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Postharvest management of fresh duku (*Lansium domesticum* var. duku): A mini review

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Abstract

Duku fruit is one of the fruits that have high economic value in Indonesia. However, because of the high respiration rate which is due to the metabolic reactions and ethylene production activity, duku decays rapidly. Some post-harvest changes of duku fruit are weight loss, fruit hardness, browning of skin, color, titratable acidity, total soluble solids and fungal growth. Post-harvest handling of duku fruit is needed to maintain its quality and value. A literature review was performed, and a bibliometric analysis was carried out on the scientific publications registered in the Scopus database. All the publications of different authors from all over the world and their positions on the paper were analyzed. The literature review of the publications and the positions of different authors on the papers studied were to be analyzed from the qualitative perspective, as shown by the examples mentioned throughout this paper. Several studies from various countries have been carried out. Special treatments to maintain the shelf life of duku include UV-C irradiation, infrared radiation, chitosan, Modified Atmosphere Packaging (MAP), and ozone. This review attempts to summarize some of the most significant findings that can be developed to maintain duku fruit quality.

Keywords: Postharvest; Duku; Shelf-Life; Physical and Biochemical Changes.

1. Introduction

Fresh fruits, after being harvested, will go through post-harvest physiological reactions that will gradually change the physical and chemical properties of the fruit. Certain fruits that fall into the climacteric category will change from unripe to ripe and have the desired properties, such as a sweet taste or a combination of sweet and sour taste, but other fruits that fall into the non-climacteric category will not experience changes in taste quality. All of these physical, chemical, and physiological changes will affect the quality and the level of acceptance by consumers. Duku (Lansium domesticum), an exotic tropical fruit known also as langsat or longkong, is one of the most recognized fruits with a pleasant aroma and taste known as langsat or longkong. However, there are a few differences between them. Longkong is almost seedless, with crispy skin. Langsat has the same size as longkong. Longkong has 15 to 25 fruits per bunch, while duku only has 4 to 12 fruits. Langsat has a thin skin containing a milky-white sticky sap compared to duku, which has thicker skin with no latex [1].

Duku is a non-climacteric fruit, and the maximum fruit drop takes place when the fruit reaches the maturity level of more than 80%, or in the over-mature stage. Fruit must be harvested and shipped when ripeness is around 70–80% to avoid fruit drop. Duku is harvested at the full-ripe stage, as indicated by the skin color change from light to dark yellow,

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dryness of the sepals, and loss of most of the green color from the peduncle (stem). Due to its non-climacteric nature, duku will not continue to ripen once harvested from the tree [1]. Generally, duku is perishable within 3 to 7 days after harvest; the skin color changes from yellow to dark brown, followed by changes in taste because of fungi [2], [3]. Another study found that after 2-3 days after harvesting, the changing of duku's color affects shelf life and decreases the price when it is sold [4]. However, duku has a high economic value because of its potential to be marketed globally. The increasing demand for duku must be followed by improving its quality. One way to improve the quality of duku is by doing a post-harvest treatment.

The application of postharvest treatment technology is an exertion to extend the role of postharvest handling to preserve the quality of agricultural products or reduce losses that can occur due to a decrease in quality products, which include normal physiological processes and reactions to appropriate conditions due to physical, chemical, and organic changes. Extending the shelf life of duku is the goal of many studies that have been performed worldwide. Basically, the research performed and the technology applied were targeted at delaying the physical and chemical changes by controlling the environment of duku storage. These studies and technologies are controlling the environment of duku storage, which results in slowing the respiration rate [5], biochemical changes, lowering the microbial initial load, and lowering the water activity of the skin. The treatments applied include modifiying the atmosphere in the packaging (MAP), dipping the whole fruit in certain materials that function as individual packaging for duku, radiation treatment for lowering the microbial load and lowering the water activity of the duku skin, and sparying or dipping in a solution that prevents the growth of microorganisms and slows respiration and biochemical changes.

2. Material and methods

A bibliometric analysis was carried out on the scientific publications registered in the Scopus database and other refereed journal publications. The position of different authors on the paper was to analyze the literature review from a qualitative perspective, as examples are mentioned throughout this paper. A systematic review strategy identified by the research focuses on information and innovation, with some steps of the process as presented on Table 1.

Table 1 The three phases of the research method**.**

Number of Phases	Phase	Description
Phase 1	Identification of research papers through Scopus publications and other refereed journals.	Identification of research papers that inquire about the questions was expressed, and the guidelines were created for collecting the literature. The publication search also extended to the countries that produce duku, such as Thailand, Malaysia, and Indonesia.
Phase 2	The works of literature were synthesized.	Construction of analysis material: Selecting some criteria for articles to be included in the review were that the article must have been published in a peer-reviewed journal. The selected papers were analyzed by the primary author (ADL), and the data extracted included: author(s), publication type, and narrative information concerning scholarly book reviews and their publication.
Phase 3	Drafting of the manuscript and final manuscript.	After the analysis carried out in the previous phase, the next step was to make the outline and draft the manuscript, which was then followed by the preparation of the final manuscript

3. Results and discussion

3.1. Physical quality changes

Fruits, in general, contain water, which is the most essential content of fruit. Most fruit consists of more than 80% water. Actual water content is the amount of water used by the tissue of fruit in the ripening process [6]. The weight loss of fruit during the storage period was caused by fruit respiration and transpiration. Respiration and transpiration proceed after harvesting, and since the produce is segregated from its source of water, photosynthates, and minerals, it is completely subordinate to its nourishment and moisture content. Water loss is a loss of saleable weight and, in this way, a direct loss to the cultivator or processor. A loss in weight of about 5% will cause many vegetables to appear shriveled, and under warm, dry conditions without the proper handling, this condition may happen in a few hours [7]. The relative humidity (RH) within a packaging is influenced by the rate of respiration, which influences whether the product loses its water vapor and the water vapor transmission rate (WVTR) of the packaging film. The parameters of weight loss are determined by time measured to the initial weight [7]. Fruit firmness correlates with weight loss, as expected for plant products, particularly fruit and vegetables; the higher the mass loss, the lower the texture. The changing of duku skin's texture was influenced by the storage time, which was analogous to weight loss [8]. Fruit firmness will affect the maturity of the fruit and determine the economic value of the product. So, duku's skin texture must be an ultimate concern for post-harvest handling and should be considered in the optimization of factors for lengthening the storage life of duku [9].

3.2. Biochemical quality changes

Changes in biochemical quality that occur in duku (Lansium domesticum) are caused by the increased respiration rate after harvesting. Longkong fruit experienced an increase in respiration (224 mg CO2 kg-1 h-1) after harvest and then decreased (206 mg CO2 kg-1 h-1) during the aging process [10]. The increase in respiration rate of duku is caused by the need for the fruit to carry out metabolic reactions. Duku fruit continues to undergo respiration and transpiration after harvest [5]. In addition, the increased ethylene production activity caused by the damage can also lead to ripening, aging, and spoilage [11]. The characteristics of changes in biochemical quality consist of browning, color, titratable acidity, total soluble solids, fungal growth, and fruit drop. Pericarp browning in fruit occurs due to the activity of browning enzymes catalyzed by polyphenol oxidase enzymes (PPO), phenylalanine ammonia lyase (PAL) and peroxidase enzymes (POD) [12]. In addition, abrasion, impact injury, environmental stress, and temperature fluctuations are factors that affect pericarp browning in longkong fruit [13]. The high phenolic content in longkong fruit can also cause pericarp browning [3]. The discoloration of the duku fruit is the most noticeable during ripening and storage. The immature duku fruit has a dark green color, while the ripe duku has a bright yellow color and changes to a dark brown during storage. The color changes of duku pericarp are due to chlorophyll degradation and the development of yellow tetraterpenoids during ripening [14]. However, the brown color change during storage was caused by the oxidoreductase enzyme [12]. The brightness value of the duku fruit decreased very significantly during storage, with a greater decline in the injured detaching duku [15]. Titratable acidity in duku can change due to changes in sugar. Organic acids will be converted into fructose and glucose [8]. The acid content in duku is a source of reserve energy and would decrease during the greater metabolic activity that occurs during maturation [16]. Duku contains the dominant maleic acid and malic acid, citric acid, and glycolic acid in large enough quantities [17]. The total soluble solid during storage is constant. This means that the total dissolved solids are not significantly affected by the harvest method or the interaction between the harvest method and storage time [18]. Fungal growth on duku is one of the causes of rot due to fungal infection during postharvest storage. Mushrooms (Meliola spp.) and (Cylindrocladium spp.) are the most common types of decay fungi found in duku [18]. Fruit drop is one of the effects that occur due to physiological and postharvest disturbances that have the most effect on duku fruit [17]. Duku fruit easily detaches itself from the group after harvesting due to ethylene production [19].

3.3. Postharvest treatments

3.3.1. UV-C.

UV-C is a safe way to replace the use of pesticides and fungicides. UV-C irradiation with low concentrations in fruit can function as an antifungal and delay the ripening process. UV-C exposure can reduce postharvest damage and increase the shelf life of fruit. The duku exposure to UV-C irradiation for 40 seconds was not effective in reducing spoilage, although it could maintain the chemical content of postharvest duku [18]. The Duku fruit that is still attached and is accompanied by UV-C irradiation treatment for 20, 30, or 40 seconds does not experience browning. Exposure to UV-C rays has a very significant effect on the weight loss of duku fruit. The duku that was attached to UV-C light had lower weight loss compared to the duku that was not attached. UV-C rays can inhibit the transpiration process of duku fruit. The UV-C irradiation treatment for 40 seconds was able to maintain the condition of duku fruit against fungal attack and vitamin C decline for 9 days at a storage temperature of 29±2 C after being harvested with attached conditions to the stalk [20].

3.3.2. Infrared radiation.

Infrared radiation is a drying method using hot air. This method can reduce water content, reduce energy use, save processing time, be safe and inexpensive, and guarantee product quality. However, this method causes the degradation of product compounds, resulting in the loss of sensory components in dry products. Infrared radiation is able to inhibit bacteria, spores, yeast, and fungi. In addition, infrared radiation can also heat the surface of the product in a short time without increasing the core temperature of the product. Duku peel exposed to infrared radiation at a temperature of 200–300 °C for 50–60 seconds and stored at a controlled temperature (12–17 °C) can retain its taste. The sugar content increased by 20.2%, and the titratable acidity decreased by 0.3% [21]. The shelf life of duku produced by infrared radiation treatment using electric infrared emitters (IRE) at a distance of 6 cm and 10 cm for heating times of 50, 60, 70, and 80 seconds and stored at 15 °C has a shelf life of 16 days [8].

3.3.3. Chitosan coating.

Chitosan is a type of polysaccharide that has antimicrobial activity against fungi, bacteria, and viruses. Chitosan acts as a good barrier because it could form a strong matrix. Chitosan can be produced from shrimp and shellfish shells through the process of deacetylation of basic N (nitrogen) molecules in chitin. Chitosan coating on duku fruit can delay or slow down the ripening process and extend the post-harvest storage period. The treatment of chitosan coating on duku fruit was able to extend the shelf life of up to 6 days, with the best treatment using 1.5% chitosan and an immersion time of 30 seconds. Chitosan coating can inhibit the reduction of water content and total dissolved solids [22].

3.3.4. MAP (Modified Atmosphere Packaging).

Modified atmosphere packaging (MAP) refers to the method of fixing respiring produce in polymeric film bundles to alter the O2 and CO2 levels inside the package atmosphere. The tolerance limits of O2 and CO2 concentrations for each fruit have a different level. It is regularly realized to generate an atmosphere low in O2 and/or high in CO2 to influence the metabolism of the product being packaged and the activity of decay-causing organisms to increase storability and/or shelf life [23]. The advantages of MAP are that it is free of synthetic chemicals, has no toxic residue left, and is eco-friendly. The massive variety of gas diffusion traits has additionally stimulated trends in MAP. The barrier properties, such as machinability and sealability, must also be considered. One inherent requirement for all MAP packs is retaining the desired atmosphere as long as possible. So, it can be achieved by choosing a film or films to provide the required gas and moisture vapor permeability characteristics and, second, by ensuring the seal integrity of the packs. In addition, the high availability of numerous absorbers of O2, CO2, and N2 [23]. Longkong fruit stored in MAP at 15 ∘C could last for 24 days with no more than 1% moisture loss. The sugar and organic acid contents in longkong fruit steadily decrease as the fruit storage life increases [24]. In spite of the fact that the standards for adjusted modified atmosphere packaging (MAP) of fresh produce are well known, innovation is still primarily connected in retail packages characterized by a high proportion between the film surface and product weight. The strategy is still restricted in bulk packaging, particularly with highly respiring items, because of the challenges in controlling in-package climate and humidity during commercial shipments. These issues very often happen when the product is exposed to temperature variances during storage or shipment [25].

3.3.5. Ozone

The other absorber has a high-energy input that parts the oxygen (O2) atom in the air into free radical oxygen. Single oxygen (O) atoms quickly combine with the available O2 to form ozone. Ozone is auto-breaking down since oxygen produced does not take off buildup in natural products and vegetables, and ozone readily decomposes to typical oxygen when uncovered to daylight [24]. Ozone is unsteady; it splits back into oxygen atoms. Ozone can be created on-site as required by discharge, UV radiation, and electrolysis. Ozone sanitization strategies are proposed for fresh-cut natural vegetables, natural products, and meat item applications [26]. Ozone has been evaluated for post-harvest disease control and other storage uses for many years; ozone was listed as a secondary direct food additive permitted in food for human consumption [27]. Ozone can be applied as an efficient method to extend the shelf life of duku for 9 days [11]. Longkong fruit was ozone-treated at 1 ppm, reducing damage and inhibiting microbial growth, at least for 12 days of storage [24], [28] also reported that apples exposed to 0.5 ppm ozone effectively reduced their growth, and microbes lasted for two months.

4. Conclusions

Fresh fruit products, such as duku, require more controlled handling and storage conditions to increase their shelf life. Postharvest treatments such as UV-C, infrared radiation, chitosan coating, MAP, and ozone treatment show some potential for lengthening the shelf life of duku. Further study should be pursued to improve the methods by slowing down the physiological and biochemical changes. The combination of the postharvest treatments could be worth pondering. Duku can also be preserved to be some food products that can be off-season.

Compliance with ethical standards

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Disclosure of conflict of interest

Authors declare that there is no conflict of interest.

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