Chitosan-based fruit coatings as postharvest treatments on two pineapple (*Ananas comosus* L. Merr) clones

P M Fahmi[1], S E Widodo[2*], A Karyanto[2], S Waluyo[3]

[1]Study Program of Magister of Agronomy, Faculty of Agriculture, University of Lampung, Bandar Lampung, Indonesia
[2]Department of Agronomy and Horticulture, Faculty of Agriculture, University of Lampung, Bandar Lampung, Indonesia
[3]Department of Agricultural Engineering, Faculty of Agriculture, University of Lampung, Bandar Lampung, Indonesia

*Corresponding author email: sestiwidodo@gmail.com

Abstract. Production of fresh pineapple fruit is dominated by the MD2 clone, while the GP3 clone is used as canned fruit. To be promoted as fresh fruit, the GP3 has some defects, namely less sweet taste and sensitive to internal browning (IB) disorders. The clones need fruit coatings, and the two might response differently. This study aimed to study the effects of chitosan-based fruit coating mixed with palm stearin and Aloe vera gel on the fruit qualities of the two clones, as well as to seek the potential of GP3 clone as a fresh fruit. The study used 2 x 4 factorials. The first factor was two clones (GP3 and MD2). The second factor was fruit coatings (control, chitosan, palm stearin + chitosan, and Aloe vera gel + chitosan). The fruits were stored at 7 ºC. The results showed that the GP3 began the incidence of IB disorders on the 21st day, much more earlier than the MD2 which was on the 35th day. The MD2 showed a ºBrix of 16.82% and vitamin C of 391.45 mg/L which were significantly higher than the GP3. Meanwhile, the GP3 showed 0.60% acidity which was significantly higher than the MD2. Fruit coatings mixed with the natural ingredients were able to maintain ºBrix and acidity values, especially in the MD2. These indicated that the GP3 should not be considered as an option for fresh fruit consumption, especially because of its sensitivity to IB and lower sweetness compared to the MD2 clone.

Keywords: Aloe_vera, chitosan, coating, internal_browning, palm_stearin

1. Introduction

Pineapple is a popular fruit used in the canning and fruit juice industry. Pineapples in the fresh fruit market or on the way to the canning industry are generally shipped without refrigeration which causes the fruit to spoil faster, especially in the decline in fruit quality. Under environmental conditions, the increase in biochemical reactions from the transformation of starch into sugar makes the fruit rich in sugar which will affect the microbial spoilage of the fruit. Thus, pineapple has a short post-harvest shelf life at room temperature and degrades quality rapidly [1]. This is a major weakness in the trade and export of fresh pineapples. Storage treatment at cold temperatures is effective in inhibiting the development of spoilage in pineapples, but can cause symptoms of cold injury, especially internal browning.

The process of fruit metabolism during post-harvest will cause several things, namely accelerating the process of loss of fruit nutrients and accelerating the aging process [2]. Another method that can be used to inhibit fruit metabolism is another practical and economical method, namely the use of coatings.

Coating is a method of applying a thin layer on the surface of the fruit to inhibit the release of gas, water vapor and oxygen so that it slows down the aging process. Chitosan is a natural coating material that is non-toxic and safe for health. Fruit coating is an effort to delay ripening which aims to extend the shelf life of horticultural products [3]. In this study, the raw materials used for fruit coating were chitosan, aloe vera gel, and stearin which is derivative products of palm oil. Chitosan is a coating material that has long been used to coat fruit. Nurhayati and Agusman (2011) [4] stated that chitosan has advantages as a coating, including biodegradable, edible and has anti-microbial activity. Chitosan is a waste from processing the fishing industry, such as shrimp and crab. Shrimp shell waste contains chitin ranging from 15 – 20% [5].

Pineapple clone GP3 is currently used to produce canned pineapple. GP3 clone has a high productivity, so it has its potential to try to be introduced into fresh pineapple market. MD2 clone which is marketed as fresh pineapple fruit, is well known to be more resistant to internal browning than GP3 clone [6]. For this reason, research needs to be carried out to open up export potential and market opportunities for Indonesian fresh pineapples to foreign countries and need to be used for business expansion and development. This study aimed to study the effects of chitosan-based fruit coating mixed with palm stearin and Aloe vera gel on the fruit qualities of the two clones, as well as to seek the potential of GP3 clone as a fresh pineapple fruit.

2. Materials and methods

2.1 Materials and treatment

This research was carried out at the Postharvest Research and Development Laboratory of Great Giant Pineapple Co. Ltd. (PG4), located on Way Kambas street, Raja Basa Lama I National Park, Labuhan Ratu District, East Lampung Province, Indonesia. The study was conducted for 35 days, starting from July to August 2022, in a cold storage at a temperature of 7 ºC. Observation time was carried out on days of 0, 7, 14, 21, 28 and 35 after application. The study used 2 x 4 factorials in a Completely Randomized Design and five replications. The first factor was two clones of GP3 (G) and MD2 (M). The second factor was fruit coatings, namely: control (K), chitosan (C), palm stearin + chitosan (P), and Aloe vera gel + chitosan (A). The coating materials consisted of palm stearin melted at 60 ºC, chitosan (1% w/v), glacial acetic acid (1% v/v), Tween 80/ Polysorbate 80 (2% v/v), and Aloe vera gel (25 % w/w). The data obtained were analyzed for variance with a 95% confidence level. If there was a treatment effect, the analysis was continued with the 5% LSD test.

Observations were made on internal browning (IB), soluble solid [ºBrix (%) with an Atago hand refractometer], free acid (as citric acid, a titration method with 0.1 N NaOH and phenolphthalein as an indicator), vitamin C (with the 2,6-dichloroindophenol titrimetric method of AOAC), glucose, fructose, and sucrose contents [using the method of High Performance Liquid Chromatography (HPLC)], fruit weight loss, respiration rate [7], and fruit coating [(analyzed with Scanning Electron Microscope (SEM)].

For IB severity assessment, the fruit was cut lengthwise into two parts. For each fruit, IB intensity was visually graded from 0 (no internal browning) to 5 (maximum internal browning). Simple IB scores ranged from 0 to 5 were score 0, no symptoms; score 1, small translucent spots turn brown (no more than 5% of the surface area); a score 2, about 10% of the tissue surface area showed IB symptoms; score 3, about 20% of the tissue surface showed IB symptoms; score 4, about 30% of the tissue surface area showed IB symptoms; and score 5, more than 30% of the tissue surface area showed symptoms of IB.

For respiration rate measurement, pineapples and jars that were used as respiration chambers were weighed to obtain initial weight data and the pineapple volume is measured. Then put a treated pineapple fruit into the glass jar, and the measurement of the respiration rate was carried out by the close system

method. A data logger for measuring CO_2 was inserted into the jar and the jar was tightly closed. The device was set to measure the amount of CO_2 for 1 hour. Then, the data is entered into the computer and the respiration rate was calculated [7].

3. Results

3.1 Internal browning

The results showed that there was a significant difference in the responses of two clones of MD2 and GP3 to internal browning (IB), starting from the observation on day 21 to day 35 (Table 1). The IB of the GP3 pineapple clone started to appear on the 21st day, while the MD2 pineapple clone appeared on the 35th day. In general, the GP3 clone (Figure 1) showed a large scale, higher incidence of IB compared to MD2 clones (Figure 2).

Table 1. The effects of fruit coatings on the occurrence of internal browning of two pineapple clones during 35 days-storage at 7 ºC

Treatment*	Internal Browning**					
	D-0	D-7	D-14	D-21	D-28	D-35
M	0	0	0	0 b	0 b	0.1 b
G	0	0	0	0.2 a	0.55 a	0.8 a
A	0	0	0	0.2 a	0.2 a	0.3 a
C	0	0	0	0 a	0.2 a	0.2 a
K	0	0	0	0.1 a	0.3 a	0.8 a
P	0	0	0	0.1 a	0.4 a	0. 5 a
MA	0	0	0	0 a	0 a	0 b
MC	0	0	0	0 a	0 a	0 b
MK	0	0	0	0 a	0 a	0.2 ab
MP	0	0	0	0 a	0 a	0.2 ab
GA	0	0	0	0.4 a	0.4 a	0.6 ab
GC	0	0	0	0 a	0.4 a	0.4 ab
GK	0	0	0	0.2 a	0.8 a	0.8 a
GP	0	0	0	0.2 a	0.6 a	1.4 ab

* M = MD2, G = GP3, A = Aloe vera gel + chitosan mix, C = Chitosan, K = Control (H_20), P = Palm stearin + chitosan mix; **The mean values in the rows of each treatment group followed by the same letters were not significantly different according to the 5% LSD test.

In general, internal browning (IB) was detected at 21 days-storage, regardless of fruit coatings (Table 1). The quicker incidence of internal browning of GP3 than MD2 was repeated in the interaction of clones and coatings. The GP3 coated with Aloe vera gel + chitosan mix, chitosan, Palm stearin + chitosan mix showed much quicker incidence of IB in 21 days storage, than MD2 coated with the same coatings (Figure 1). Moreover, MD2 coated with Aloe vera gel + chitosan mix and chitosan alone did not showed IB even up to 35 day storage (Figure 2).

3.2 Soluble solid content (ºBrix value)

ºBrix values in both clones showed a significant difference (Table 2). MD2 clones consistently showed higher ºBrix values than GP3 clones, right from harvest up to 35 days storage. On the 35th day, MD2 clones had a ºBrix value of 16.81%, while GP3 clones had 14.12%.

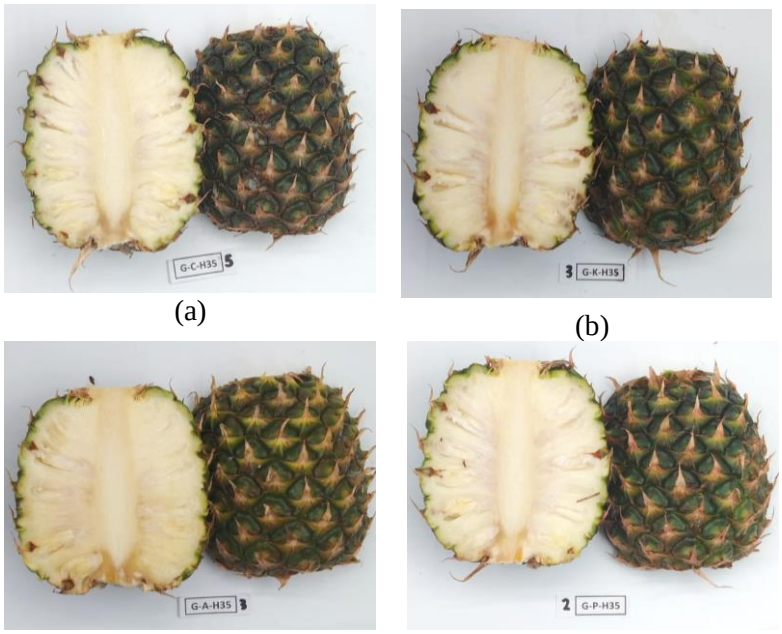


Figure 1. The occurrence of internal browning in pineapple clones GP3 at 35 days of observation with fruit coating (a) control (b) chitosan, (c) chitosan+Aloe vera, and (d) chitosan+Palm stearin

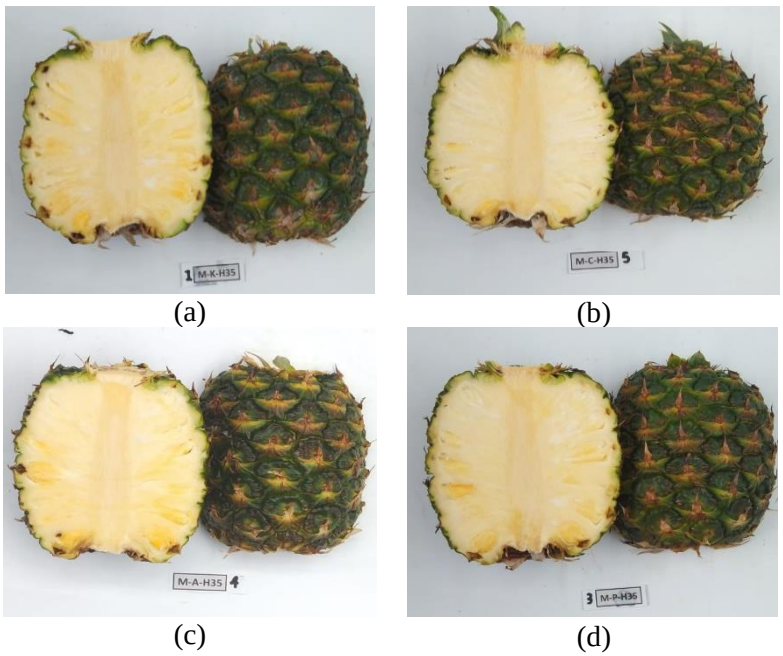


Figure 2. The occurrence of internal browning in pineapple clones MD2 at 35 days of observation with fruit coating (a) control (b) chitosan, (c) chitosan+aloe vera, and (d) chitosan+palm stearin

Figures 1-2 show that the GP3 pineapple clone was more sensitive to internal browning seen from its occurrence on the 35th day, while in the MD2 clone pineapple, on the 35th day there was no internal browning except for the control treatment.

Table 2. The effect of fruit coatings on the soluble solid content (ºBrix value) of two pineapple clones during 35 days-storage at 7 ºC

Treatment*	ºBrix (%)**					
	D-0	D-7	D-14	D-21	D-28	D-35
M	15.68 a	15.52 a	16.92 a	15.37 a	16.23 a	16.81 a
G	10.74 b	13.69 b	14.07 b	13.31 b	13.51 b	14.12 b
A	13.29 a	15.12 ab	15.48 a	14.76 a	14.88 a	15.02 ab
C	12.22 a	14.03 ab	15.39 a	13.98 a	14.93 a	14.92 b
K	13.34 a	13.65 b	15.97 a	14.86 a	15.04 a	16.65 a
P	14.00 a	15.63 a	15.14 a	13.76 a	14.65 a	15.29 ab
MA	15.70 a	16.28 a	17.02 a	15.48 a	16.30 a	16.40 ab
MC	15.06 a	15.26 ab	16.92 ab	16.20 a	15.86 ab	16.10 ab
MK	15.92 a	14.16 ab	17.20 a	15.82 a	16.96 a	18.02 a
MP	16.06 a	16.40 a	16.54 ab	13.98 ab	15.82 ab	16.74 a
GA	10.88 b	13.96 ab	13.94 c	14.04 ab	13.46 c	13.64 b
GC	9.38 b	12.80 b	13.86 c	11.76 b	14.00 bc	13.74 b
GK	10.76 b	13.14 b	14.74 bc	13.90 ab	13.12 c	15.28 ab
GP	11.94 b	14.86 ab	13.74 c	13.54 ab	13.48 c	13.84 b

* and **, see in Table 1.

In general, different fruit coatings alone did not significantly affect soluble solid content (ºBrix value) throughout storage period (Table 2). Again, the coated MD2 consistently showed higher soluble solid content than the coated GP3, regardless of fruit coatings, and the difference was more obvious in 35 days storage.

3.3 Acid content

The two clones did not differ on acid content up to 14 days storage, but they differed later (Table 3). The acidity of MD2 was significantly higher than GP3 at 21 and 28 days storage, but at 35 days storage the GP3 was higher than MD2. In general, fruit coatings alone and its combination with clones did not significantly affect acidity.

Table 3. The effect of fruit coatings on the acid content of two pineapple clones during 35 days-storage at 7 ºC

Treatment*	Acidity (%)**					
	D-0	D-7	D-14	D-21	D-28	D-35
M	0.45 a	0.63 a	0.69 a	0.64 a	0.68 a	0.53 b
G	0.45 a	0.58 a	0.68 a	0.55 b	0.59 b	0.59 a
A	0.44 a	0.64 a	0.65 a	0.57 a	0.58 b	0.61 a
C	0.48 a	0.59 a	0.71 a	0.60 a	0.70 a	0.57 ab
K	0.45 a	0.63 a	0.70 a	0.59 a	0.60 ab	0.46 b
P	0.43 a	0.55 a	0.69 a	0.61 a	0.66 ab	0.61 a
MA	0.49 a	0.67 a	0.67a	0.61 a	0.62 ab	0.57 ab
MC	0.45 a	0.64 a	0.64 a	0.69 a	0.75 a	0.54 ab
MK	0.43 a	0.66 a	0.73 a	0.68 a	0.67 ab	0.45 b
MP	0.44 a	0.54 a	0.72 a	0.58 a	0.68 ab	0.57 ab
GA	0.39 a	0.61 a	0.63 a	0.53 a	0.55 b	0.66 a
GC	0.52 a	0.54 a	0.77 a	0.52 a	0.65 ab	0.60 ab
GK	0.47 a	0.61 a	0.67 a	0.50 a	0.54 b	0.48 ab
GP	0.42 a	0.56 a	0.66 a	0.65 a	0.64 ab	0.64 ab

* and **, see in Table 1.

3.4 Fruit weight loss

GP3 consistently showed higher fruit weight loss than MD2, and their weight losses were increased at longer day-storages, reaching 17.54% at 35 days of GP3 and 15.30% at that of MD2 (Table 4). Comparing to control treatment (K), coatings alone generally did not affect fruit weight loss. Therefore, the effects of their interactions depended on the significant effects from clones. Regardless of coatings, MD2 generally showed lower fruit weight loss.

Table 4. The effect of fruit coatings on the fruit weight loss of two pineapple clones during 35 days-storage at 7 ºC

Treatment*	Fruit Weight Loss (%)**					
	D-0	D-7	D-14	D-21	D-28	D-35
M	0	3.52 b	6.30 b	9.00 b	11.94 b	15.30 b
G	0	4.14 a	7.17 a	10.53 a	14.16 a	17.54 a
A	0	3.93 a	6.96 a	10.06 a	13.44 ab	16.68 ab
C	0	3.70 a	6.18 a	9.02 b	12.23 b	15.49 b
K	0	3.96 a	6.80 a	9.65 ab	12.78 ab	16.18 ab
P	0	3.74 a	7.01 a	10.34 a	13.74 a	17.33 a
MA	0	3.59 a	6.45 a	9.01 bc	12.01 bc	15.25 bc
MC	0	3.26 a	5.69 a	8.21 c	11.23 c	14.62 c
MK	0	3.52 a	6.03 a	8.46 c	11.18 c	14.47 c
MP	0	3.70 a	7.02 a	10.33 ab	13.34 ab	16.87 abc
GA	0	4.26 a	7.48 a	11.11 a	14.86 a	18.12 a
GC	0	4.13 a	6.66 a	9.83 abc	13.24 abc	16.36 abc
GK	0	4.40 a	7.56 a	10.83 a	14.38 a	17.88 ab
GP	0	3.78 a	7.00 a	10.36 ab	14.14 a	17.79 ab

* and **, see in Table 1.

3.5 Vitamin C content

MD2 showed significantly higher vitamin C content than GP3, and their difference was wider as the fruit stay longer in the 7 ºC storage (Table 5). In general, as they stayed longer in the storage, their vitamin C content decreased. However, MD2 experienced lesser vitamin C decrease than GP3. During 35 days storage at 7 ºC, MD2 lossed 24.53% of its vitamin C content, while GP3 lossed 54.14% of it.

Table 5. The effect of fruit coatings on the vitamin C content of two pineapple clones during 35 days-storage at 7 ºC

Treatment*	Vitamin C (mg/L)**					
	D-0	D-7	D-14	D-21	D-28	D-35
M	518.67 a	573.86 a	568.71 a	483.33 a	378.62 a	391.45 a
G	108.67 b	113.14 b	131.43 b	91.81 b	76.65 b	49.84 b
A	308.00 ab	340.00 a	354.00 a	261.58 ab	219.74 a	250.32 a
C	311.00 ab	357.14 a	361.43 a	307.91 ab	246.71 a	217.10 ab
K	336.33 a	340.00 a	348.86 a	253.67 b	213.82 a	188.06 b
P	299.33 b	336.86 a	336.00 a	327.12 a	230.26 a	227.10 a
MA	520.67 ab	573.14 a	590.86 a	433.90 a	375.00 a	440.64 a
MC	523.33 ab	584.57 a	552.57 a	516.38 a	384.21 a	381.93 bc
MK	547.33 a	575.43 a	580.57 a	424.86 a	359.21 a	340.64 c
MP	483.33 b	562.29 a	550.86 a	558.19 a	396.05 a	402.58 ab
GA	95.33 c	106.86 b	117.14 b	89.27 b	64.47 b	60.00 d
GC	98.67 c	129.71 b	170.29 b	99.43 b	109.21 b	52.26 d
GK	125.33 c	104.57 b	117.14 b	82.49 b	68.42 b	35.48 d
GP	115.333 c	111.429 b	121.143 b	96.045 b	64.474 b	51.613 d

* and **, see in Table 1.

In general, comparing to control treatment (K), coatings did not affect vitamin C content. Therefore, as in fruit weight loss (Table 4), the effects of their interactions depended on the significant effects from clones. Regardless of coatings, MD2 generally showed higher fruit vitamin C content.

3.6 Fruit respiration rate

During cold storage at 7 ºC, higher respiration rate of GP3 than MD2 clone was detected only up to 7 days storage, and generally, their difference in respiration rate was not detected at later days storage (Table 6). In general, the respiration rate of the clones was also not affected with coatings and their interactions.

Table 6. The effect of fruit coatings on the respiration rate of two pineapple clones during 35 days-storage at 7 ºC

Treatment*	Respiration Rate (mg CO_2 /kg.h)**					
	D-0	D-7	D-14	D-21	D-28	D-35
M	1.15 b	2.97 b	4.24 a	4.10 a	4.10 a	4.07 b
G	1.68 a	3.67 a	3.78 a	4.20 a	4.16 a	4.35 a
A	1.27 a	3.17 a	4.51 a	4.32 a	3.97 a	4.04 b
C	1.31 a	3.44 a	3.78 a	3.82 a	4.03 a	4.17 ab
K	1.63 a	3.65 a	3.79 a	4.34 a	4.26 a	4.52 a
P	1.45 a	3.02 a	3.95 a	4.13 a	4.25 a	4.10 ab
MA	1.18 a	2.75 a	4.52 a	4.12 a	3.75 a	3.96 b
MC	1.13 a	3.01 a	4.21 a	3.93 a	4.20 a	4.03 ab
MK	1.39 a	3.66 a	4.16 a	4.12 a	4.33 a	4.24 ab
MP	0.92 a	2.47 a	4.07 a	4.24 a	4.10 a	4.04 ab
GA	1.36 a	3.58 a	4.50 a	4.52 a	4.18 a	4.11 ab
GC	1.50 a	3.87 a	3.35 a	3.72 a	3.86 a	4.30 ab
GK	1.88 a	3.64 a	3.42 a	4.56 a	4.19 a	4.81 a
GP	1.99 a	3.57 a	3.83 a	4.02 a	4.40 a	4.16 ab

* and **, see in Table 1.

3.7 Glucose, fructose, and sucrose contents

Of sugar types, sucrose significantly dominated, and its percentage was slightly decreased during storage (Table 8). While glucose content of MD2 was decreased, that of GP3 was slightly increased during storage. Fructoses of both clones were significantly increased during storage. Coatings, neither individual nor interaction, did not significantly change of both sugar composition and contents.

Table 8. The effect of fruit coatings on the glucose, fructose, and sucrose content of two pineapple clones during 35 days-storage at 7 ºC

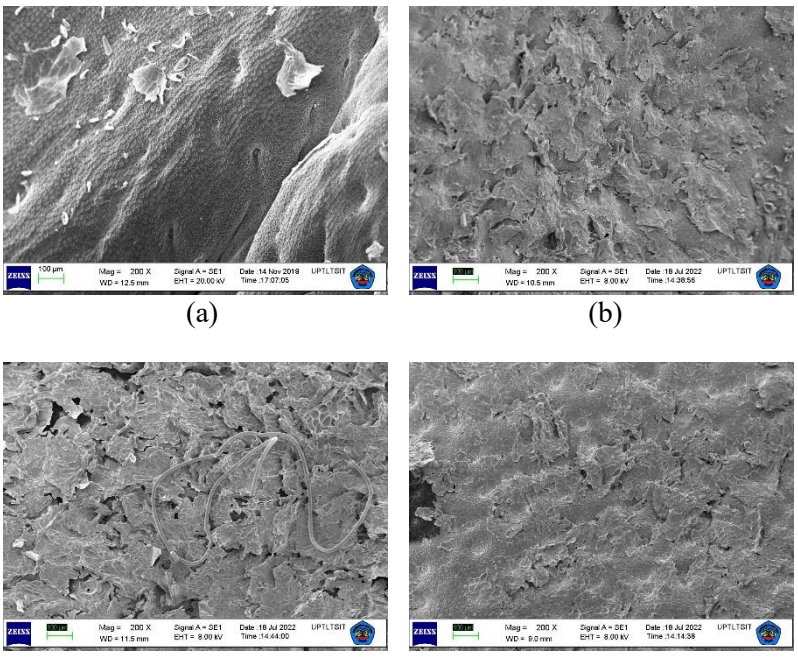
Treatment	Glucose (%)		Fructose (%)		Sucrose (%)	
	D-0	D-35	D-0	D-35	D-0	D-35
M	2.48 a	1.87 b	1.92 a	2.18 b	9.49 a	9.20 a
G	2.39 a	2.44 a	1.86 a	2.79 a	7.46 b	6.25 b
A	2.57 a	2.03 a	2.06 a	2.37 a	9.00 a	7.56 a
C	2.21 a	1.96 a	1.67 a	2.22 a	7.60 a	8.17 a
K	2.53 a	2.47 a	1.94 a	2.88 a	8.56 a	7.45 a
P	2.45 a	2.17 a	1.91 a	2.47 a	8.71 a	7.72 a
MA	2.56 a	1.93 a	1.98 a	2.30 a	9.65 a	8.41 a
MC	2.41 a	1.72 a	1.65 a	1.94 a	9.62 a	10.32 a

MK	2.59 a	2.17 a	2.01 a	2.59 a	9.78 a	8.14 a
MP	2.37 a	1.66 a	1.82 a	1.87 a	8.89 a	9.94 a
GA	2.58 a	2.12 a	2.14 a	2.43 a	8.35 a	6.72 a
GC	2.00 a	2.19 a	1.68 a	2.50 a	5.58 a	6.03 a
GK	2.46 a	2.77 a	1.88 a	3.17 a	7.37 a	6.77 a
GP	2.53 a	2.68 a	1.99 a	3.07 a	8.53 a	5.49 a

* and **, see in Table 1.

3.8 Fruit coating image results with scanning electron microscope (SEM)

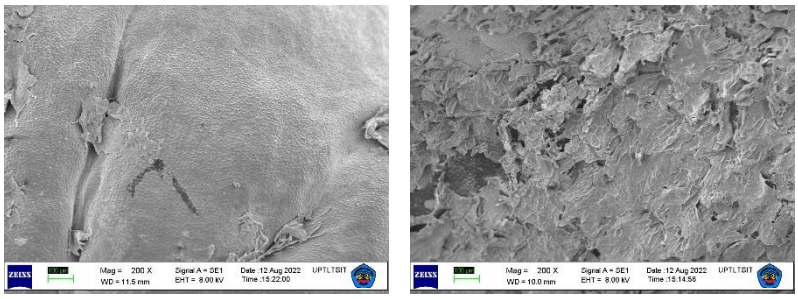
Figures 3 and 4 show layers of pineapple fruit rind surface that were given various kinds of fruit coatings, and analyzed under Scanning Electron Microscope (SEM). The SEM scannings show that coating materials coated evently the fruit rind of both clones. The most event coating was performed by the palm stearin + chitosan mix, followed by chitosan, and Aloe vera + chitosan mix.



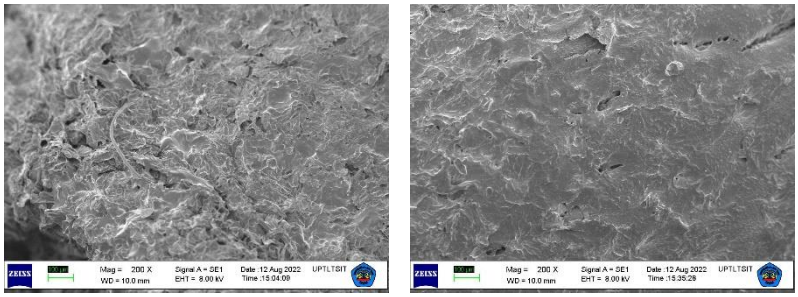
(a) (b)

(c) (d)

Figure 3. Photo of fruit coating (a) control, (b) chitosan, (c) chitosan+aloe vera, and (d) chitosan+palm stearin using a scanning electron microscope on the fruit rind layer of the clone MD2



(a) (b)



(c) (d)

Figure 4. Photo of fruit coating (a) control, (b) chitosan, (c) chitosan+aloe vera, and (d) chitosan+palm stearin using a scanning electron microscope on the fruit rind layer of the clone GP3

4. Discussion

Pineapple clone MD2 is a clone that is usually produced for distribution as fresh pineapple. This is because it tastes sweeter and is less sensitive to internal browning [6]. In this study, it was seen that the internal browning of the pineapple clone GP3 appeared faster than that of the MD2 clone. This is because the pineapple clone GP3 is more sensitive to the occurrence of internal browning. Internal browning is also a physiological disorder of pineapple which is mostly caused by exposure to low temperatures after harvest. The occurrence of IB is caused by extreme temperature shifts, from low temperatures directly to high temperatures. In a study conducted by [8] showed that PPO activity was directly related to the development of IB symptoms in pineapple fruit storage at different storage temperatures. There was a relationship between an increase in IB symptoms and an increase in temperature, and the greatest value was found in fruit stored at 25°C, followed by fruit stored at 10 and 6°C. According to research [8] also showed that internal browning can be influenced by the activity of the enzyme polyphenol oxidase (PPO). The MD2 pineapple clone in this study showed a higher and significantly different vitamin C yield than the GP3 clone. So that the MD2 clone can be a choice of fresh fruit that has a high vitamin C content when consumed directly.

Fruit coating is a material that needs to be done during the post-harvest process. The many types of fruit coatings cause us to need to know the best mixture to use as a pineapple coating option. Edible coating is a method of applying a thin layer on the surface of the fruit to inhibit the release of gas, water vapor and avoid contact with oxygen, so that the ripening and browning process of fruit can be slowed down. Edible coatings on fruits and vegetables have the prospect of improving the appearance quality and shelf life of fruits or vegetables. Pineapple coated with Aloe vera+chitosan showed a lower respiration rate compared to other treatments. This can be caused by the polysaccharide content found in aloe vera gel which can inhibit the transfer of CO_2 and O_2 gases, and contains many components that can inhibit the damage of postharvest products that function as anti-microbial, and slow down the rate. respiration and transpiration that occurs so that water loss can be minimized [9]. Chitosan has the ability as a coating to increase shelf life, reduce respiration rate, inhibit the growth of pathogens, and reduce the formation of ethylene, carbon dioxide, and can form suitable films and have biodegradable properties so that damage and ripening of fruits and vegetables can be inhibited [10]. The chitosan treatment which was added with aloe vera and palm stearin showed a higher vitamin C value than the other treatments. This is due to the addition of palm stearin which serves to help maintain the structure and shape of the product during fluctuations in storage temperature [11].

In the brix variable, the control treatment showed the highest brix value among other treatments, this was due to the occurrence of a high respiration rate due to the absence of protection from pineapple fruit from exposure to gas and environmental temperature. Commodities with high respiration rates will show a tendency to decompose more quickly. Respiration rate depends on temperature, oxygen (O_2), carbon dioxide (CO_2), humidity (RH), mechanical injury (wounds & bruises) and pest and disease infection

[12]. The results also showed that the treatment combination of GP3 clones without coating also showed the highest respiration value compared to other treatment combinations. Respiration generates heat because the sugars, fats, and proteins in plant cells are oxidized. The decrease in fruit weight is mainly related to respiration and evaporation of water through the skin. The coating acts as a barrier, thereby limiting water transfer and protecting the fruit skin from mechanical injury and delayed dehydration [13].

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6. Conclusion

Pineapple clone GP3 began the incidence of IB disorders on the 21st day, much more earlier than the MD2 which was on the 35th day. The MD2 showed a ^{o}Brix of 16.82% and vitamin C of 391.45 mg/L which were significantly higher than the GP3. Meanwhile, the GP3 showed 0.60% acidity which was significantly higher than the MD2. Fruit coatings mixed with the natural ingredients were able to maintain ^{o}Brix and acidity values, especially in the MD2. These indicated that the GP3 should not be considered as an option for fresh fruit consumption, especially because of its sensitivity to IB and lower sweetness compared to the MD2 clone.

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