Effects of Aminoethoxyvinylglycine, Chitosan, and Storage Temperatures on Fruit Shelf-Life and Qualities of 'Cavendish' Banana

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***Abstract*—**'Cavendish' banana is marketed domestically on its early ripening stage after receiving ethylene gassing. Once its ripening is promoted, however, its fruit qualities are quickly deteriorated making its shelf-life very short. This research was conducted to study the effects of applications of aminoethoxyvinylglycine (AVG), chitosan, storage temperatures, and their interactions on the fruit shelf-life and quality of 'Cavendish' banana. This research was conducted in the Horticultural Postharvest Laboratory, Faculty of Agriculture, Lampung University from July to August 2014. Treatments were arranged in a completely randomized design, run in three replications, and laid out in a 2 x 2 x 2 factorial design. The first factor was AVG (with and without 1.25 ppm AVG), the second factor was chitosan (with and without 2.5% chitosan), and the third factor was storage temperature (a room temperature and 18 °C). The results showed that (1) AVG did not significantly affect fruit shelf-life, physical and chemical fruit qualities such as fruit firmness, weight loss, soluble solid and acid contents, and sweetness; (2) 2.5% chitosan increased fruit shelf-life, but it accelerated fruit softening and increased fruit weight loss, and did not affect chemical fruit qualities; (3) lower storage temperature significantly lengthened fruit shelf-life and inhibited fruit softening, but did not affect physical and chemical fruit qualities; (4) no interaction was found among the three treatments, in fact, a significant effect of an individual application of chitosan or lower storage temperature dominated the effects of its combinations.

***Keywords*—** avg, banana, chitosan, postharvest, temperature.

I. Introduction

As 'Cavendish' banana may be the only banana cultivar that is traded worldwide, it has a high economic value. It is a climacteric fruit that is expected to ripe and increase its palatability during storing periode. However, different from most other climacteric fruits, when its fruit is harvested in the stadium I (green rind), its fruit remains green in vacuum polyethylene bags inside cartoon packs during transportation and its qualities are maintained as long as its ripening is not promoted with ethylene gassing and its fruit weight loss and shrunken or wilted rind are avoided. Once its ripening is promoted and reached stadium III and the fruits are started to be distributed locally, brown spots are very quickly developed on its yellow rind and the fruits are quickly soften or its flesh firmness is quickly decreased in 3-4 days periode. The fruits are said to reach the end of the ripening stage of stage VII, a fruit stage of the end of economical values. Consequently, its postharvest handling problems are not laid before its fruits are promoted with ethylene [1] and [2], but after it, and therefore, retarding this quick fruit deterioration has an economical benefit.

Based on the research conducted by [3] and [4], it was suggested that any attempts to retard banana fruit ripening should be addressed at stage V (perfectly yellow with green tip and greenish-yellow peduncle) because application to earlier ripening stadium would result in an imperfect fruit color development [3] and [4].

Aminoethoxyvinylglycine (AVG) is believed as the most potent chemical among anti-ethylene substances, because it directly inhibits ACC synthesis activity mechanism [5] and [6]. By applying AVG to inhibit ethylene synthesis, in combination with the fruit coating of chitosan to decrease respiration and transpiration rates [7], [8], and [9] and a low storage temperature, delaying fruit deterioration are expected, and therefore, lengthening the fruit shelf-life and maintaining qualities of 'Cavendish' banana can be achieved.

This research was conducted to study the effects of applications of aminoethoxyvinylglycine (AVG), chitosan, storage temperatures, and their interactions on the fruit shelf-life and quality of 'Cavendish' banana.

II. Materials and Methods

This research was conducted on September-October 2014 in the Horticultural Postharvest Laboratory, Department of Agrotechnology, Faculty of Agriculture, University of Lampung, Bandar Lampung, Indonesia. The samples of 'Cavendish' banana fruit of stages V (perfectly yellow with green tip and greenish-yellow peduncle; [3] and [4]) were received directly from Nusantara Tropical Farm, Co. Ltd. (NTF, Co. Ltd.), Way Jepara, East Lampung, Indonesia.

Treatments were arranged in a completely randomized design with three replications and laid out in a 2 x 2 x 2 factorial design. The replications were applied to each experimental unit consisting of one cluster fruit of two fingers each. The first factor was AVG (with and without 1.25 ppm AVG, by dipping in 10 minutes), the second factor was chitosan (with and without a quick dip in 2.5% chitosan), and the third factor was storage temperature (a room temperature

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and 18 °C). The chitosan was diluted in 0.5% acetic acid [3], [4], [10], and [11].

Treated fruits were then placed in storage rooms of a room temperature of 28 ± 1 ºC and a low temperature of 18 ± 1 ºC. The storage room temperature of 18 ± 1 ºC was the lowest possible temperature that could be achieved in the storage room of 5.8 x 2.8 x 3.15 m^3 with two ACs, one humidifier, and one thermohygrometer.

A unit treatment was ended when the banana fruit reached stage VII (yellow with browning spots; [3] and [4]). The variables used were days of storage (shelf-life), weight loss, ºBrix, free acidity, firmness, and sweetness level. ºBrix was analyzed with an Atago N-1E hand refractometer, free acidity was analyzed by a titration with 0.1N NaOH and phenolphthalein as an indicator, and fruit firmness was analyzed with a penetrometer type FHM-5, Takemura Electric Work, Ltd., Japan. Sweetness level was a °Brix/acidity ratio. All data were analyzed with ANOVA, and further tested with Least Significantly Difference (LSD) at 5%.

III. Results and Discussion

Consumers of 'Cavendish' usually judge the quality of 'Cavendish' banana based on its rind color, not on its fruit firmness. On the beginning of this research, its fruit firmness was 11.76 kg/cm^2 (Table 1, footnote) and in 4-7 days storage the fruits soften quickly, reached as low as 0.31 kg/cm^2. The data in Table 1 showed that AVG did not significantly lengthen its fruit shelf-life compared to the control. Its fruit firmness and weight loss were not also affected significantly. A thick rind of banana might play a barrier for anti-ethylene to take into effects on both the ripening rind color stadium development, flesh softening [12] and water loss.

In addition, AVG concentration applied in this postharvest research might be considered very low. However, references on postharvest applications of AVG to 'Cavendish' banana are very lacking. Comparing to the concentrations used by [2] and [13] should be done with cautions because [2] applied it in different stages and with a different chemical, and [13] applied it as a preharvest application, and consequently they used very high concentrations which might be considered uneconomical.

AVG did not also affect other quality parameters, such as soluble solid (°Brix), free acid contents, and its sweetness (Table 2). These three fruit quality parameters were not affected because the observation was terminated at the same stage [3, 4, 9, and 10].

As other fruit coatings generally do, chitosan plays a physical barrier for O_2 and CO_2 movements, and develops a modified atmosphere around the fruits with less O_2 and more CO_2. Data in Table 1 showed that the modified atmosphere developed with chitosan lengthened the shelf-life of 'Cavendish' banana fruits by more than two days. A decreased respiration rate of the fruit [14] and [15] might explained the increase. 2.5% chitosan might also inhibited water loss from the fruits as also reported by [16] - [18]. A significantly higher fruit weight loss than the control as observed in Table 1 was believed as a direct effect of a lengthened fruit shelf-life.

While other fruit qualities, such as soluble solid (°Brix), free acid, and sweetness, were not affected (Table 2), 2.5% chitosan significantly decreased fruit firmness or accelerated fruit softening (Table 1). Heat deliberated from respiration and trapped inside wrapping might increase temperature inside wrapping, and consequently, accelerated fruit softening [19].

The treatment of low temperature of 18 ± 1 °C applied in this experiment significantly lengthened its ripening rind color stadium development of the fruit which was perceived as fruit shelf-life (Table 1). 'Cavendish' banana fruits are usually shipped under a low temperature of 13.33-14.44 °C (56-58 °F; Rachmansyah A. Wardhana, Chairman of R&D Division of NTF Co. Ltd., personal communication). Therefore, we believed that if a much lower temperature than that of 18 ± 1 °C was applied, a much longer fruit shelf-life could be achieved. Low temperature also significantly delayed fruit softening (Table 1) and other fruit chemical qualities such as soluble solid (°Brix), free acid, and sweetness (Table 2), because it might delay respiration rate [20].

A more significant effect of individually applied chitosan was significantly dominated when it was applied in combination with AVG and low storage temperature (Table 1). In fact, a combined application of AVG, chitosan, and low storage temperature increased fruit shelf-life by four days storage compared to the control, but generally they did not affect physical and chemical fruit qualities (Table 2). Again, the reason was due to because the observation was terminated at the same stage of fruit ripening [3], [4], [9], and [10].

IV. Conclusion

The results showed that (1) AVG did not significantly affect fruit shelf-life, physical and chemical fruit qualities such as fruit firmness, weight loss, soluble solid and acid contents, and sweetness; (2) 2.5% chitosan increased fruit shelf-life, but it accelerated fruit softening and increased fruit weight loss, and did not affect chemical fruit qualities; (3) lower storage temperature significantly lengthened fruit shelf-life and inhibited fruit softening, but did not affect physical and chemical fruit qualities; (4) no interaction was found among the three treatments, in fact, a significant effect of an individual application of chitosan or lower storage temperature dominated the effects of its combinations.

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TABLE I
EFFECTS OF AVG, CHITOSAN, AND STORAGE TEMPERATURE ON THE FRUIT SHELF-LIFE, FIRMNESS, AND WEIGHT LOSS OF 'CAVENDISH' BANANA[1]

Treatments	Shelf-life (days)	Firmness (kg/cm^2)	Weight loss (%)
AVG:			
Control (A0)	5.08 a	2.34 a	11.79 a
AVG (A1)	5.42 a	2.49 a	12.48 a
Chitosan:			
Control (C0)	4.08 b	4.23 a	10.85 b
Chitosan (C1)	6.42 a	0.61 b	13.43 a
Temperature:			
Room (T0)	4.83 b	1.68 b	11.29 a
Cool (T1)	5.67 a	3.21 a	12.99 a
AVG*Chitosan:			
A0C0	4.00 b	3.97 a	10.55 b
A0C1	6.17 a	0.71 b	13.04 ab
A1C0	4.17 b	4.53 a	11.15 ab
A1C1	6.67 a	0.46 b	13.82 a
AVG*Temp.:			
A0T0	4.67 a	1.58 a	10.70 a
A0T1	5.50 a	3.11 a	12.88 a
A1T0	5.00 a	1.73 a	11.87 a
A1T1	5.83 a	3.31 a	13.10 a
Chitosan.*Temp.:			
C0T0	3.83 c	2.95 b	10.08 b
C0T1	4.33 c	5.55 a	11.62 b
C1T0	5.83 b	0.36 c	12.49 ab
C1T1	7.00 a	0.81 c	14.37 a
AVG*Chitosan* Temp.:			
A0C0T0	3.67 d	2.85 bc	9.37 b
A0C0T1	4.00 d	3.05 bc	10.80 ab
A0C1T0	5.67 bc	0.31 d	12.04 ab
A0C1T1	6.00 ab	0.41 d	12.93 ab
A1C0T0	4.33 cd	5.04 ab	11.73 ab
A1C0T1	4.33 cd	6.06 a	11.50 ab
A1C1T0	6.67 ab	1.12 dc	14.03 a
A1C1T1	7.33 a	0.51 d	14.70 a

[1]Values in the same column of each treatment followed with the same letters were not significantly different at LSD 5%. Fruit firmness in the day of treatment (shelf-life 0 day) was 11.76 kg/cm².

TABLE II
EFFECTS OF AVG, CHITOSAN, AND STORAGE TEMPERATURE ON THE FRUIT °BRIX, ACIDITY, AND SWEETNESS OF 'CAVENDISH' BANANA[1]

Treatments	°Brix (%)	Acidity (g/100 g)	Sweetness[2]
AVG:			
Control (A0)	7.13 a	0.35 a	20.24 a
AVG (A1)	6.91 a	0.35 a	19.60 a
Chitosan:			
Control (C0)	6.98 a	0.35 a	19.82 a
Chitosan (C1)	7.06 a	0.35 a	20.03 a
Temperature:			
Room (T0)	6.91 a	0.35 a	19.60 a
Cool (T1)	7.13 a	0.35 a	20.24 a
AVG*Chitosan:			
A0C0	7.25 a	0.35 a	20.57 a
A0C1	7.02 a	0.35 a	19.91 a
A1C0	6.72 a	0.35 a	19.06 a
A1C1	7.10 a	0.35 a	20.15 a
AVG*Temp.:			
A0T0	6.82 a	0.35 a	19.34 a
A0T1	7.45 a	0.35 a	21.14 a
A1T0	7.00 a	0.35 a	19.86 a
A1T1	6.82 a	0.35 a	19.35 a
Chitosan.*Temp.:			
C0T0	6.92 a	0.35 a	19.63 a
C0T1	7.05 a	0.35 a	20.01 a
C1T0	6.90 a	0.35 a	19.58 a
C1T1	7.22 a	0.35 a	20.48 a
AVG*Chitosan* Temp.:			
A0C0T0	6.67 bc	0.35 a	18.92 bc
A0C0T1	7.17 ab	0.35 a	20.33 ab
A0C1T0	6.97 abc	0.35 a	19.77 abc
A0C1T1	6.83 bc	0.35 a	19.39 bc
A1C0T0	7.83 a	0.35 a	22.23 a
A1C0T1	6.27 c	0.35 a	17.79 c
A1C1T0	7.07 abc	0.35 a	20.05 abc
A1C1T1	7.37 ab	0.35 a	20.91 ab

[1]Values in the same column of each treatment followed with the same letters were not significantly different at LSD 5%. °Brix, acidity, and sweetness in the day of treatment (shelf-life 0 day) were 8.00%, 0.35 g/100 g, and 22.70, consecutively; [2]°Brix/acidity ratios.

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[AVG, 2.5% chitosan, and lower storage temperature lengthened fruit shelf-life and maintain fruit qualities, but the three were not interacted.]