A Review of Post Harvest Handling of Mango *(Mangifera Indica L.)* in Indonesia

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Abstract. Mango (*Mangifera indica* L.) is a climacteric fruit category horticultural commodity, namely fruit that is able to continue the ripening process after being harvested, has a respiration rate, and high ethylene production so that mango is a fruit that is easily damaged and the marketing distance is limited. So it is necessary to do further postharvest handling to inhibit the rate of respiration. This article aims to give the better understanding og mango post harvest handling in Indonesia. The method used in the postharvest handling process of mango fruit is the coating method with chitosan by dipping mangoes into a sucrose solution. The mango slices were dipped in a sucrose solution of up to 40% with the addition of preservatives (potassium metabisulfite, potassium sorbate, and sodium benzoate). Subsequently, the mango then was put into a glass bottle with a cold treatment of 13 °C and a room temperature of 25–28 °C. Applying a coating using chitosan on mangoes suppresses the respiration rate, inhibits the release of gas and water vapor, and avoids contact with oxygen.

Keywords: Chitosan · Coating · Mango

1 Introduction

Indonesia is a country located on the equator with a tropical climate, so it has much biological diversity, including fruits. The level of consumption of fruits in Indonesia has increased because the fruit has good benefits for health. Fruit is one of the essential components in the human body because fruit contains many antioxidants and vitamins needed by the body. One of the most popular fruits in Indonesia is the mango. The mango plant is an annual fruit plant in the form of a tree originating from India. This plant then spread to Southeast Asia, including Malaysia and Indonesia. Mango plants come from the *Anacardiaceae* family, genus Mangifera, species Mangifera indica [1]. The Central Statistics Agency (BPS) reported that mango production in Indonesia reach 2.84 million tons in 2021. That number decreased by 2.07% compared to the previous year, which was 2.9 million tons. Meanwhile, the highest mango production was in East Java in 2021 with 1.19 million tons, and mango production in Central Java is recorded at 457,674 tons. Then, West Java produced 444,073 tons of mangoes. Further,

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mango production in West Nusa Tenggara and South Sulawesi were 131,394 tons and 116,175 tons, respectively. Mango (*Mangifera indica* L.) is a climacteric fruit category horticultural commodity, namely fruit that is able to continue the ripening process after being harvested. According to [2], the quality of harvested mangoes can be seen from several characteristics such as fruit size, leaf bones, acidity, sweetness level, texture, and skin color. There are two techniques commonly used to assess fruit quality. The first technique is to obtain physicochemical characteristics such as color gradation and pH. This technique provides accurate information about the content contained in the fruit, but it takes a relatively long time because the object being tested must be formed in liquid. Therefore peeling, slicing, squeezing, perforating, smoothing the shape, or making fruit juice to obtain a liquid sample. The second method is a non-destructive technique in which the testing does not need to damage the object, so the testing in a relatively fast time.

[3] Reported that mango is a climacteric fruit that has a high respiration rate and ethylene production, so that mango is a fruit that is easily damaged, and the distribution is limited. Total yield loss in mangoes due to improper post-handling is estimated at 30%. Postharvest application and poor storage caused damage to mangoes by 30%. Post-harvest is a fruit-handling activity carried out as soon as possible after harvesting. Post-harvest aims to ensure uniformity of fruit quality, free fruit from pests and diseases, and ensure the fruit is safe for consumption. Postharvest activities of mango include picking, field collection, transportation, sorting, grading, packaging, and storage. Therefore, postharvest technology is needed to reduce metabolic activity and extend the shelf life of mangoes. Therefore this article aims to give the better understanding og mango post harvest handling in Indonesia.

2 Characteristics of Mango Fruit

Mango is a fruit with a certain level of maturity in a short time. The distribution of mangoes in various regions makes it important to classify them based on their maturity level. There are six levels of mango ripeness that can be distinguished based on the color of the mango. The ripeness levels of the unripe mango are green, with breakers turning yellow, light orange, and orange. Thus, the color of the mango becomes an important indicator in determining the level of maturity and its quality [4]. Mangoes can be identified based on the size and shape of the panicle, flower color, and flower panicle stalk [5]. The shape of mango flower is generally a pyramid with a length of 12 - 49 cm and a diameter of 13 - 40 cm. Mango flower length can reach 12 - 49 cm with a diameter of 10 - 43 cm. The diversity of mango flower sizes may be caused by different climates, cultivation techniques, and tree conditions. Some studies reported mango flowers bloom perfectly at 03:00 $\pm$ 07:00 or 12:00. Mango flowers are panicles formed from terminal twigs consisting of several thousand individual flowers. In one panicle, there are perfect flowers and male flowers with a proportion of 1:4 to 1:2. The male flower structure consists of flower stalks, petals, crowns, and filaments (consisting of 5 pieces with different lengths; long filaments have fertile pollen while short filaments have infertile pollen), anthers (consisting of pouches and pollen), and the flower base. A perfect flower consists of a flower stalk, petals, crown, pistil stalk, ovary (future fruit), and flower base. Characteristics of mango fruit can be identified physically and chemically.

The characteristics of mangoes, according to [6] and [2], can be seen from the size of the fruit, the leaf bone, acidity level, sweetness level, firmness, and color pattern on the skin. The physical characteristics of the mango fruit are 15.59 cm in length, 6.08 cm in diameter, and oval in shape. The color of the fruit is grass green, the surface texture of the skin of the fruit is smooth, the shape of the tip of the fruit is tapered, the color of the skin of the ripe fruit is light yellow, the depth of the stalk cavity is absent, the neck of the fruit is lumpy, and the ridge of the fruit is sloping. The beak type of the fruit is clearly visible; there is a waxy layer of shallow fruit sinus type; the color of the fruit in ripe mangoes is creamy yellow, with solid fruit aroma, medium endocarp fiber, medium fiber texture, and oval seed shape [5]. Meanwhile, the chemical characteristics of mangoes are that they contain higher levels of Vitamin C, Vitamin A, and dietary fiber than other fruits. Vitamin C in mangoes can meet 46% of the body's daily needs while Vitamin A can meet 15% of the body's daily needs [7]. Mango fruit has a myriad of benefits, containing a lot of high vitamin C, and rich in fiber contained in mangoes can help lower cholesterol levels in the human body. Fresh mango fruit is rich in potassium, which is needed by the body to balance the body's fluid cells which help control blood pressure and heart rate. In addition, mango can prevent cancer and increase endurance [8].

3 Destructive and Non-destructive Testing of Mango

There are two techniques commonly used to assess fruit quality. The first technique is the destructive method, namely testing by damaging the fruit to obtain physicochemical characteristics such as color gradation and pH. This technique provides accurate information about the content contained in the fruit. The disadvantage of the destructive method is that it takes a relatively long time because the object has to be damaged. The destructive method requires several additional activities such as peeling, slicing, squeezing, perforating, smoothing the shape, or making fruit juice to obtain a liquid sample. The second method is a non-destructive technique that measures the object without damaging the object being tested in a relatively fast time. Measurement techniques such as can be done by emitting electromagnetic waves using an antenna that functions as a sensor. This technique produces a dielectric value which can then be used to determine the characteristics of the mango fruit [9]. One application of the non-destructive method is the LDR (Light Dependent Resistor) sensor. The LDR sensor is a light sensor that interacts directly with the pigment (color) on the fruit, where this interaction involves a reflection and absorption reaction of light. The mechanism of LDR sensor action on the mango fruit surface is the vibration of the atoms on the surface of the mango skin caused by the photoelectric. Its effect so that the dye molecule cut off, which is then drawn and reabsorbed by the LDR sensor so that there is a change in the output voltage received by the LDR sensor using chemisorption events that lead to charge transfer from the adsorption particles to the sensor surface [10].

The electrical transport mechanism of the LDR sensor detects the presence of dye, where there is an interaction between the light emitted by the LDR sensor and the mango skin. When the mango fruit material and the LDR sensor are under the influence of the photoelectric effect to break the chemical bonds of the dye in the mango fruit, then it is absorbed and attracted to the LDR sensor, electrons enter the valence band and combine

with holes and reduce the number of holes present and increase the sensor output voltage [11] The dye is removed from the sensitive surface of the LDR sensor, electrons move away from the conduction band, thereby increasing the number of holes and lowering the output voltage of the LDR sensor. The green color of the mango has a short wavelength of 4920–5770 nm compared to the orange color of 6220–7700 nm, so the green mango has a high output voltage.

4 Postharvest Handling of Mango

Post-harvest is a fruit-handling activity carried out as soon as possible after harvesting. Postharvest activities include picking, field collection, transportation, sorting, grading, packaging, and storage. The climacteric characteristics of mangoes cause postharvest handling of mangoes to be carried out, especially in inhibiting the respiration rate of fruit after harvest and inhibiting ethylene production so that the shelf life of mangoes can be maintained. One method to maintain fruit quality during storage is fruit coating. Fruit coating can be made from various materials, such as chitosan. Chitosan coating affects the respiration rate of sweet arum mango. Chitosan can inhibit the release of gas, water vapor, and avoid contact with oxygen so that the respiration rate can be suppressed [12, 13]. Reported that mangoes can also be treated with coatings using beeswax. Mangoes are coated using beeswax with different concentrations and mixed into an emulsion containing a mixture of sesame oil and citronella oil. The combination of sesame oil and citronella oil emulsion effectively reduced weight loss and intensity of damage and maintained the firmness of mangoes during storage. Coating mango fruit with beeswax in an emulsion based on sesame oil and citronella oil can slow down the physical changes of the fruit and provide the best sensory preference for aroma, color, taste, and texture of fruit flesh during fruit storage at room temperature (26–32 °C).

Postharvest handling of mango can also be done by dipping mangoes into a sucrose solution. The mango slices were immersed in a sucrose solution of up to 40% with the addition of preservatives (potassium metabisulfite, potassium sorbate, and sodium benzoate) from a solution of the same concentration in a glass bottle in a refrigerator at 13 °C, and room temperature 25–28 °C. The advantage of this process is that potassium metabisulfite is more effective in maintaining maximum quality, followed by sodium benzoate and potassium sorbate. Mango slices that were given this treatment and stored in refrigeration conditions had higher quality than room temperature and could last for 3 months of storage [14]. The low quality of mangoes can be affected by several factors, one of which is the high level of pest attacks on the fruit, which makes the mango skin not smooth. The primary pest of mango plants is fruit flies (*Bactrocera dorsalis*). In order to avoid fruit flies, handling can be done by wrapping mangoes using newspapers. The treatment of fruit packaging using paper can help reduce qualitative damage that affects the quality of the harvest and quantitative damage that affects the amount of harvest. Packaging of fruit using newspapers results in color change, bright colors, high total dissolved solids, high carotene content, and a low percentage of fruit damage. But the newsprint treatment did not give high fresh fruit weight, high fruit tenderness, and low vitamin C content [15].

Postharvest handling can also be done by ripening using calcium carbide on mangoes. Calcium carbide can accelerate the fruit ripening process and give a color effect to the

fruit, so the fruit is not stored for too long and it is expected to reduce the damage of vitamin C by air and enzymes. Ripening using this method can affect the vitamin C content of mangoes. The concentration of vitamin C in mangoes (mg/100 g of fruit juice) which is ripened with the addition of calcium carbide [16].

Exports of mangoes in Indonesia are also quite a lot. The Central Statistics Agency (BPS) states that exports of mangoes will be 2.1 million tons in 2021. According to [17], harvesting for export of mangoes can be done by sorting and grading, waxing, and packaging. Sorting is done to separate the viable fruit selling and not fit for sale in order to obtain fruit uniform in shape, color, size and maturity while grading is done to obtain uniform fruit sizes such as large, medium, small or very small. Postharvest handling of mangoes can be done by wax coating or waxing which can reduce the rate respiration, so this treatment is one alternative to extend the period save fruits. After that the installation is done. Packaging is done by giving net foam lining. This case does for prevent physical damage from impact during transportation. After done packaging with net foam, and then put in a carton which is sectioned in a wax coating. Storage is carried out in cold temperatures. Cold storage aims to limit spoilage without causing occurrence of abnormal maturity or other changes that are not desired and maintain quality until into the hands of consumers in the long term long. On the transportation of mangoes to the destination both export and domestic must use a car equipped with a cooler. This matter is to keep the cold chain during transportation.

5 Preservation of Mango

Various efforts have been made to extend the shelf life of fruit commodities, including the application of edible coatings. The edible coating is an alternative that functions as a carrier for food additives, such as anti-browning agents, antimicrobials, dyes, flavoring agents, nutrients, and seasonings [18]. Edible coatings can come from easily renewable raw materials, such as a mixture of lipids, polysaccharides, and proteins [19]. The most potential polysaccharide-based edible coating and has been widely studied is starch-based. The starch-based edible coating has the advantage of reducing water activity on the surface of the material so that damage by microorganisms can be avoided because the edible film layer protects it. The edible coating improves the surface structure of the material so that the surface becomes shiny, reduces the occurrence of dehydration so that weight loss can be prevented, reducing oxygen contact with ingredients so that oxidation or rancidity can be inhibited, the original properties of the product such as flavor do not change, and can improve the appearance of the product [20].

[21] reported that one alternative to improve the mechanical and functional properties of carbohydrate-based edible coatings such as pectin and chitosan is to incorporate nanoparticles to form bio nanocomposites. ZnO nanoparticles have been known to have an antimicrobial activity such as inhibiting the growth of gram-negative bacteria, gram-positive bacteria and molds. NP-ZnO is known to actively inhibit the growth of *B. cereus*, *E. coli* and *Penicillium* sp. The application of chitosan and pectin-based edible coatings incorporating ZnO nanoparticles on mangoes showed a delay in increasing weight loss and preventing damage. The extension of the shelf life of mangoes treated with an edible coating of pectin + NP-ZnO and chitosan + NP-ZnO was 2–3 days longer than

the control. Mango fruit can be preserved by coating using an edible coating of corn starch and chitosan. Edible coating from corn starch and chitosan can reduce respiration rate and physiological disorders and extend the fruit's shelf life [22]. Mango coating can also be done using materials from cassava starch and chitosan. Coatings of starch will improve flavor, texture and color, increase stability during sales and storage, improve the appearance and reduce spoilage. The addition of starch to edible chitosan coating has a significant effect on postharvest damage. According to [23], the best chitosan edible coating between corn starch and cassava starch is corn starch because it has an extensive effectiveness index test from cassava starch.

6 Conclusion

Postharvest handling of mangoes can use various methods, such as chitosan, beeswax, and coating with newspaper. Coating mango with chitosan is that it affects respiration rate, inhibits the release of gas and water vapor, and avoids contact with oxygen, so the respiration rate can be suppressed. Postharvest handling using a coating method with chitosan can be done by dipping mangoes into a sucrose solution. The mango slices were dipped in a sucrose solution up to 40% with the addition of preservatives (potassium metabisulfite, potassium sorbate, and sodium benzoate) from the same concentration solution and then put into a glass bottle with a cold treatment of 13 °C and room temperature of 25–28 °C. Preservation of mango fruit is done by making edible coating using pectin, starch, and chitosan. Edible coatings have the advantage of reducing water activity on the surface of the material, improving the surface structure of the material, reducing the occurrence of dehydration, oxidation or rancidity can be inhibited, the original properties of the product such as flavor do not change, and can improve the appearance of the product.

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