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Assessment of cassava starch biofilm in the quality and shelf life of banana 'prata'

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Abstract: Brazil is now the world's fourth-largest banana producer in the world with an annual production of 6.953,747 tons per year. In Brazil, the banana (*Musa* spp.) stands out, not only because it is the most widespread, but also because it is the most consumed by all social classes. Cassava is a renewable, almost unlimited resource and one of the most abundant substances in nature. It is one of the most important starchy root crops of the tropics used for food and industrial purposes. The present study evaluated the use of biofilms based on cassava starch in maintaining the quality and shelf life of the 'Prata' banana at room temperature. Initially, filmogenic solutions were produced using the casting technique for two treatments. T1 (2.6% starch / 500 mL of distilled water); T2 (2.6% starch / 500 mL of distilled water + 1 g of gelatin). Additionally, thickness, weight, and, subsequently, the biofilms were applied in the film-forming solution for 1 min and suspended for further drying at room temperature. After this process, were evaluated the loss of fresh mass, pH, and totals soluble solids. The present study revealed the efficiency of biofilm coating with and without gelatin to reduce the rate of enzymatic browning and increase the shelf life of bananas. It was possible to verify a smaller reduction in fresh weight loss in the treatments. Besides, no significant difference was observed in the addition of gelatin to the parameters evaluated in the fruit.

Keywords: cassava starch, biofilms, food security.

Adherence to the BJEDIS' scope: This paper presents Tukey's test to analyze all the variables obtained. In addition to using regressions to determine the behavior of fresh mass loss as a function of the two biofilms during 12 days of the experiment.

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1. INTRODUCTION

Brazil is now the world's fourth-largest banana producer in the world with an annual production of 6,953,747 tons per year [1].
Among the countless varieties of fruit produced in the world, the banana stands out, not only because it is the most widespread, but also because it is the most consumed by all social classes. The banana, the world's most widely produced and commercialized fruit, is grown in all tropical regions of the world, being strongly present in local businesses and subsistence crops serving as an important source of nutrients for the poorest populations [2].
In Brazil, the banana (*Musa* spp.) stands out, not only because it is the most widespread, but also because it is the most consumed by all social classes [3].
Biodegradable packaging, also known as biofilms, is developed by polymers, from natural sources, such as corn, cellulose, cassava, etc. In which the degradation occurs by microorganisms in weeks or months under favorable conditions of biodegradation [4].
Although there are many processing possibilities for fruits, there is an increasing search for methods that less alter the physical-chemical and sensory characteristics of these foods. One way to preserve the original characteristics of fruits and vegetables and increase shelf life is to apply minimal processing. Minimally processed vegetables are those that undergo only physical changes, maintaining their state of freshness, including operations such as selection, washing, sanitizing, peeling, cutting, centrifugation, packaging, freezing storage [5].
Despite guaranteeing a food closer to natural, minimal processing still lacks a longer shelf life. There are, however, some possibilities for mild treatments that can increase the shelf life of minimally processed vegetables and fruits. Among them, the use of edible coatings or biofilms, bleaching, various forms of refrigeration, and the use of substances for protecting food can be highlighted [6].
Cassava is a renewable, almost unlimited resource and one of the most abundant substances in nature. It is one of the most important starchy root crops of the tropics used for food and industrial purposes [7]. In the quest for developing more sustainable materials, several works with biofilms of cassava starch have been developed [8; 9; 10]. With the addition of cellulosic fibers [11; 12] clay [13], and several other additives.
The present study aimed to evaluate the use of biofilms based on cassava starch in maintaining the quality and shelf life of 'Prata' banana at room temperature.

2. MATERIALS AND METHODS

2.1 Production of the film starch solution

Filmogenic solutions were developed using the casting technique, according to Souza et al. [14], with adaptations. Two treatments were used. T1 (2.6% starch (m/v) + 300 mL of distilled water); T2 (2.6% starch (m/v) + 1 g of gelatin + 300 mL of distilled water). Initially, the starch was gelatinized to approximately 85 °C under constant agitation for 25 min. For the T2 treatment, gelatin diluted in 20 mL of water was added, starting at 70 °C through drip. Then, the material was placed in Petri dishes to dry at room temperature with three replicates by treatment.

2.2 Physical characterization

2.2.1 Thickness

The thickness of the biofilms was measured with the aid of a DIGIMESS micrometer with a scale from 0 to 0.25 mm with an accuracy of 0.001 mm. The final thickness of this corresponded to the arithmetic mean of five random points from each sample [15].

2.2.2 Grammage

To calculate the grammage, the ratio between the quantity of the solution divided by the area occupied by the film was used [16]. The weight is given by the equation: G = 10000 * p / α. where, G is the weight expressed in g/cm^2 p is the sample mass and α is the sample area. With that, the result was given in g/cm^2.

2.3 Application of biofilm in fruits

To evaluate the protective properties of the biofilm, the treatments described in item 2.1 were used, in addition to a negative control group (without the biofilm) [17]. A completely randomized design was adopted, with three replications by treatment. The fruit chosen for the covering was the silver banana (*Musa* sp., cultivar Prata), because it is a climacteric fruit [18]. They were selected by format, color, and degree of ripeness, without damage or presence of rot, all from the same bunch, purchased at a supermarket in Méier / RJ. The fruits were cleaned by immersion, for five minutes, in sodium hypochlorite solution (2%), followed by rinsing by immersion in running water before processing [19]. Additionally, the fruits were immersed in the film-forming solution for 1 min and suspended for further drying at room temperature (Figure 1).

Figure 1. Process of immersing banana (*Musa* sp., cultivar Prata) in the film-forming solution for 1 min.

2.5 Fresh mass loss

The loss of fresh weight was obtained by the difference between the initial weight of the fruits and after each time interval (3, 6, 9, and 12 days), with the results expressed as a percentage [20].

2.6 pH and totals soluble solids

After the end of twelve days of biofilm application, and the pH and ºBrix of the fruits were evaluated. For pH measurement, 10 g of sample was macerated with 90 g of distilled water in a blender. The paste supernatant obtained was used for direct reading on an AKSO Combo 5 digital multiparameter meter [21]. The content of total soluble solids was determined using a portable refractometer, model RCZ, with a reading of the 0 a 32 ºBrix, after extracting a sample of the pulp from the central region of each fruit, the result being expressed in ° Brix [22; 20].

3. STATISTICAL ANALYSIS

The means of the variables obtained were compared using Tukey's test at 5% probability using the SigmaPlot 12.5 program.

4. RESULTS AND DISCUSSION

The biofilms synthesized by the casting technique presented a good visual aspect, transparency, homogeneity, and flexibility. The T1 film proved to be more malleable than T2. Figure 2 shows the biofilms after removing the Petri dish.

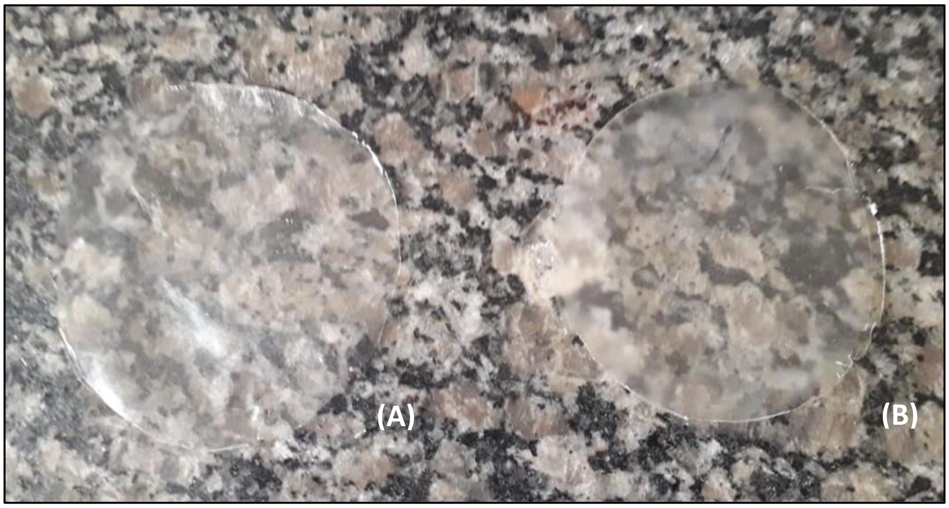


Figure 2 - Visual aspect of cassava starch biofilms. (A) T1 (2.6% starch (m/v) + 300 mL of distilled water); (B) T2 (2.6% starch (m/v) + 1 g of gelatin + 300 mL of distilled water).

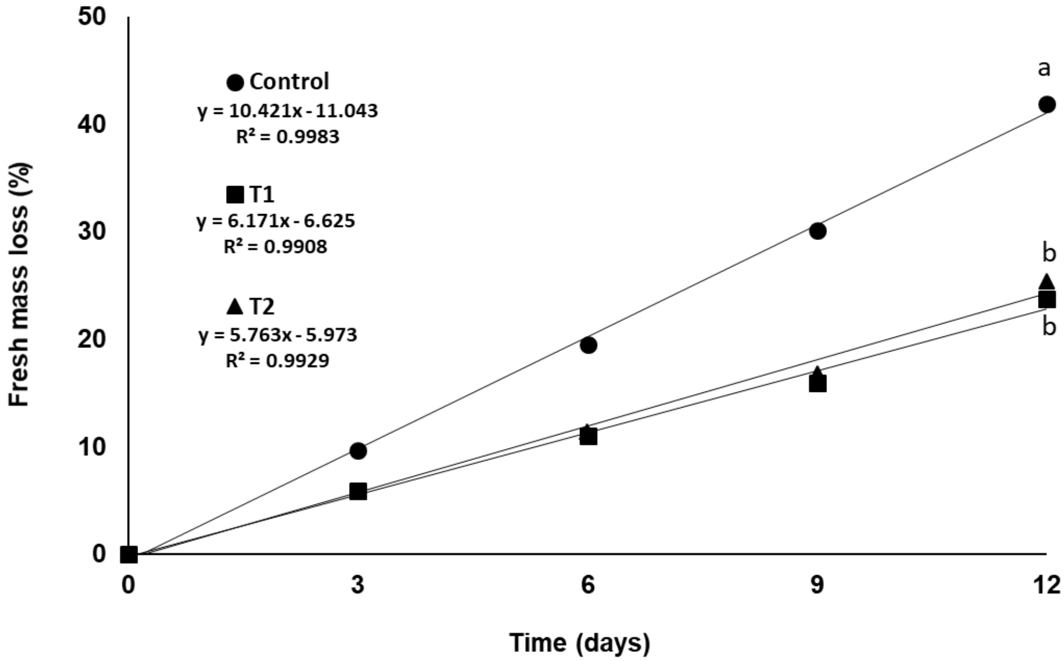
The means values of the thickness and grammage of the biofilms are shown in Table 1. For the T1 treatment, the thickness was 0.05 mm and the grammage 3.98 g / cm^2. For T2, the thickness was 0.11 mm and the grammage 47.81 g / cm^2. Significant differences were found for these parameters. Similar thickness results for cassava biofilm and gelatin use have already been reported [23; 24]. The grammage is directly related to the mechanical resistance of the films. Larger weights offer greater mechanical resistance [25]. It appears that the introduction of gelatin as a plasticizing agent conferred a greater weight for the T2 treatment.

Table 1. Thickness and grammage results.

Treatments	Thickness (mm)	Grammage (g/cm²)
T1	0.05[a]	3.98[a]
T2	0.11[b]	47.81[b]

Means followed by the same lowercase letter in the column do not statistically differ from each other by the Tukey's test at 5% probability.

The means values of fresh mass loss as a function of time are shown in graph 1. At the end of the analysis period, the control group had a 41.88% loss, followed by T1 (23.77%) and T2 (25.41%). No significant differences were found for biofilm treatments. The mass loss occurs through the outlet in the form of water vapor to the environment [26], so the results obtained demonstrated that the biofilms protected fruits by minimizing water loss through perspiration, avoiding fruit shrinkage and shriveling as a natural indication of ripeness.



Graph 1. Fresh mass loss as a function of the two biofilms during 12 days of the experiment. (●) Control group; (■) T1 (2.6% starch (m/v) + 300 mL of distilled water); (▲) T2 (2.6% starch (m/v) + 1 g of gelatin + 300 mL of distilled water). Means values followed by the same lower-case letter do not differ statistically by Tukey's test at 5% probability test.

We observed that the samples treated with biofilm showed a better appearance and were the ones that had the least loss of water during the analysis period (Figure 3). On the other hand, the group without coating showed a different color at the end. The application of biofilm was efficient to reduce the fruit's contact with oxygen in the air, delaying the enzymatic browning, and formed a barrier to water loss, reducing exudation, and guaranteeing better quality of fruits for a longer time [17]. Biofilms produced with cassava starch with concentrations of 3% for strawberry protection, managed to retain the color of the fruits for a longer time, providing greater quality in post-harvest life [27].

Figure 3. Application of biofilm in banana (*Musa* sp.Cultivar Prata) during 12 days of the experiment. (A) Control group; (B) T1 (2.6% starch (m/v) + 300 mL of distilled water); (C) T2 (2.6% starch (m/v) + 1 g of gelatin + 300 mL of distilled water).

The means values of pH and totals soluble solids are shown in Table 2. The values found for pH were 5.0 for all treatments and °Brix ranged from 21.9 to 22.2 °Brix. The decrease in pH during ripening is expected to be associated with the accumulation of sugar and acid constituents during the ripening of fruits. As soluble sugars are precursors of organic acids, with a predominance in bananas, of malic acid, their accumulation decreases pH during ripening [28]. During the ripening of the fruit, the conversion of starch into sugars occurs, providing an increase in soluble sodium content [29].

Table 2. Result of pH and totals soluble solids.

Treatments	pH	Totals soluble solids (°Brix)
Control	5.0^a	22.2^a
T1	5.0^a	20.7^a
T2	5.0^a	21.8^a

Means followed by the same lowercase letter in the column do not statistically differ from each other by the Tukey's test at 5% probability.

The soluble solids in banana, range from 19.72 to 22.36 °Brix for the ripe fruit [30; 22]. Several factors are related to the content of soluble solids, among them, the state of ripeness, edaphoclimatic conditions in which the fruit was produced, conditions of artificial ripening and storage [31]. No significant differences were found for the values of soluble solids. However, the values found are within the acceptable range for ripe fruit and in good condition for consumption.

5. CONCLUSION

This study revealed the efficiency of biofilm coating with and without gelatin to reduce the rate of enzymatic browning and increase the shelf life of bananas. It was possible to verify a smaller reduction in fresh weight loss in the treatments. Besides, no significant difference was observed in the addition of gelatin to the parameters evaluated in the fruit.

Sample CRediT author statement

Sérgio Thode Filho: Conceptualization, Methodology, Data analysis, and Writing-Original draft preparation. **Emanuele Nunes de Lima Figueiredo Jorge**: Conceptualization, Supervision, Reviewing and Editing. **José Armando dos Santos Souza**: Reviewing. **Ana Carolina Valle da Silva:** Reviewing. **Fabíola da Silveira Maranão**: Reviewing and Editing. **Fernando Gomes de Souza Junior**: Methodology, Supervision, Data analyses and Reviewing.

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