Fruit Qualities of Two Export Quality Pineapple Clones Applied with Postharvest Fruit Coatings During Cold Storage

Soesiladi Esti Widodo[1*], Agus Karyanto[1], Sri Waluyo[2], Putri Mariska Fahmi[3], and Ahmad Ziaurrahman[3]

[1]Department of Agronomy and Horticulture, Faculty of Agriculture, University of Lampung, Bandar Lampung, Indonesia 35145.
[2]Department of Agricultural Engineering, Faculty of Agriculture, University of Lampung, Bandar Lampung, Indonesia 35145.
[3]Study Program of Magister of Agronomy, Faculty of Agriculture, University of Lampung, Bandar Lampung, Indonesia 35145.
*sestiwidodo@gmail.com

Abstract. The most produced pineapple clones in Indonesia are MD2 for fresh fruit and GP3 for canning. If the GP3 is promoted for a fresh fruit, it needs fruit coatings. This research aims to examine the responses of MD2 and GP3 clones to various fruit coating treatments through their response to internal browning (IB) and other fruit qualities. This study was arranged in a 2 x 6 factorial with five replications. The first factor was two pineapple clones (MD2 and GP3), the second factor was six fruit coatings [control/water, OE6012 (10% v/v), Sta-Fresh2952 (10% w/v), chitosan (1% w/v), a mixture of *Aloe vera* gel (25% w/v) + chitosan, a mixture of palm stearin (1% w/v) + chitosan]. The results showed that (1) based on its sensitivity to IB, lower ºBrix and vitamin C values, GP3 clone pineapples were not suitable as fresh pineapple, especially for overseas shipments of more than 14 days. However, for domestic shipments that require less than 14 days, GP3 clone may still be considered. (2) Fruit coatings from domestically coating materials, such as chitosan, *Aloe vera* gel, and palm stearin, were able to compete with the existing-imported materials, such as OE6012 and Sta-Fresh2952.

Keywords: Fruit Coating, Internal Browning, Pineapple.

1 Introduction

Pineapple is a fruit that is widely produced in Indonesia. Pineapple production in Indonesia in 2019 is the 4th largest in the world after Costa Rica, the Philippines and Brazil [1]. Lampung Province is the largest contributor to pineapple fruit production in Indonesia, which is 30.51% of the national pineapple production [2]. The most widely produced pineapple clones in Indonesia are Smooth Cayenne (GP3) and hybrid (MD2) types. GP3 pineapple clones are widely produced as canned fruit, this is because GP3 clones have a high level of sensitivity to internal browning (IB). MD2 pineapple clone

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is a fruit that is usually produced as fresh fruit and has many advantages compared to other types of pineapple, namely having a golden yellow skin and flesh color, a higher content of vitamin C and total soluble solids, and resistance to cold storage. Research [3] showed that the intensity of IB attacks on MD2 clones was lower compared to Smooth Cayenne.

Promoting GP3 clones as fresh pineapples for domestic marketing may fill the short supply of MD2 clones if global consumer demand for MD2 pineapples continues to increase. The use of GP3 as fresh pineapple needs to be studied considering the concern that the risk of IB can be minimized because domestic marketing does not require a long cold storage. It is hoped that the use of fruit coating on GP3 clones will further reduce the risk of IB, because coatings have been reported to reduce internal browning [4, 5]. Unfortunately, studies on the use of GP3 clone as fresh pineapple are difficult to obtain. In addition, if the GP3 clone may still be promoted to be used a fresh fruit, at least for domestic consumption, it definitely needs fruit coating. Unfortunately, information on suitable fruit coatings for GP3 is also difficult to be found.

The distribution of fresh pineapple for export sometimes has several obstacles, one of which is fruit damage due to IB stored at low temperatures [6]. IB is a physiological damage to fruit that can reduce fruit quality and cause the flesh around the core to turn brown. IB cannot be identified from outside the fruit, but the fruit needs to be split to determine the severity of IB. Fruit browning occurs due to the reaction between phenolic compounds and polyphenol oxidase (PPO) enzymes under aerobic conditions [7].

Fruit coating is one of the postharvest treatments that can be used to maintain fruit quality and prevent fruit damage. Fruit coating is an effort to delay ripening which aims to extend the shelf life of horticultural products [8]. OE6012 and Sta-Fresh2952 are coatings that are commercially used to coat fruit and available in the market. The addition of natural ingredients such as palm stearin, *Aloe vera* gel, and chitosan is expected to be able to compete with the types of coatings that are widely sold in the market. Therefore, this study aims to examine the response of MD2 and GP3 pineapple clones to the various coating treatment of fruits through their response to internal browning and other fruit qualities. The primary aims are to give academic considerations whether GP3 clone may compete with MD2 clone for fresh fruit, and what kind of fruit coatings are suitable for it.

2 Material and Method

This study was conducted in the Laboratory of the Great Giant Pineapple Co. Ltd. (PG4), Labuhan Ratu District, East Lampung, Indonesia. The study was conducted starting from July to August 2022, in cold storage of 7 ºC. Observations were conducted on days 0, 7, 14, 21, 28, and 35 after application. A 2 x 6 factorial arranged in a Completely Randomized Design and five replications were used. The first factor was clones of GP3 (G) and MD2 (M).). The second factor was fruit coatings, namely: control (without coating; K), OE6012 (10% v/v equivalent to ºBrix 5.5) (O), Sta-Fresh2952 (10% w/v equivalent to ºBrix 5.5) (S), chitosan (1% w/v; a pharmaceutical grade, product of CV. ChiMultiguna, https://tokopedia.link/QTJzC8BK7lb) (C), a mixture of *Aloe vera* gel (25% w/v; a product of Herbavera, https://id.shpee/gdGqyXM) + chitosan (A), a mixture of palm stearin (1% w/v; a raw palm wax, product of Waxchemie, https://tokopedia.link/bGYXKOoK7lb) + chitosan (P). The coatings consisted of palm stearin melted at 60 ºC, chitosan (1% w/v) dissolved in glacial acetic acid (1% v/v), *Aloe vera* gel (25 % w/w), and Tween 80/Polysorbate 80 (2% v/v). The data were analyzed for variance, and if there was any treatment effect, the analysis was continued with the 5% Least Significant Different (LSD) test.

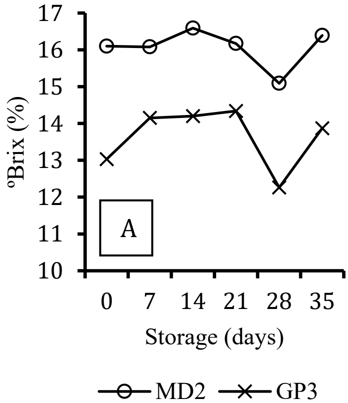
Observations were internal browning (IB) scores, soluble solid content [ºBrix (%) with an Atago® hand refractometer], free acid (as citric acid, titrated with 0.1 N NaOH and phenolphthalein as an indicator), vitamin C (with the 2,6-dichloroindophenol titrimetric method of Association of Official Analytical Chemists (AOAC)), respiration rate, and fruit weight loss.

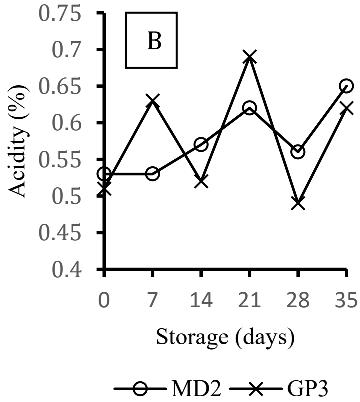
The IB severity measurement was made by visually grading from 0 (no IB) to 5 (maximum IB) on the fruit that was cut lengthwise into two parts. Simple IB scores were score 0 (no IB symptoms), score 1 (small translucent brown spots of no more than 5% of the surface area), score 2 (about 10% of the surface area showed IB symptoms), score 3 (about 20% showed IB symptoms), score 4 (about 30% showed IB symptoms), and score 5 (more than 30% showed symptoms of IB).

For respiration rate measurement, the method of [9] was adopted. A jar as a respiration chamber with a treated pineapple inside was weighed to obtain initial weight data, and the pineapple volume was measured. A data logger for measuring CO_2 was inserted into the jar, and the jar was tightly closed. Then, the measurement of the respiration rate was carried out by the comparative system method. The device was set to measure the amount of CO_2 for 1 hour.

3 Result and Discussion

The °Brix values of the MD2 clone were constantly higher than that of the GP3 clone (Fig. 1-A). During 35 days of storage both clones showed relatively constant changes in °Brix values, ranging from 16.1% on day-0 to 16.39% on day-35 for MD2 clone, and 13.03% on day-0 to 13.87% on day-35 for GP3 clone. Research [9] showed that the °Brix content of MD2 pineapple clones ranged from 15.4-16.6%. The relatively constant changes in the °Brix values of the two clones during 35 days of storage at 7°C will make consumers have a very wide choice to obtain good quality pineapple fruits. MD2 fruits were reported to experience a decrease in °Brix value if stored at 10 °C [10], and the decline would be faster if stored at 25 °C [11].





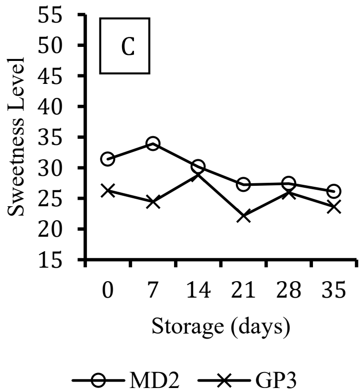


Fig. 1. Changes of soluble solid content (ºBrix, A), acidity (B), and sweetness level (ºBrix-acidity ratio, C) of two pineapple clones during 35 days of storage at 7 ºC.

The acidities of both MD2 and GP3 clones of pineapple tended to increase during 35 days of storage at 7 °C (Fig. 1-B). At 10 °C storage, MD2 clones were also reported to increase in total acidity [10] or to decrease in pH [11].

Because the changes in the °Brix values of the two clones were relatively constant, while the acidities of the fruits tended to increase during 35 days of storage at 7 °C, the expected results were that the levels of sweetness (°Brix/acidity ratios) of the fruit of the two clones would decrease slightly (Fig. 1-C). The sweetness level of MD2 pineapple clones usually ranges from 20 to 30 [9]. The sweetness level of the GP3 clones in this study showed values between 22-26 during 35 days of storage, while the MD2 clones showed values between 26-33. During 35 days of storage at 7 °C, the sweetness level of the MD2 clones was consistently higher than that of the GP3 clones. However, the difference in the sweetness level of the two clones was not significant between 14 and 35 days of storage (Fig. 1-C). This suggests that judging from the level of sweetness of the fruit, the GP3 clone has the potential to compete with the MD2 clone as fresh fruit.

The most significant differentiator between the qualities of MD2 and GP3 fruit was the content of vitamin C. During storage at 7 °C for 35 days, the vitamin C content of MD2 pineapple far exceeded that of PG3 pineapple (Fig. 2-A). The MD2 pineapple vitamin C content was consistently at a level above 500 ppm, while the GP3 pineapple vitamin C on day-0 storage was recorded at 100.22 ppm and decreased on day-35 to reach as low as 53.07 ppm. The content of vitamin C in the MD2 clone has also been reported to be higher than Smooth Cayenne [12]. Other researchers [13] reported that the content of vitamin C at the mature green stage of MD2 reached 631.7 ppm and this content continued to decrease following the level of fruit ripening and reached 461.1 ppm at the ripe stage (100% yellow).

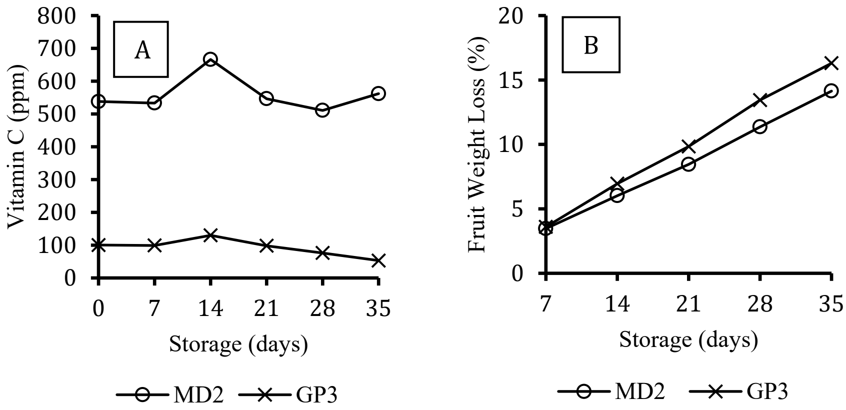


Fig. 2. Changes of vitamin C content (A) and fruit weight loss (B) of two pineapple clones during 35 days of storage at 7 ºC.

Both clones showed a linear increase in weight loss during 35 days of storage at 7 °C and consistently the GP3 clone experienced higher weight loss than the MD2 clone (Fig. 2-B). At a shelf life of 7 days, the GP3 clone experienced a weight loss of 3.60%, while the MD2 clone experienced a lesser weight loss of 3.47%. This weight loss increased linearly up to 16.30% for the GP3 clone and 14.14% for the MD2 clone. Other researchers [14] reported that GP3 clones experienced weight loss reaching 13.40-14.70%, while MD2 clones reaching 7.10 - 9.52% during 37 days of storage at 7 °C. Weight loss through crowns contributed to 3.13-3.40% for GP3 clones, while MD2 reached 1.66-2.38% [14]. Therefore, the body of pineapple fruit dominated the fruit weight loss in both clones.

The respiration rate in this study showed that the GP3 clone seemingly had a slightly higher respiration rate than the MD2 clone, but they were not significantly different (Fig. 3). The respiration rate of both clones showed a high increase on the 7th day of observation. However, the GP3 clone showed a significantly higher occurrence of internal browning (IB) and was significantly different compared to the MD2 clone. IB in the GP3 clone began to appear on the 14th day of observation and significantly increased up to the end of observation on 35 days-storage, while in the MD2 clone it began to appear slightly on the 21st day and keeping it low (Fig. 3). Therefore, based on its sensitivity to IB, especially for shipments of more than 14 days such as overseas shipments, GP3 clone pineapples are not suitable as fresh pineapples. However, for shipments that require less than 14 days such as shipments to domestic destinations, GP3 clone pineapples can still be considered.

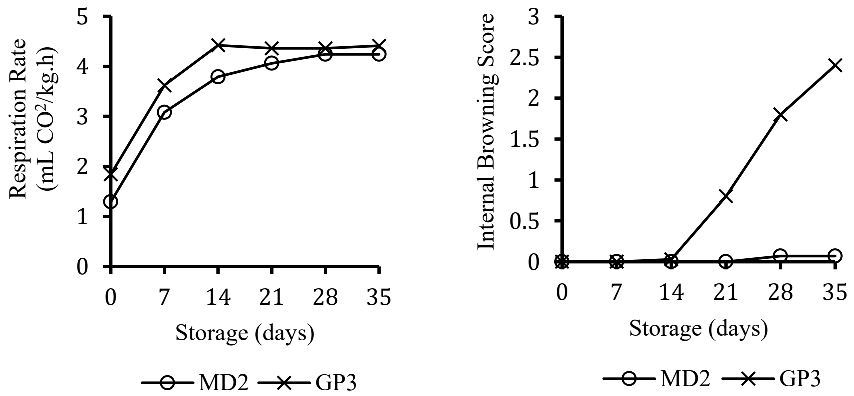
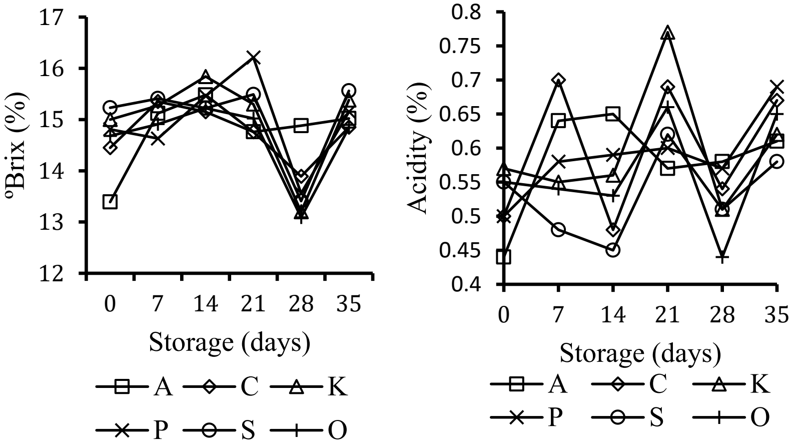


Fig. 3. Changes of respiration rate and internal browning score of two pineapple clones during 35 days of storage at 7 °C

The changes of respiration rate and the occurrence of IB of both pineapple clones (Fig. 3) told us that the method of detecting the occurrence of IB non-destructively by capturing heat released from pineapple fruit respiration as thermal images, just like having been done in pineapples and other fruits [15-22], seemed to be difficult. That was because the pattern of IB occurrence did not strictly follow that of respiration rates (Fig. 3).

This study showed that fruit coatings did not mostly have a significantly different effect on the variable °Brix, the level of acidity and that of sweetness (Fig. 4), vitamin C content and fruit weight loss (Fig. 5), respiration rate and IB (Fig. 6). These results proved that fruit coatings prepared from domestically coating materials, such as chitosan, the mixture of *Aloe vera* gel + chitosan, and the mixture of palm stearin + chitosan, were able to compete with the existing-imported materials of fruit coatings, such as OE6012 and Sta-Fresh2952. The only superiority of the existing-imported fruit coating was shown by Sta-Fresh2952 on preventing fruit weight loss. The Sta-Fresh2952 fruit coating showed the lowest weight loss among other fruit coatings, namely between 7-12% compared to other fruit coatings between 9-17% (Fig. 5).

Internal browning (IB) is a physiological disorder of pineapples that is mostly caused by exposure to low temperatures after harvest. The occurrence of IB is caused by temperature transfer, from low temperature directly to high temperature. Appearance of IB is indicated by the start of a brownish color on the surface of the pineapple core when it is split. Research [23] showed that polyphenol oxidase (PPO) enzyme activity was directly related to the development of IB symptoms in pineapple at different storage temperatures. The formation of brown color is caused by the oxidation of phenolic and polyphenolic compounds by phenolase and polyphenolase enzymes to form melanin (brown pigment). The IB occurrences in this study are shown in Fig. 7.



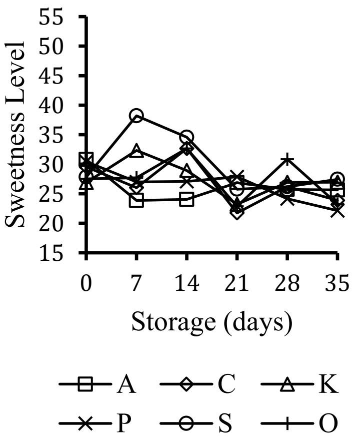


Fig. 4. Changes of soluble solid content (ºBrix), acidity, and sweetness level (ºBrix-acidity ratio) of pineapple fruits coated with different coatings during 35 days of storage at 7 ºC; A = *Aloe vera* gel (25% w/v) + Chitosan mix; C = Chitosan (1% w/v); K = Control (H_2O); P = palm stearin (1% w/v) + chitosan mix; S= Sta-Fresh2952 (10% w/v equilized to ºBrix 5.5); O = OE6012 (10% v/v equilized to ºBrix 5.5).

Fruit coating applied in this study did not show a significant effect on IB. Research [11] showed that fruit browning during storage occured because the respiration rate that occurs in fruit was high. The increase in respiration rate since the beginning of storage allowed the IB of the pineapple flesh to continue to increase. The differences in the types of coatings also did not affect the rate of respiration (Fig. 6), so that the thermal image method could not be used to analyze IB non-destructively. However, giving pineapple a coating can improve the appearance of the fruit so that pineapple will be more attractive than without coating.

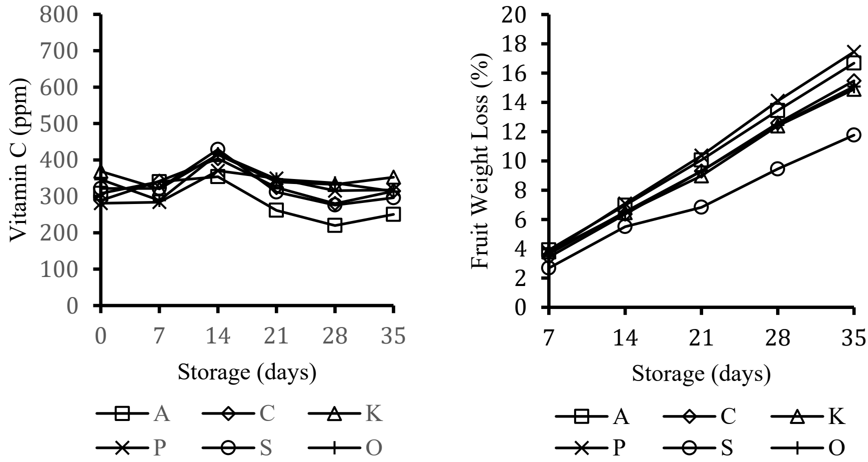


Fig. 5. Changes of vitamin C content and fruit weight loss of pineapple fruits coated with different coatings during 35 days of storage at 7 ºC; see at Fig. 4 title's note.

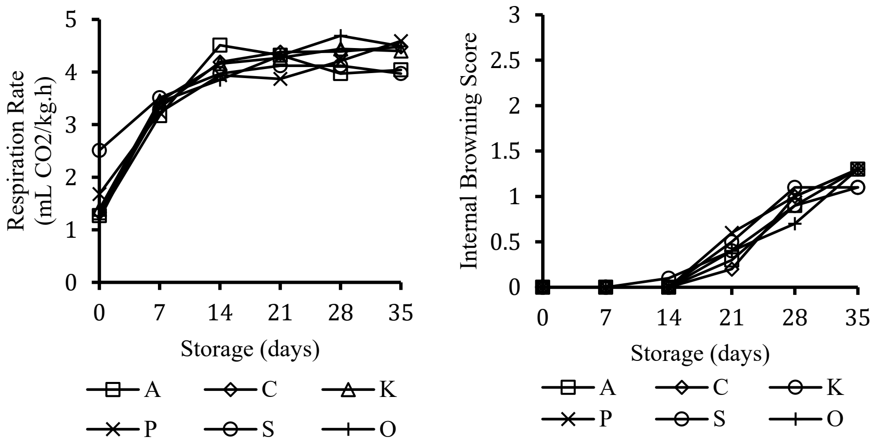


Fig. 6. Changes of respiration rate and internal browning score of pineapple fruits coated with different coatings during 35 days of storage at 7 ºC; see at Fig. 4 title's note.

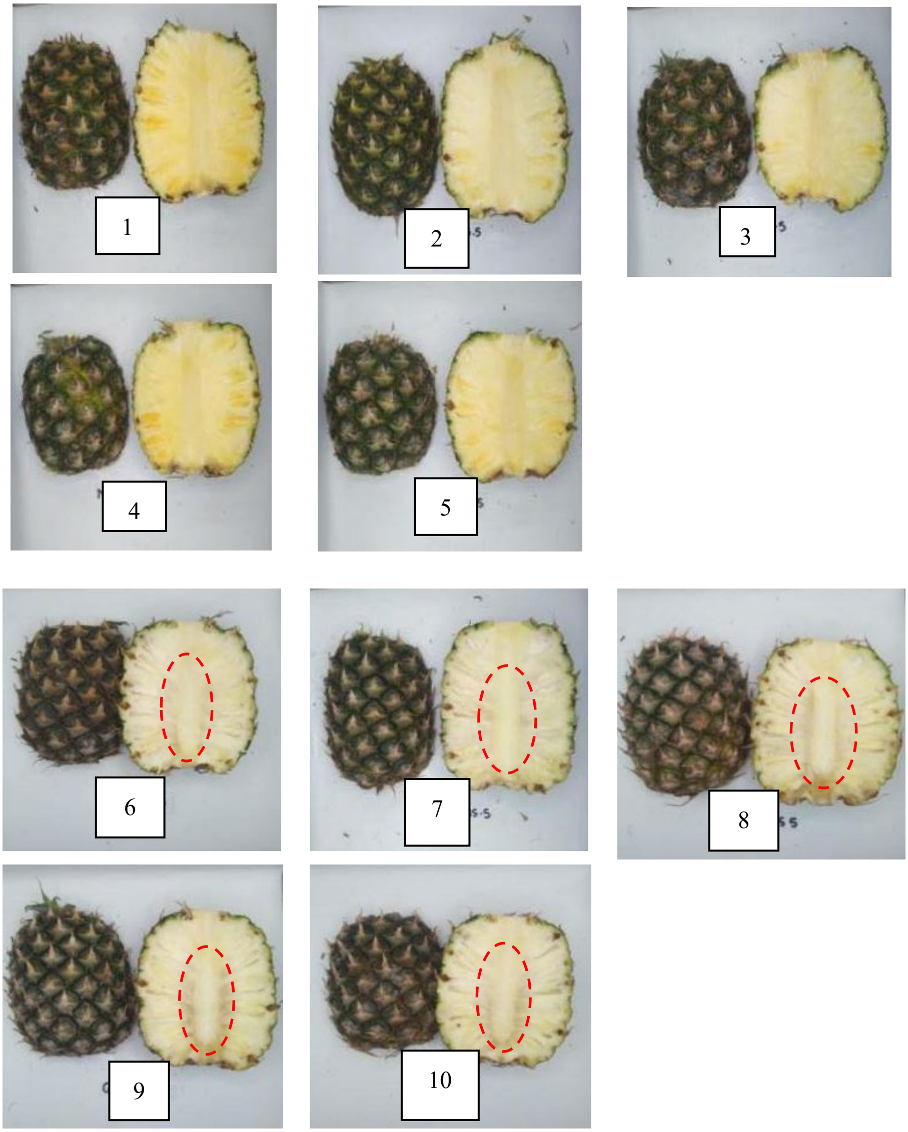


Fig. 7. Fruit-coated MD2 (upper, 1-5) and GP3 (lower, 6-10) clone pineapple flesh after being stored for 35 days. No IBs on MD2 clones (five upper), but IBs in the red circles on GP3 clones (five lower). 1-5 are coatings with palm stearin, Sta-Fresh2952, chitosan, OE6012, and control, consecutively. 6-10 are coatings with palm stearin, Sta-Fresh2952, chitosan, OE6012, and control, consecutively.

4 Conclusion

The results showed that (1) based on its sensitivity to internal browning, lower ºBrix and vitamin C values, GP3 clone pineapples were not suitable as fresh pineapples, especially for shipments of more than 14 days such as overseas shipments. However, for shipments that require less than 14 days such as shipments to domestic destinations, GP3 clone pineapples may still be considered. (2) Fruit coatings prepared from domestically coating materials, such as chitosan, *Aloe vera* gel, and palm stearin, were able to compete with the existing-imported materials of fruit coatings, such as OE6012 and Sta-Fresh2952.

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