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The Effect of Harvest Age on The Texture and Organoleptic Properties of Mas Kirana Bananas During Storage Stage

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ABSTRACT: Bananas are classified as superior perishable and climacteric fruits, so they require proper postharvest handling, especially in harvesting and storage. Fruit softness, water content, and organoleptic tests can be indicators of determining the quality of bananas. This study aims to determine the effect of different harvesting ages and storage techniques on the value of fruit softness, water content, and organoleptic test on Mas Kirana bananas for five days of storage. The study used a two-factor, Completely Randomized Design (CRD) with four replications. Factor 1 is the harvest age of 40 and 57 days after anthesis (DAA). Factor 2 is a storage technique without cardboard boxes, cardboard boxes without KMnO4, and cardboard boxes with KMnO4. The data obtained were analyzed using the Analysis of Variance (ANOVA) and continued with Duncan's Multiple Range Test (DMRT) at a confidence interval of α = 5%. The results showed that harvesting age and storage techniques did not significantly affect fruit softness on days 1st, 3rd, and 5th of storing Mas Kirana bananas. Harvesting age had a significant effect on water content on the first and third days of storage and was not significant on the fifth day of storage. Storage techniques did not have a significant effect on the water content of Mas Kirana bananas during storage. Organoleptic tests significantly affect color, flavor, aroma, and texture during storage. The highest average flavor and scent values were found in the 40 DAA harvesting technique storage without a cardboard box (U1P1).

Keywords: KMnO4, texture, bananas, harvest age, organoleptic.

INTRODUCTION

Bananas are climacteric fruits with significant economic value at all stages of maturity. During the young phase, bananas tend to have a hard texture, so they are more suitable for consumption by processing them into banana chips to make slicing them thinly easier. Raw or green bananas were blanched and fried to make banana chips (Jackson, Bourne, & Barnard, 2006). In the ripe ripeness phase, bananas can be consumed fresh because they have softened and have the right texture, namely, not hard and not too soft, like when bananas enter the overripe phase. Texture is one of the essential characteristics that can be considered to evaluate the eating quality of bananas (Jaiswal, et al., 2014). The process of hydrolysis of starch into sugar can play a role in influencing changes in the texture of bananas. The hydrolysis of starch into sugar is related to the water content of bananas. The higher the ripeness phase of the banana, the more softened the texture with the higher water content. The ripening period is reported to significantly affect the hardness of banana skin and flesh (Jaiswal, et al., 2014)

Bananas can undergo a ripening process while still on the tree or after being harvested, so the age of picking or harvesting must be determined precisely. Bananas that are harvested too quickly before the physiological maturity phase can accelerate the decline in quality, such as less sweet flavor, wrinkles, and small banana fruit size. However, if the banana is harvested too late, it can complicate the marketing process because the banana fruit tissue softens and rots quickly (Zulkarnain, 2009).

Post-harvest losses of bananas are reported to be around 10-15% in Chitwan, Nepal, after mangoes, oranges, and apples (Joshi, Kalauni, & Tiwari, 2020). Storage temperature and physiological age at harvest greatly affect the concentration (long contact time) of ethylene needed for the ripening of bananas (Brat, Bugaud, Guillermet, & Salmon, 2020). The harvest age for Raja Bulu bananas is around 110 Days After Anthesis (DAA), and Kepok bananas are around 110 DAA (Sutowijoyo & Widodo, 2013). (Rahayu, Widodo, & Suketi, 2014) reported that Raja Bulu bananas can be stored for up to 10 days when harvested at 85 DAA.

Bananas are classified as climacteric fruits that can experience a spike in respiration rate and increased ethylene levels. Ethylene is generally known as a hormone substance that can trigger the ripening process of bananas. Banana fruit, as a climacteric fruit, can be ripened by triggering the respiration rate with artificial ethylene and can also be maintained in a raw condition by inhibiting the respiration rate by breaking down ethylene, including the compound potassium permanganate ($KMnO_4$). $KMnO_4$ produces CO_2 and water from the oxidation process on ethylene (Elzubeir, Abu-Goukh, & Osman, 2017). $KMnO_4$ breaks the double bond in ethylene gas into KOH, manganese (II) oxide, and CO_2 (Pradhana, Hasbullah, & Purwanto, 2013).

The process of controlling ethylene gas with $KMnO_4$ can be optimized by using the proper packaging. (Lisawengeng, Wenur, & Longdong, 2020) reported that mechanical damage to cardboard boxes was better than plastic sacks and had a total damage of 36.56% during the transporting of bananas. The lowest respiration rate of bananas was obtained in the $KMnO_4$ treatment with a concentration of 15% (Arista, Widodo, & Suketi, 2017). Cardboard boxes are also good at controlling ethylene gas, respiration rate, and weight loss in fruit (Kaur & Kaur, 2019). This research aims to determine the effect of harvest age and different storage techniques on fruit softness (texture), water content, and organoleptic tests on Mas Kirana bananas for seven days of storage.

METHOD

Sample and KMnO4 Preparation

Mas Kirana Bananas (Musa acuminata L.), as the main ingredient of this study, were harvested from a banana garden in Argapura Village, Cigudeg District, Bogor Regency, West Java, at the harvesting age of 40 and 57 Days After Anthesis (DAA). Mas Kirana banana plants were selected at around 17 months old and flowered at 8-10 months (Rachmadan, 2015). Banana buds that have not yet bloomed are marked with a label containing the date, month, and year of the start of flowering (Fig. 1a). Shredding with blue plastic (Fig. 1b) refer to (Muchui, et al., 2010). The bananas are ready to be picked and cut down, and the fruit bunches are taken. Mas Kirana's bananas were transported to the research location, namely the Fundamental Laboratory of Campus F7, Gunadarma University, using a car with bearings on each comb of bananas. Bananas are washed with running water and air-dried in a para-para. Banana combs are sorted with the criteria of uniform size, color, and no defects. Mas Kirana bananas were selected with a straight-cylindrical fruit shape, finger length of 9.55 □ 3.09 cm, and finger circumference of 3.06 □ 1.74 cm (Prahardini, Yuniarti, & Krismawati, 2010). Potassium permanganate (KMnO4) was prepared according to by dissolving 25 grams in 100 ml of distilled water. Silica gel was put in KMnO4 solution for 10 minutes, then filtered and dried until ready to be used in a 28x28x10 cm board box packaging while storing Mas Kirana bananas. The edges of the cardboard box are modified with insulation to prevent the lid of the cardboard box from opening.

a)


Fig. 1. a) Labeling Banana Trees, b) Selling Banana Bunches

Texture, Water Content and Organoleptic Evaluation

Observation of fruit softness using a penetrometer with a diameter of ~8 mm at the tip, middle, and base of the banana flesh on days 1, 4, and 7 of storage of Mas Kirana bananas. Calculation of water content using the oven method according to (Yan, et al., 2016). Twenty-five persons carried out organoleptic testing as untrained panelists. The scale used in the organoleptic test consists of 7 levels (Wichchukit & O'Mahony, 2015), namely 1 (like very much), 2 (like), 3 (somewhat like), 4 (neutral), 5 (somewhat dislike), 6 (dislike) and 7 (dislike very much). The parameters observed in the organoleptic test were color, flavor, aroma, and texture. Water content and organoleptic evaluation were observed on days 1, 3, and 5 of banana fruit storage.

Experimental Design and Data Analysis

The research used a 2-factor Completely Randomized Design (CRD). Factor 1 is harvest age 40 (U1) and 57 (U2) Days After Anthesis (DAA). Factor 2 is storage techniques without cardboard boxes (P1), cardboard boxes without KMnO4 (P2), and cardboard boxes with KMnO4 (P3). The treatment was repeated four times to obtain 24 experimental units.The treatment combinations used in this study include: harvest age 40 DAA with storage technique without board box and KMnO4 (U1P1), harvest age 40 DAA with storage technique with board box without KMnO4 (U1P2), harvest age 40 DAA with storage technique with board box and KMnO4 (U1P3), harvest age 57 DAA with storage technique without board box and KMnO4 (U2P1), harvest age 57 DAA with storage technique with board box without KMnO4 (U2P2), harvest age 57 DAA with storage technique with board box and KMnO4 (U3P3). Storage was carried out at room temperature ranging from 25°C to 27°C, and observations were made during seven days of storage.

The observation data was processed using Analysis of Variance (ANOVA) at P 0.0, if significantly different, continued with Duncan's Multiple Range Test (DMRT) at $p<0.05$ using the Statistical Analysis System (SAS) software. The organoleptic test was analyzed using the Friedman Test using the Statistical Package for the Social Science (SPSS) software.

RESULT AND DISCUSSION

Fruit softness

The results of observations in the 40 and 57 DAA harvest age treatments had no significant effect ($P>0.05$) on the fruit softness value during storage of Mas Kirana bananas (Table 1). The highest average was at harvest age 40 DAA on the fourth day of storage with a value of 4.07 N/mm2. The treatment of Mas Kirana banana storage techniques had no significant ($P>0.05$) effect on the softness value of the fruit during storage too. The highest average was found in the cardboard box storage technique without KMnO4 on the fourth day of storage with a value of 3.95 N/mm2. The interaction between the two factors has not significant ($P>0.05$) on the softness value of the fruit during storage.

Table 1. Banana fruit softness (N/mm^2)

Treatment	Fruit softness (N/Mm^2)		
Harvest age (U)	D1	D4	D7
40 DAA	2.82	4.07	3.95
57 DAA	3.77	3.65	3.17
Storage Techniques (P)			
Without cardboard box	2.88	3.80	3.67
Cardboard box without KMnO4	3.88	3.83	3.54
Cardboard box with KMnO4	3.12	3.95	3.47

Means within columns with the different letter are significantly different using *Duncan's Multiple Range Test* at $p < 0.05$.

During the fruit ripening and storage process, some of the water-insoluble propectin turns into water-soluble pectin, thereby reducing the cohesive power of the cell walls that bind the cells to one another; as a result, the fruit hardness decreases, and the fruit becomes soft (Johansyah, Prihastanti, & Kusdiyantini, 2014). The analysis of variance showed that different storage techniques and harvest ages had no significant influence on the softness of rising fruit during storage at a significance of 0.05. The more significant number shown on the penetrometer scale indicates the fruit is softer (Weliana, Sari, & Wahyudi, 2014). During the ripening process, there is a change in fruit softness, which is one of the physiological changes as a direct result of water loss in horticultural products. High respiration can stimulate ethylene biosynthesis, which plays a role in fruit ripening. The ethylene produced will increase during the ripening phase of the fruit (ripening) and decrease towards the withering phase (senescence). Hardness decreases during storage (Dhakal, Aryal, Khanal, Basnet, & Srivastava, 2021) thought to be due to disruption of cell integration, changes in maturation and activity of pectin enzymes, pectin methylesterase (PME) and polygalacturonase (PG) (Sharma, et al., 2010). The breakdown of carbohydrates can cause tissue breakdown in the fruit so that the fruit becomes soft. The transpiration process can cause the fruit to wilt and shrivel so that the fruit becomes soft. Softening is also possible due to damage tocell walls, decrease in the bonds of the middle lamella as a result of dilution of pectin substances and the movement of water from the skin to the flesh of the fruit or osmosis during the ripening phase (Zewter, Woldetsadik, & Workneh, 2012). The increased level of fruit softness occurs due to evaporation. In general, the increasing level of maturity of the fruit is followed by the process of softening the skin and flesh of the fruit (Widodo, Suketi, & Rahardjo, 2019).

Water content

The results of observations in the 40 and 57 DAA harvest age treatments had a real influence significant ($P<0.05$) on the water content values up to 3 days of storage and no real influence significant ($P>0.05$) on Mas Kirana bananas' 5 day of storage. The highest average was at harvest age 57 DAA on the fifth day of storage with a value of 68.50%. The treatment of Mas Kirana banana storage techniques had no significant influence ($P>0.05$) on the water content value during storage. The highest average was found in the cardboard box storage technique without KMnO4 on the fifth day of storage, with a value of 69.37%. The interaction between the two factors had a real influence up to 3 days of storage and no real influence significant ($P>0.05$) on the fifth day of storage on the water content value of bananas.

Tabel 2. Water content of banana fruit (%)

Treatment	Water Content (%)		
Harvest age (U)	D1	D3	D5
40 DAA	62.50^b	64^b	66.67
57 DAA	65.50^a	68.25^a	68.50
Storage Techniques (P)			
Without cardboard box	65.25	68.12	68
Cardboard box without KMnO4	63.87	65.12	65.37

Cardboard box with KMnO4	62.87	65.12	69.37

Means within columns with the different letter are significantly different using *Duncan's Multiple Range Test* at $p < 0.05$.

Moisture content is an essential factor in the storage period of bananas because it will affect the durability of bananas. The longer the bananas are stored, the water content of Mas Kirana's banana flesh will increase. Mas Kirana bananas' additional water content comes from carbohydrates used during the respiration process from the fruit skin. The movement of water from the skin to the fruit flesh is caused by increased osmotic pressure in the fruit flesh, which is caused by the sugar content in the fruit flesh increasing faster than the increase in the sugar content in the fruit skin (Pradhana, 2017). Changes in water content in fruit occur due to the respiration process, which causes the breakdown of starch into simple molecules, water vapor, and carbon dioxide (Irawan , Suhaidi, & Karo-Karo, 2016). The water content of Mas Kirana bananas using the boxless storage technique on the fifth day of storage decreased because the respiration process was still running slowly, but the transpiration process was already underway. As a result, the water content is reduced, and water from the respiration process has yet to be formed (Markiah, Hustiany, & Rahmi, 2020).

Organoleptic Test

Organoleptic testing was carried out to determine the level of preference or dislike of the panelists for Mas Kirana bananas with different harvesting ages and storage techniques. The test was carried out by giving a score to each treatment for the color, aroma, falvor, and texture of the fruit. The organoleptic test was carried out when the fruit had been treated. Organoleptic tests can provide indications of quality deterioration, spoilage, and other damage to the product (Wahyuningtyas, 2010). The color organoleptic net graph of the Mas Kirana banana fruit is presented in Fig. 2 (a). The storage technique for Mas Kirana bananas with different harvest ages was obtained at 72,752 with a significance level of 0.000 ($P<0.05$), which means that the storage technique for Mas Kirana bananas with different harvest ages had a real significant effect ($P<0.05$) on fruit color organoleptic during days 1, 3 and 5 storage.

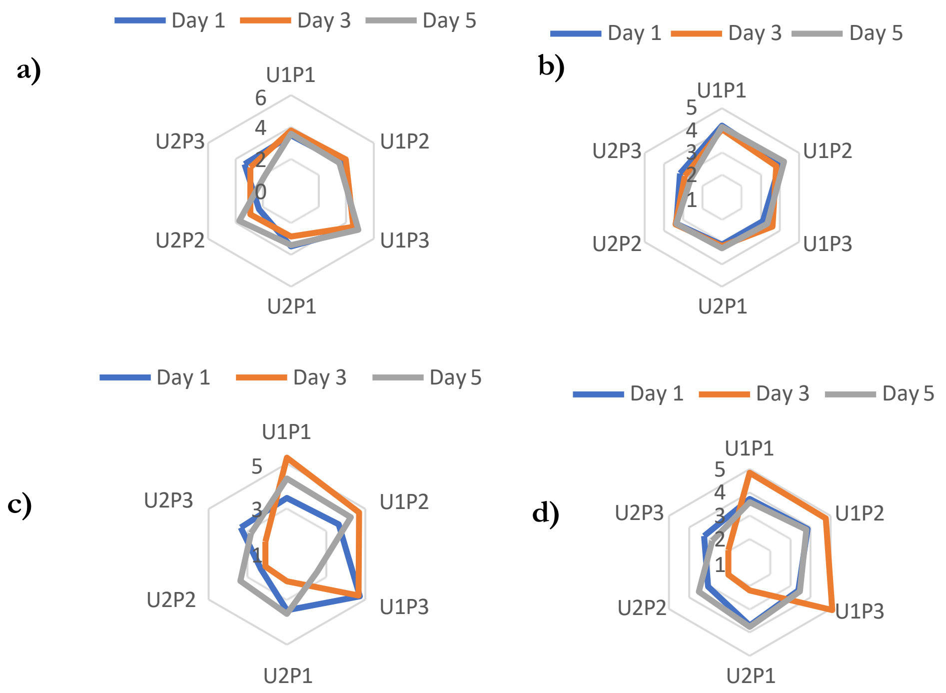

Fig. 2. a) The color organoleptic of banana fruit, b) The flavor organoleptic of banana fruit, c)The aroma organoleptic of banana fruit, d) The texture organoleptic of banana fruit

The average value of Mas Kirana's banana peel color is 3 to 5 with the criteria of dislike and somewhat like. Based on the results of organoleptic tests that have been carried out, it shows that the average color value of Mas Kirana bananas with different harvest ages and storage techniques is U1P1 with an average value of 3.99, somewhat like U1P2 with an average value of 4.09 neutral, U1P3 with an average value -average 4.65 neutral, U2P1 with an average value of 3.59 somewhat disliked, U2P2 with an average value of 3.43 somewhat disliked and U2P3 with an average value of 3.35 somewhat disliked. The highest average value of the panelists' assessment of the skin color of Mas Kirana bananas during storage was U1P3, with a neutral value of 4.65.

The flavor organoleptic net graph of the Mas Kirana banana fruit is presented in Fig. 2. (b). The storage technique for Mas Kirana bananas with different harvest ages has a natural significant ($P<0.05$) effect on the flavor of the fruit during days 1 and 5 storage. The average value of Mas Kirana's banana flavor is 5 to 6 with the criteria of liking and liking. Based on the results of organoleptic tests that have been carried out, it shows that the average flavor value of Mas Kirana bananas during storage with different harvest ages and storage techniques is U1P1 with an average value of 6.11 likes, U1P2 with an average value of 6.08 likes, U1P3 with an average value of an average of 5.71 somewhat likes it, U2P1 with an average value of 5.65 somewhat likes it, U2P2 with an average value of 5.61 somewhat dislikes it, and U2P3 with an average value of 5.4 somewhat likes it. The highest average value of the panelists' assessment of the flavor of Mas Kirana bananas during storage was U1P1, with a value of 6.11 likes.

The aroma organoleptic net graph of the Mas Kirana banana fruit is presented in Fig. 2. (c). Based on the Friedman test, the chi-square value of the storage technique for Mas Kirana bananas with different harvesting ages was 68,780 with a significance level of 0.000 ($P<0.05$), which means that the storage technique for Mas Kirana bananas with different harvesting ages had a significant effect on fruit aroma during days 3 and 5 storage. The average value of Mas Kirana's banana aroma is 4 to 6 with neutral and like criteria. Based on the results of organoleptic tests that have been carried out, it shows that the average value of the aroma of Mas Kirana bananas during storage with different harvest ages and storage techniques is U1P1 with an average value of 5.57 somewhat like, U1P2 with an average value of 5.52 somewhat like, U1P3 with an average value of 5 somewhat like it, U2P1 with an average value of 4.52 neutral, U2P2 with an average value of 4.28 neutral and U2P3 with an average value of 4.35 neutral. The highest average score for the panelists' assessment of the aroma of Mas Kirana bananas during storage was U1P1, with a score of 5.57.

The texture organoleptic net graph of the Mas Kirana banana fruit is presented in Fig. 2 (d). The storage technique for Mas Kirana bananas with different harvest ages was obtained at 64,153 with a significance level of 0.000 (< 0.05), which means that the storage technique for Mas Kirana bananas with different harvest ages has a real significant ($P<0.05$) effect on the texture of the fruit during days 3 storage. The hypothesis states that storage techniques significantly affect Mas Kirana bananas' characteristics during room temperature storage so that they can be accepted. The average value of Mas Kirana banana fruit texture is 4 to 6 with neutral and like criteria. Based on the results of organoleptic tests that have been carried out, it shows that the average texture value of Mas Kirana bananas during storage with different harvest ages and storage techniques is U1P1 with an average value of 5.76 somewhat like U1P2 with an average value of 5.88 somewhat like, U1P3 with an average value of 5.83 somewhat like it, U2P1 with an average value of 4.84 neutral, U2P2 with an average value of 4.71 neutral and U2P3 with an average value of 4.61 neutral. The highest average score for the panelists' assessment of the texture of Mas Kirana bananas during storage was U1P2, with a score of 5.88, which is somewhat like it.

CONCLUSION

Harvest age and storage techniques did not significantly affect fruit softness on days 1, 3, and 5 of storage of Mas Kirana bananas. Harvest age had a significant effect on water content on days 1 and 3 of storage and was not significant on day 5 of storage. Storage techniques did not have a real influence on the water content of Mas Kirana bananas during storage. Organoleptic tests provide a real influence on color, flavor, aroma, and texture during storage. The highest average value of flavor and aroma was found in the 40 HSA harvest age treatment using the storage technique without cardboard boxes (U1P1). The highest average texture value was found in the 40 HSA harvest age treatment, cardboard box storage technique without $KMnO_4$ (U1P2). The highest average color value was found in the 40 HSA harvest age treatment using the cardboard box storage technique with $KMnO_4$ (U1P3).

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