Article Review: Post-harvest Handling of Cavendish Banana (*Musa acuminatacavendish*)

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Abstract. Because of its nutritional value, banana fruit is very important for food security and the economy in many tropical and subtropical countries. However, banana is a climacteric fruit with a short shelf life, so an alternative method is needed to delay their ripening. This article aims to explain postharvest handling in accordance with the characteristics of Cavendish bananas. The ripening process of climacteric plants is accompanied by increased respiration and the production of ethylene, a hormone involved in fruit ripening. Currently, several technologies can extend the shelf life of Cavendish bananas, namely by vacuum packaging with a low storage temperature (9°C), the best active packaging to extend shelf life with active packaging made from activated charcoal as much as 10 g with LDPE packaging, and vacuum packaging. Using 1% alum treatment can last up to 2 weeks, showing low total dissolved solids, low total titrated acid, and high hardness.

Keywords: Banana · Cavendish · Handling · Postharvest

1 Introduction

Indonesia is a country rich in abundant agricultural and plantation products. Agricultural products have a short shelf life, which makes the product spoil quickly. Agricultural products that are easily damaged are called horticultural products. In addition, agricultural products that are not processed further have a minimum value. Damage to crop yields causes a smaller selling value. Horticultural plants usually grow in tropical countries, one of which is Indonesia. Horticultural plants will thrive under environmental conditions with sufficient water so that the plants do not dry out. Horticultural crops with a lot of environmental conditions that support the production of agricultural products are very abundant. According to [1], the production of Fruit Horticultural Commodities in 2018 reached 21.5 million tons. Most of the harvest is continued with sales domestically and abroad without any prior handling. Moreover, [2] stated that Indonesian fruit export commodities have low quality when they arrive in the destination country. This low quality happens because postharvest handling has not been maximized or even not handled at all.

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Bananas are one of the fruits that are often exported. The type of banana that is exported in considerable quantities is the Cavendish banana. According to [3], the export volume of Cavendish bananas reached 22 thousand tons in 2019. Cavendish bananas have a concise shelf life and are susceptible to physical, chemical, and biological damage. An example of a disease that attacks Cavendish bananas after harvest is crown rot disease. Therefore, this article aims to determine postharvest handling in accordance with the characteristics of Cavendish bananas.

2 Characteristics of Cavendish Banana

The Cavendish banana is a type of banana originating from Brazil which has been widely cultivated in Indonesia. The Cavendish banana type is the primadonna of agribusiness because it has high production and high export volume. [4] reported that Indonesia's Cavendish banana production was 5.8 million tons in 2010. Cavendish bananas have a high carbohydrate content. The carbohydrate content in Cavendish bananas is 97%, while the protein content in Cavendish bananas is 3% [5]. Meanwhile, according to [6], Ambon bananas (Cavendish banana family) contain 99 kcal of calories, 1.2 g protein, 0.2 g fat, 26 g carbohydrates, 8 mg calcium, 5 mg iron, 28 mg phosphorus, 146 SI vitamin A, and B1 0.08 mg, vitamin C 3 mg, and water 72 g in 100 g Ambon bananas. In addition, there is a fiber that can help the digestive tract. One of the characteristics of the Cavendish banana is that it undergoes a rapid respiration process. After going through the harvest process, Cavendish bananas will experience a spike in the respiration process which causes the fruit to ripen, age, and rot quickly. Ripe Cavendish bananas have a yellow and slightly green color, white flesh, and a sweet taste. In addition, [7] stated that Bananas with storage at cold temperatures will cause chilling injury with the lowest storage temperature limit of 13.5 °C.

3 Destructive and Non-Destructive Testing of Banana

Tests on horticultural products can be divided into two types: destructive testing and non-destructive testing. The definition of destructive testing is testing on material by damaging the material. The various types of destructive testing of bananas are shown in Table 1.

Based on Table 1, the destructive testing of bananas consisted of respiration rate, water content testing, total dissolved solids, hardness, pH, and titratable acidity. Respiration rate testing was carried out by titration, which liberates CO2 in the material. The respiration rate can detect the level of ripeness in bananas. According to [8], the increase in banana respiratory rate will impact the breakdown of compounds such as carbohydrates in fruit and produce CO2, which is a sign of ripe bananas. The water content test was carried out by taking the banana flesh and drying it in the oven. [8] reported that the water content increases along with the ripening process. The addition of water comes from the breakdown of carbohydrates (glucose) in respiration into carbon dioxide, energy, and water. The total soluble solids test was carried out by crushing the banana to extract its juice and using a refractometer to obtain the sugar content in the banana. Sugar can detect fruit ripeness because the amount of simple sugars increases during ripening.

Hardness testing was carried out using a texture analyzer which included 2 measurement values, namely the value of hardness on the skin of the fruit (yield point) and

Table 1. Destructive test of banana

Testing	Method	Quality characteristics
Respiration rate [8]	The titration method is to measure the rate of CO2 per kg per hour on a sample of bananas	Respiration rate of bananas
Moisture content [8]	The gravimetric method is the measurement of water content (wet basis) using an oven.	Banana moisture content
Total Dissolved Solids (TPT) [8]	Using a hand refractometer by dripping banana juice onto a glass slab handrefractometer	Sugar content of bananas
Hardness [8]	Using a texture analyzer (TA)	Banana texture
pH [9]	Using a pH meter by taking the pulp from bananas.	Acidity content of bananas

the hardness on the flesh (flesh firmness). Ripe bananas have a lower hardness value than unripe bananas. The pH test was carried out by measuring the banana pulp with a pH meter. According to [10], in the banana process towards maturity, the pH value will increase, but after the ripening period, there will be an increase in metabolic activity and the formation of sugar which causes a decrease in acid concentration. Titratable acidity testing was carried out using the titration method to determine the total acid content in bananas. The difference between the pH test and titrable acidity (TA) is that the pH test only measures the concentration of free protons, while the TA measures the total number of free protons and undissociated acids.

Non-destructive testing is a test on horticultural materials without damaging the material or materials. According to [9], various studies have expanded non- destructive techniques to determine internal parameters involving other technologies, such as spectrophotometers, backscattering, and hyperspectral imaging systems. Table 2 shows the types of non- destructive testing in bananas.

Based on Table 2, banana non-destructive testing was conducted by color and NIR testing. In testing Machine vision system uses two parts, namely the image acquisition system to take pictures and Matlab for data analysis. The result is from RGB to HSV and L*a*b*. The NIR test uses a spectrum with the result that the value of the spectrum test is related to the sugar content in bananas. So, measurements using NIR can predict the amount of sugar in bananas. Image processing testing is done by taking pictures and processing data from the image so as to get results in the form of color, texture, and area of bananas. According to [2], color intensity is measured using the RGB (Red, Green, Blue) color model.

Texture measurement is carried out using four features introduced by Harlick et al. in 1973: Energy, Contrast, Homogeneity, and Entropy. The area measurement is done by first converting the color image into a binary image to distinguish the object and background through a thresholding process with a particular threshold value. The color test was carried out using a chromameter, with the results of the banana color getting L*, a*, and b* values [8]. The NIR test carried out by [11] measured bananas with a spectrometer, then the data from the NIR test would be compared with the hardness and dissolved solids test data on bananas. It was found that the value of the NIR test was able to represent the value of hardness and dissolved solids in bananas.

Table 2. Non-destructive test banana

Testing	Method	Quality characteristics
Machine vision system [10]	Taking pictures of bananas and analyzing them using MATHLAB	Banana color
NIR [9]	Measuring bananas with a 100N spectrometer FT-NIR and processed using FTIR software to obtain spectrum conversion.	NIR can predict quality characteristics, namely sugar content non-destructively in bananas.
Image processing [2]	Taking images, image processing, and data processing.	Color, texture, and area of bananas
Color measurement [8]	Measuring the color of bananas using a chromameter.	Banana color
NIR [11]	Measuring bananas with a NIR reflectance spectrometer equipped with a	NIR halogen lamp can predict the quality of Cavendish bananas, hardness, and dissolved solids.

4 Postharvest Handling of Banana

Postharvest handling is the activity of processing harvested products to maintain their quality so that they are marketable. Postharvest handling of bananas involves several stages, including ripening, storage, and transportation. The first stage is ripening bananas which aims to speed up and uniform the ripeness of the fruit. According to [12], the methods for ripening bananas are traditional ripening, composting ripening, carbide curing, ethylene gas curing, ethephon curing, and Gamal leaves curing. Traditional ripening is done by storing jars made of clay for 2–3 days. Composting is done in the soil and smoked using coconut leaf fire smoke. The curing of carbide is done by placing a lump of carbide in the center of the banana comb. Ethylene gas ripening is done by flowing ethylene gas into an airtight room containing bananas that have been arranged on shelves and covered with plastic. Ethephon curing was done by soaking bananas in 1% v/v ethereal solution for 30 s. Gamal leaves ripening is done by putting 20% Gamal leaves of the banana weight on top of the bananas and are placed into the basket.

Banana handling controls market demand without causing much damage or quality loss [12]. Storage can be divided into two types: natural storage and storage using specific means. Natural storage is done by moving banana trees that bear fruit and are ready to be harvested to another place by removing the tree roots first. Storage uses specific means, namely storage of bananas with modifications at low temperatures, wax coating, KMnO4, CaCl2, and storage in plastic. According to [13], the storage and packaging of bananas can be done using controlled atmospheric storage (CAS) and modified atmospheric packaging (MAP). CAS is a technique that controls the amount of CO2 and O2 in the packaging. Meanwhile, MAP is a packaging technique that modifies the amount of O2

Table 3. Preservation of bananas using packaging method

The method used	The results obtained
The application of KMnO4 with clay carrier media on the shelf life of mas bananas [17]	Treatment of KMnO4 with gauze and paper wrapping Tea wrappers can extend the shelf life of Pisang Mas up to 12 days.
Control of Postharvest Crown Rot Disease in Cavendish Banana with Aluminum Sulfate and Vacuum Packaging [18]	Vacuum packaging with 1% alum treatment can last up to 2 weeks, showing low total dissolved solids, low total acid titration, and high hardness.
Efforts to maintain the Shelf Life of Kepok Bananas with Active Packaging Made from Palm Oil Shell Active Charcoal [19]	The best active packaging to extend the shelf life of Kepok bananas is Kepok bananas with active charcoal packaging of as much as 10 g with LDPE packaging.
Effect of Different Packaging Materials on Shelf Life and Quality of Banana (Musa spp) [20]	In general, it can be concluded that polyethylene bags can increase shelf life and maintain banana fruit quality after harvest from weight loss testing, but inversely for TSS testing.
Shelf life extension of Saba banana: Effect of preparation, vacuum packaging, and storage temperature [14]	Vacuum packaging with a low storage temperature (9°C) can extend the life of bananas where banana samples show slight moisture content and color changes during the storage period by slowing the ripening and browning reactions.

and CO2 in the packaging. Another storage technique was also carried out in the study [14], namely by storing bananas in vacuum sealers and at low temperatures.

Vacuum packaging and low storage temperature (9 °C) can extend the life of bananas where banana samples show slight changes in moisture content and color during the storage period by slowing the ripening and browning reactions. The last stage of handling is the transportation of bananas to consumers. Things that need to be considered in the banana transportation process are loading carefully, arranging patterns properly without piling up each package, paying attention to the distance between packages so they do not collide, and unloading one by one. According to [13], transportation causes mechanical damage to bananas, so they must be packed in layers in specially ventilated cartons with plastic pads to minimize mechanical damage. Meanwhile, [15] stated that the best transportation handling is using wooden boxes because it has the lowest mechanical damage value of 32.59%.

5 Preservation of Banana

[16] explained that food preservation is a process to maintain food security, and quality, extend shelf-life, and prevent spoilage. Cavendish banana is easily damaged because it is a climacteric fruit still undergoing ripening even though it has been harvested. The way to overcome this problem is to improve harvest handling so that the quality can

be maintained after harvest. There are many ways to handle postharvest storage, one of which is postharvest technology in maintaining product quality, which reduces damage to agricultural products due to the respiration process. Several studies have been done on preserving bananas using packaging, as shown in Table 3.

Table 3 shows several studies of banana packaging by modifying the packaging materials or improving traditional packaging practices. Despite this fact, the marketing of fresh produce, including bananas postharvest, loses both quantity and quality between harvest and consumption. The advantage of using packaging is that it offers versatile and cost-effective packaging. It is also considered an aid to marketers' goals. This packaging delays the physiological deterioration of the fruit and prevents condensation inside the package [21].

6 Conclusion

The Cavendish banana is a tropical fruit popular with the community. This fruit contains high enough nutrients, especially carbohydrates, Vitamins A, B, and C. Cavendish bananas have perishable properties. The method of testing can be done destructively, such as respiration rate, water content testing, total dissolved solids, hardness, pH, and titratable acidity. aIn addition, non-destructive, such as using MATLAB, color, and NIR. Efforts to extend the shelf life of Cavendish bananas effectively using vacuum packaging with 1% alum treatment can last up to 2 weeks which shows low total dissolved solids, low total titrated acid, and high hardness.

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