The Effects of Fruit Maturities, Coatings, and Storage Temperatures on the Qualities and Green-Life of 'Cavendish' Banana

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Abstract*— 'Cavendish' banana is climacteric fruit with a fast response to ethylene and very high respiration rate during storage. This shortens green-life and fastens fruit damage, thus affecting its economic value. The aims of this research were to study the effects of fruit maturities (immature, full, and over mature), fruit coatings (control, 1% chitosan, 150 ppm GA_3, 1% chitosan and 150 ppm GA_3mix), and storage temparatures (room and cool temperature of 16±1 °C) on qualities and green-life of 'Cavendish' banana. The result showed that the fruit maturities significantly lengthened green-life, detained firmness, diameter loss, acidity and starch, but did not affect weight loss, brix and glucose. 1% chitosan, 150 ppm GA_3 and both combination were not significant and did not affect to all parameters. Meanwhile, low temperature was able to delay senescence, promote starch degradation, detained firmness and diameter loss. The combined application of maturities and storage affected all parameters while maturities and coatings, coatings and storage combination affected firmness, acidity and starch only. 1% chitosan coating coverage analyzed with Scanning Electron Microscope showed fully covered surface of M1 finger rind tip and some crack points on finger rind base, full coverage on both M2, and some crack points on M3.

Key Words *: 'Cavendish' banana, maturity, coating, storage*

I. INTRODUCTION

The 'Cavendish' banana is an high economic valued and high nutritional contents fruits such as carbohydrates, minerals, vitamin B6 and C. It is exported world-wide in its green-life stage and it will receive ethylene gassing to promote ripening with temperature treatment at 16ºC in the market destination. As a climacteric fruits, 'Cavendish' Banana has an high respiration and ethylene production rates that cause fast degradation of its qualities. These are believed as the cause of 'Cavendish' Banana short shelf-life. Attempts that have been conducted to lengthen its shelf-life are usually focused on decreasing its respiration through applications of fruit coatings. [1].

Chitosan as an edible coating chemically plays a role in inhibiting the movement of O_2 and CO_2, with the presence of materials around fruits with less O_2 and more CO_2, it is expected to reduce the respiration rate of fruit during storage [2]. The application of chitosan causes the flesh of the fruit to be soft even though the skin remains green, so it is necessary to add anti-ethylene. The addition of other ingredients that can inhibit ethylene production is considered effective in controlling ripening in the fruit when clusterined with the application of chitosan.

Gibberelic Acid (GA_3) is a growth regulator that can cause greening in citrus fruits and delay the appearance of red color in tomatoes [3]. GA_3 can delay the ripening of bananas by counteracting ethylene and retaining chlorophyll so as to maintain the green color of bananas, minimum weight loss, percentage of moisture content and low dry weight of the fruit [4]. The concentration of GA_3 greatly affects the success of the application, GA_3 is able to delay in ripening of 'Cavendish' bananas for 3-4 days was obtained from the application of a concentration of 50-250 mg/L GA_3 [5]. As another factor, storage temperature greatly affects the shelf life of fruit . Temperature directly affects the rate of respiration, at low temperatures the rate of respiration can be slowed down. This is also supported by the delivery process of 'Cavendish' bananas which are usually given a low temperature treatment ranging from 13-14 ºC [6]. Therefore, the objective of this research were to study the effects of fruit level maturity, fruits coating, and storage temperature on the qualities and green shelf-life of 'Cavendish' banana fruits.

II. MATERIALS AND METHOD

This research was conducted in the Laboratory Horticulture and Postharvest, Department of Agronomy and Horticulture, Faculty of Agriculture, University of Lampung,

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Indonesia during July to September 2022. 'Cavendish' banana of this study consisted of fruit clusters from 'Cavendish' banana fruit bunches with three levels of fruits maturity. They were physiologically immature, full mature, and over-mature phases based on our previous study [7]. Banana samples were received from Great Giant Foods Co. Ltd., Plantation Group 4, formerly Nusantara Tropical Fruits Co. Ltd., Labuhan Ratu, East Lampung in stage I (green phase) which was relatively uniform, both in terms of harvest age and physical appearance.

This study were arranged in a Completely Randomized Design in a factorial 3 x 4 x 2 with 3 replications. The first factor was the banana fruit cluster at 3 levels of maturities: physiologically immature (5th cluster from the top of the bunch), full mature (3rd cluster from the top of the bunch), and over mature (1st cluster from the top of the bunch) [7]. The second factor was fruit coating (non-coating/control, 1% chitosan, GA_3 150 ppm, 1% chitosan + GA_3 150 ppm mix and applied on the fruit rind tip and base, while the third factor was storage temperature [room temperature (27 ± 1 ºC) and cold temperature (16 ± 1 ºC). The research observation was discontinued, either if the fruit rind changed to stage III (greenish yellow) as the end of the green shelf-life, or fruit flesh was softened or past 35 days according to practically cold storing in the postharvest handling.

The variables used were days of storage (green shelf-life), fruit firmness, weight loss, diameter loss, ºBrix, free acidity, glucose, starch, and SEM. Storage (green shelf-life) was measured by counting the first day until the day when observation was terminated. Fruit firmness was analyzed with a penetrometer type FHM-5, Takemura Electric Work, Ltd., Japan. Weight and diameter loss were analyzed by digital scales and vernier calipers. ºBrix was analyzed with an digital refractometer, free acidity was analyzed by a titration with 0.1N NaOH and phenolphthalein as an indicator, glucose and starch were analyzed by adding saturated Pb-acetate, Na-oxalate and aquades to sample extraction and heated in 90ºC during 30 minutes and rind surface pores was observed with SEM. All data were analyzed with ANOVA, and further tested with Tukey's honestly significance difference (HSD) at 5%.

III. RESULTS AND DISCUSSION

The observation of this research was terminated when the green life of banana ended with fruit flesh softening or 35 days of its shelf life. The green life of banana determines its shelf life and export quality, the longer green life the lower risk of material loss during shipping time because importers expect bananas to arrive fresh green before receiving ethylene gassing in the destination. According to the data in Table I, the shelf life of 'Cavendish' banana was able to be lengthened by the application of maturities, storage, both combination and coatings storage mix, but coatings did not affect. The best result was M2S2 (full maturity in cold storage) that showed shelf life of 34.75 days.

Full physiological maturity refers to the maximum growth and maturation of the fruit development and it means set to normal ripening, so it was able to reach its optimum performance when combined with cold storage. Storage in low temperature is one of manipulation of environmental conditions which can decrease metabolic activity rate that substantially lead to senescence and fruit quality degradation [8]. Maturities significantly affected the firmness and diameter loss, M1 showed higher firmness and diameter loss, then followed by M2 and M3. 1% chitosan coating on C2 and C4 were only applied on the fruit rind tip and base, so there were still chitosan uncoverage rind area and did not significantly affect to all parameters of observation, the application of control (C1) and GA_3 150 ppm on C3 and C4 as well, there were not difference in between. Cold temperature of storage was able to lengthen shelf life and maintain firmness but not to detain weight and diameter loss.

However, the data in Table II showed maturities significantly affected acidity and decreased starch content, but did not affect other chemical qualities such as ºBrix and glucose. The observation of parameters were done in the same criterias for each samples (the end of green life and the occur of flesh fruit softening) in the same stage so that ºBrix might be not affected. Glucose is a simple sugar or monosaccharide and there are other forms of sugar that was not observed here but might be the reason glucose was not affected. ºBrix, acidity, glucose, and starch did not significantly difference to control treatment due to coatings and storage, except the effect of storage treatment on starch content. Low temperature of storage affected lower starch content because the degradation of starch can be accelerated. Based on enzymes activities, low temperature storage promotes the starch degradation through the pathway of alpha-amylase over the pathway of betha-amylase in coldstored bananas and show difference starch granules structures [9].

Table I. The Effect of Maturities, Coatings, and Storage on the Fruit Shelf Life, Firmness and Diameter Loss

Treatments	Shelf-life (days)	Firmness (kg/m²)	Weight Loss (%)	Diameter Loss (%)
Maturities				
M1	28.31a	2.73a	0.21a	0.15a
M2	28.31a	1.66b	0.20a	0.12ab
M3	25.87b	1.47b	0.18a	0.10b
Coatings				
C1	28.00a	2.05a	0.20a	0.14a
C2	27.92a	2.03a	0.20a	0.13a
C3	27.25a	1.88a	0.20a	0.12a
C4	26.83a	1.86a	0.19a	0.12a
Storage				
S1	33.92a	2.39a	0.21a	0.13a
S2	21.08b	1.51b	0.18a	0.12a
Maturities* Coatings				
M2 C2	29.25a	1.63ab	0.19a	0.13a
M1 C1	29.00a	3.23a	0.20a	0.15a
M1 C2	28.75a	2.71ab	0.21a	0.13a
M2 C1	28.25a	1.05b	0.18a	0.11a
M2 C3	28.00a	1.26ab	0.20a	0.11a
M1 C3	27.75a	2.80ab	0.20a	0.18a
M1 C4	27.75a	2.19ab	0.22a	0.16a
M2 C4	27.75a	1.92ab	0.22	0.15a
M3 C1	26.50a	1.36ab	0.19a	0.09a
M3 C4	26.25a	1.96ab	0.16a	0.10a
M3 C2	26.00a	1.81ab	0.20a	0.10a
M3 C3	24.75a	1.52ab	0.18a	0.10a
Maturities* Storage				
M2 S2	34.75a	0.75c	0.21ab	0.12ab
M1 S2	33.62a	2.24ab	0.22a	0.14ab

M3 S2	33.37a	1.55bc	0.20ab	0.12ab
M1 S1	23.00b	3.22a	0.20ab	0.16a
M2 S1	21.87b	2.19ab	0.19ab	0.13ab
M3 S1	18.37c	1.77bc	0.16b	0.078b
Coatings* Storage				
C1 S2	34.67a	1.34a	0.20a	0.11a
C2 S2	34.17a	1.64a	0.21a	0.11a
C4 S2	34.17a	1.73a	0.22a	0.15a
C3 S2	32.67a	1.35a	0.21a	0.14
C2 S1	21.83b	2.46a	0.20a	0.13a
C1 S1	21.17b	2.42a	0.18a	0.12a
C3 S1	21.00b	2.37a	0.18a	0.12a
C4 S1	20.33b	2.32a	0.18a	0.12a

[1]Values in the same column of each treatment followed with the same letters were not significantly different at HSD 5%. Fruit firmness in the day of treatment (Day 0) was 4.21 kg/m^2.

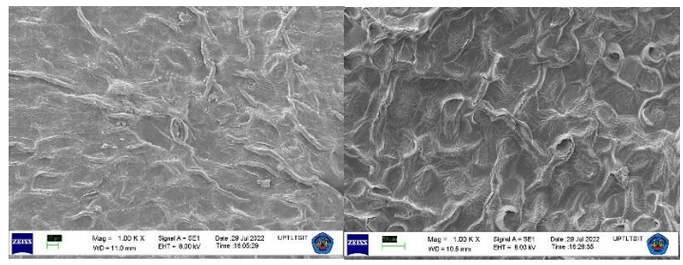
The combined application of maturities and coatings, coatings and storage temperatures affected acidity and starch only while the combined application of maturities and storage temperatures showed the difference all observed chemical qualities such as ºBrix, acidity, glucose and starch content to control. Coatings mostly did not affect the parameters of observation because the application of 1% chitosan coating was done on the tip and base of the rind only, so that these treatment can not inhibit the movement of O_2 and CO_2 of the fruit to reduce the respiration rate due to uncoated stomata areas. Slower rates of weight loss in coated fruits can be attributed to the barrier properties for gas diffusion of stomata, the organelles that regulate the transpiration process and gas exchange between the fruit and the environment [10]

Table II. The Effect of Maturities, Coatings, and Storage on the Fruit ºBrix, Acidity, Glucose and Starch

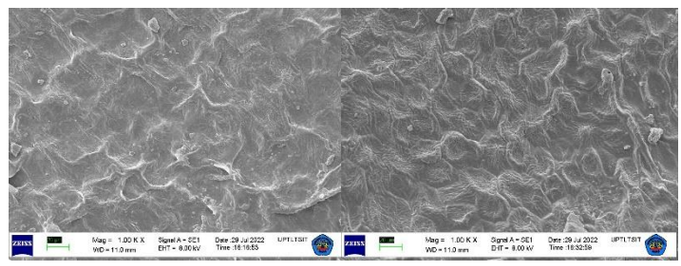
Treatments	ºBrix (%)	Acidity (mg/100 g)	Glucose (mg/100 mg)	Starch (mg/100 g)
Maturities				
M1	18.72a	0.75a	6.24a	22.87a
M2	18.27a	0.60b	5.78a	19.46b
M3	18.09a	0.57b	5.77a	19.44b
Coatings				
C1	18.78a	0.68a	6.32a	21.12a
C2	18.78a	0.65a	6.17a	20.63a
C3	18.06a	0.64a	5.80a	20.56a
C4	17.81a	0.59a	5.41a	20.06a
Storage				
S1	18.97a	0.76a	6.28a	22.51a
S2	17.75a	0.52a	5.58a	18.68b
Maturities* Coatings				
M2 C2	16.82a	0.59ab	5.41a	18.72b
M1 C1	19.82a	0.59ab	6.40a	18.83b
M1 C2	18.07a	0.54ab	5.37a	19.42b
M2 C1	18.67a	0.50b	6.31a	18.92b
M2 C3	19.67a	0.50b	5.07a	20.86ab
M1 C3	18.47a	0.69ab	5.74a	18.94b
M1 C4	16.70a	0.58ab	5.59a	20.66b
M2 C4	19.70a	0.69ab	6.30a	19.28b
M3 C1	17.85a	0.96a	5.81a	22.42ab
M3 C4	17.02a	0.67ab	7.07a	23.43a
M3 C2	19.27a	0.63ab	6.63a	23.55a
M3 C3	18.20a	0.73ab	5.44a	22.09ab
Maturities* Storage				
M2 S2	16.62b	0.52b	5.60ab	18.78b
M1 S2	17.57ab	0.56b	5.51ab	18.83b
M3 S2	19.05ab	0.49b	7.72a	18.42b
M1 S1	18.96ab	0.64b	6.04ab	20.09b
M2 S1	20.81a	0.62b	5.94ab	20.11b
M3 S1	17.12ab	1.01a	4.75b	27.33a
Coatings* Storage				
C1 S2	17.93a	0.43c	6.56a	18.37c
C2 S2	19.03a	0.52bc	5.93a	18.83bc
C4 S2	17.05a	0.55bc	7.15a	18.88bc
C3 S2	16.98a	0.59bc	5.47a	18.63c
C2 S1	17.08a	0.65abc	5.68a	22.30a
C1 S1	19.63a	0.94a	5.78a	21.74ab
C3 S1	20.58a	0.69abc	5.35a	22.63a
C4 S1	18.57a	0.75ab	5.49a	23.37a

[1]See Table 1. Fruit ºbrix, acidity, glucose and starch in day 0 storage were 13.97%, 0,65 mg/100 g, 2.90 mg/100 g, and 28.47 mg/100 g.

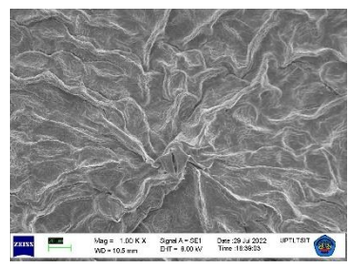
According to Figure I, 1% chitosan coating coverage analyzed with Scanning Electron Microscope (SEM) showed fully covered surface of fruit rind tip and some crack points on fruit rind finger base on M1 finger. However, M2 finger showed perfect coverage of 1% chitosan coating that no pore and crack point seem while M3 finger showed some crack points both on rind tip and base. The crack points might be caused by the difference rind texture between these 3 maturity levels.

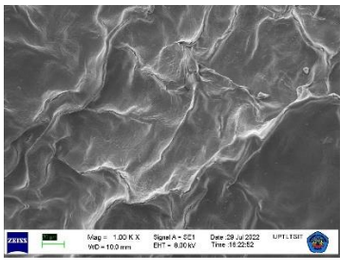


(a) Tip-M1 (b) Base-M1



(c) Tip-M2 (d) Base-M2





(e) Tip-M3 (f) Base-M3

Fig. I. SEM Analyses on 'Cavendish' banana finger rind tips and bases of 5th cluster from the top of the bunch (a) and (b), 3rd cluster from the top of the bunch (c) and (d), 1st cluster from the top of the bunch (e) and (f) with scanning electron microscope 1000x.

CONCLUSION

The application of maturities significantly lengthened fruit green-life of its shelf life, detained the firmness, diameter, acidity and starch content, but did not reduce weight loss and affect brix and glucose content. Applications of 1% chitosan, GA_3 150 ppm and both combination that were applied on fruit rind tip and base were not difference to control and did not affect to all parameters. Meanwhile, low storage temperature (16 ± 1 ºC) was able to delay senescence, promote starch degradation, detained firmness and diameter. The combined application of maturities and storage affected all parameters of observations while maturities and coatings, coatings and storage affected firmness, acidity and starch content only and did not affect other qualities. 1% chitosan coating coverage analyzed with Scanning Electron Microscope (SEM) showed fully covered surface of tip finger rind and some crack points on base finger rind on sM1, fully cover on both M2, and some crack points on M3.

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