis of 11,70%, following for 2% of *Chlorella* sp. (8,27) and the
 230 other coatings *Scenedesmus* sp., *S. platensis*, with 4,04% and 4,10%, respectively. At the end of the
 231 storage it is observed that the fruits covered with *S. platensis* presented the largest values (9,08),
 232 following for *Chlorella* sp. (8,52), values inferior were certain in the fruits no covered (6,82), close
 233 values to the obtained with 2% of *Scenedesmus* sp. (6,63). In agreement with [6], (2005) the
 234 increases of total sugars are associated with the the elevation of the tenors of soluble solids, (Figure
 235 5C), although the measurement of these, don't represent the exact tenors of the produced sugars,
 236 therefore other substances also one find dissolved in the vacuolar sap: (vitamins, phenolics, pectins,
 237 organic acids, etc.); however, the sugars are the most representative, getting to constitute up to 85 -
 238 90% of the soluble solids.



239

240 Figure 5. Soluble solids (%) (A), SS/TA ratio (B) and total soluble sugars (%) (C), in bananas 'Prata
 241 Anã' submitted the different coatings the microalgae base during the storage under $25 \pm 2^\circ\text{C}$ and 65
 242 $\pm 5\%$ UR, after 10 days.

4. CONCLUSION

The microalgae *Spirulina platensis*, *Chlorella sp.* and *Scenedesmus sp.*, used to 2% in the coating of bananas 'Prata Anã' they reduce the ripening, the loss of pulp firmness and the mass loss, potentiating the conservation of the fruits for to eight days under storage in atmosphere conditions ($25 \pm 2^\circ\text{C}$ and $65 \pm 5\%$ UR).

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