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Post-Harvest Application of Giberelic Acid as a Retarding Agent of Ripening Banana from the Tropic of Cochabamba

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Abstract: The banana crop is one of the crops with the greatest economic and social impact in the tropics of Cochabamba, but it presents waste due to it is short shelf life. For this reason and the increasing demand for this fruit, a ripening retardation technique based on plant growth regulators for agricultural use is proposed. The work evaluated the effect of gibberellic acid (AG_3) on the shelf life of sweet banana *Musa* variety *Cavendish Robusta Valery* after harvest. Three treatments were carried out with doses of gibberellic acid, plus the control; then controls were carried out on the maturation times. Bunches were taken from a single plot with a dose for each box of bananas, which contains approximately 120 units. The bananas, harvested with all the green skin, were sprayed with gibberellic acid minutes before packing, in the following treatments: 10, 15 and 20 cc/l of AG3. The bananas were stored in a controlled environment (20 ± 1°C, with 40% humidity). Spray application of gibberellic acid to bananas provided 1.5 days of additional pot life. After 10 days of storage, the AG_3 doses of 15 cc/l and 20 cc/l were the most propitious for post-harvest storage of *Musa* variety *Cavendish Robusta Valery* sweet banana.

Keywords: Cavendish, Gibberellins, Vegetable Hormones, Muse

1. Introduction

Musa banana cultivation is one of the crops with the greatest economic and social impact in the Cochabamba tropics, with cultivated areas that have increased considerably in the last ten years [6]. In 2015-2016, a cultivated area of 19,837 hectares and a production of 299,580 metric tons were recorded in Bolivia [8].

There is increasing competition in terms of price and quality of bananas at the national level among companies engaged in the trade of this [3], these data require having or resorting to appropriate technologies and techniques, which allow bananas to be preserved with good quality for longer, to be intended for human consumption or processing [5].

Currently there is information on ripening technology and techniques, but not for the retardation of banana ripening, which allows a homogeneous ripening of the fruit in consumption grade that is grade 6, without losing the quality and in that way supplying the market with a banana with longer shelf life [14].

According to the Von Loesecke Scale, banana ripening grades according to color range from grade 1, completely green, to grade 7, completely yellow, the maximum ripening level [12].

The banana crop in the Cochabamba Tropics region is wasted due to post-harvest handling problems and short shelf life. The other problems, such as, fruit malformation, growth scar, among others, are classified in the selection stage [12]. To extend the shelf life of banana, a ripening retardation technique is proposed based on plant growth regulators for agricultural use, as is the case of gibberellic acid (AG3). About 65 gibberellins have been identified in plants, of which 12 are exclusively in the Gibberella fungus [2]. Gibberellin number 3 has been the most studied due to it is high effectiveness and presence in plant tissues; it is known as Gibberellic Acid [4]. Gibberellic acid is a phyto-regulator with hormonal action that stimulates and regulates plant development (working at the cellular level) and belongs to the group of gibberellins [9].

The objective was to evaluate the ripening of banana from the Cochabamba tropics with the application of gibberellic acid as a ripening retardant agent.

2. Methodology

The steps for the phytosanitary treatment with gibberellic

acid were as follows: first, the solution was prepared with fungicide and alum as usual for banana phytosanitary treatments, the gibberellic acid was added together with the alum and the fungicide in the defined doses.

Secondly, the mixture was applied with the help of a spray backpack (with a cone type nozzle filled with 10 liters) on the crowns and the sanitation of the segments [15].

The boxes were then packed in hard plastic boxes with perforations that allow air circulation, provided by Ebita SRL. The boxes were identified with colored ribbons according to the dose of gibberellic acid used, being red, yellow and green for the control, green for the minimum dose, yellow for the medium dose and red for the high dose.

Finally, once the boxes were packed, ready to be covered from the sun, the truck picked them up, just as it does with the fruit that is marketed in the city of Cochabamba.

Table 1. *Characteristics of harvested bananas.*

Harvest age and ribbon color	12 weeks - green ribbon
Harvest and packing date	Oct-16-2019
Packaging process	Packing by loose finger system
Application of gibberellic acid	Oct-16-2019
Treatments	10, 15 y 20 cc/l de AG_3
Time and method of application	Spraying (10 seconds) on the crown of banana
Quantity of bananas treated	1 box (120 units) for treatments

Scale	1	2	3	4	5	6	7
%	14,3	28,6	42,9	57,1	71,4	85,7	100

Source: Based on Soto (2008).

Figure 1. *Maturation scale used in evaluation.*

Figure 1 shows the ripening scale used in the evaluations. where; (1) completely green, state in which it is harvested and should reach the ripening chambers. (2) light green, first color change in the peel, indicates the beginning of color change. (3) light green with yellow, ripening is in process, shipment to wholesalers in temperate climate conditions. (4) yellow with green, color recommended for shipment to wholesaler and next display. (5) yellow with green tips, recommended for display and at higher temperatures the fruit may ripen faster. (6) Totally yellow, state suitable for sale and consumption, has firmness and good flavor. (7) yellow with brown freckles, completely ripe, high nutritional value and more sweetness. The percentage of maturity was obtained by the rule of three [(n/7)*100], taking into account the maturity scale.

3. Results and Discussion

3.1. Peel Color

Treated bananas were evaluated every day at 8:00 a.m. for a period of 10 days (day two was not evaluated since the boxes were inside the ripening chamber unopened). According to [13], loss of green color is one of the ripening symptoms leading to fruit senescence; fruits treated with AG3 100 mg/l in the study conducted by [13], had minimal hue angle, which is indicative of a possible action of AG3 to slow chlorophyll degradation, as gibberellins have the function of slow fruit ripening, which mainly affects the color changes of the peel.

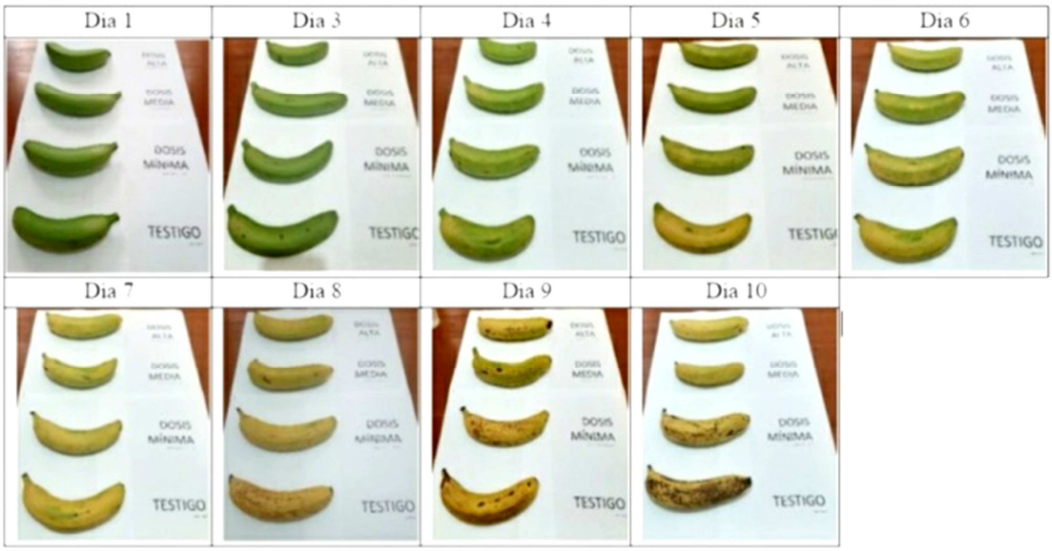

Figure 2. *Change of shell color per day.*

Figure 2 shows the sequence of the ripening process according to the treatments evaluated, being T1: 0 cc/l AG3 (control), T2: 10.0 cc/l AG3 (minimum dose), T3: 15.0 cc/l AG3 (medium dose) and T4: 20.0 cc/l AG3 (maximum dose). It was observed that on the fifth day the control (T1) already turned yellow, while the bananas with gibberellic acid still remained green (T2, T3 and T4). On day eight it was observed that the control (T1) was already at maturity grade 7, fully ripe with freckles, while the dose with 20.0 cc/l of AG3 (T4) remained at maturity grade 5 for days seven and eight. On day ten, the control (T1) already had a maturity higher than grade 7, while the bananas with gibberellic acid (T2, T3 and T4) remained at favorable consumption grades (maturity grades 5 and 6), giving two more days of yellowish coloration on the peel.

3.2. Degree of Ripening

The change in the degree of ripening is represented in Figure 3, it can be observed a change in the degree of ripening from the second day, changing 1.5 degrees of ripening each day in all samples, being the control (T1) that presented a higher rate of change in the degree of ripening. Banana slices treated with mannitol solution (120 mmol/l), with 0.1 mmol/l AG3, showed a delay in ripening [11]. In this regard, [10] noted that loss of pulp firmness is associated with enzymatic activities related to the degradation of cell wall and pectic components of the middle lamina and the conversion of starch to sugars during ripening.

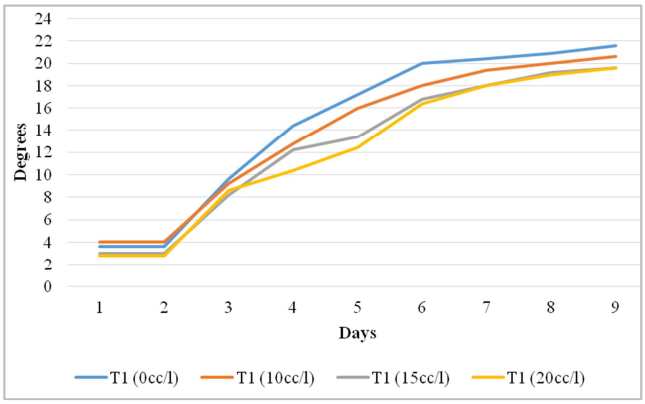

Figure 3. *Degree of ripening of banana according to treatment.*

3.3. Flesh Color

The change in banana flesh color over the nine days of ripening showed that the control (T1) had the fastest color change, while bananas with T4 had a slower color change. Treatments T2 and T3 also showed a slower rate of color change than the control T1. Flesh coloration changes differed between the control (T1) and bananas with the different applied doses of gibberellic acid (T2, T3 and T4) from day three of ripening. It was be observed that fruits treated with 10 mg/l phenylurea and 50 mg/l GA3 remained firm with a transparent white flesh color (immature) after 16 days of storage at 23°C and 75-90% relative humidity [7].

3.4. Change in Sugars (°Brix)

Figure 4 shows that the control (T1) had an accelerated ripening, reaching 21.6° Brix on the ninth day, compared to treatments T3 and T4 (medium and high doses of gibberellic acid), which are below 20° Brix (19.6° Brix). In Apple banana at stage 6 (ripe), the sugar content was 25.7° Brix; the soluble solids content in fruits is also indicative of the sugar content in the fruit [1].

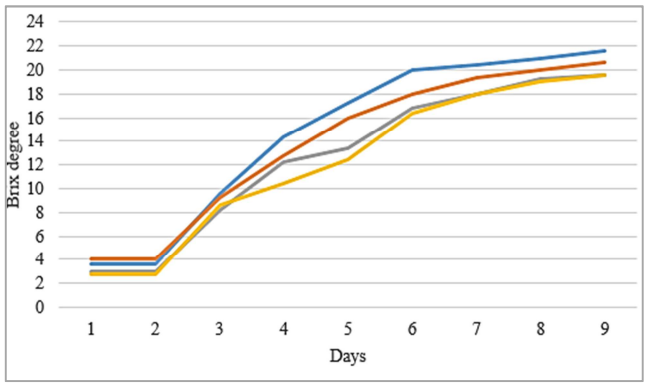

Figure 4. *Brix degrees of banana according to treatments.*

4. Conclusion

The analyses comprised: speed of ripening change, peel color, Brix degrees and pulp consistency, which helped in the determination of the degree of maturity of bananas with and without AG3 treatment. The results showed that both the 15 cc/l and 20 cc/l treatments prolonged the shelf life of the banana Cavendish by up to 1.5 days, and that both produced the same results. However, for cost reasons, the 15 cc/l dose is the most favorable concentration for the post-harvest conservation of Cavendish Valery bananas from the Cochabamba tropics, giving profits to the marketing company.

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