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Evaluation of the Quality of Fresh-Cut Mango, Mangosteen, and Rambutan Under Cold Storage

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Abstract

Fresh-cut tropical fruit is a popular product because it is convenient, healthy, safe, and good quality. Fresh-cut fruits of different types produce different qualities during storage. Mango, mangosteen, and rambutan are three tropical fruits that contain nutrients that are good for health. The research design used a one-factor randomized block design, namely the type of fruit, with three replications. The physical characteristics of the whole fruit are to be processed and determined by their picking age, maturity stage, skin color, and texture. Fresh-cut mango preparation was carried out by peeling and cutting to a size of 4 x 4 x 2cm while mangosteen and rambutan only removed the skin. Fresh-cut mango, mangosteen, and rambutan were stored at a cold temperature of 7±1°C in a plastic box, and periodic observations of days 0, 3, 6, and 9. The quality attributes of fresh-cut fruit during storage that have been observed include acidity, vitamin C, moisture content, total dissolved solids, weight loss, texture, color differences, and browning index. The recommendation of this research is the removal of the skin followed by cutting the fruit as in the mango, the shelf life at cold temperatures is shorter than without cutting, such as mangosteen and rambutan. Fresh-cut mango at cold storage only lasts 3 days, while mangosteen and rambutans last up to 6 days.

Keywords: Cold; Storage; Quality; Fruit; Shelf-life.

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1. Introduction

Fruit consumption in the world is currently on the rise, stimulated by increased awareness of health, storage technology, transportation, and marketing systems. Increasing fruit consumption, especially tropical fruits, is a global strategy and priority in improving public health levels [1]. Tropical fruits contain bioactive components such as phenolic compounds, carotenoids, organic acids, vitamins, and fiber that are very beneficial for health. Besides being delicious to eat tropical fruit also serves as a functional food, facilitates digestion, overcomes obesity,boosts immunity, as an antioxidant, anticancer, anti-inflammatory, and antimicrobial [2]. Tropical fruit types vary greatly in terms of a specific shape, size, texture, and taste [3] Tropical fruit is produced by most developing countries including Indonesia. Mangosteen, mango, and rambutan are three tropical fruits produced by Indonesia. These three types of fruit have high economic value and are favored by foreign people. The market outlook is very potential and continues to increase.

Fruits are perishablecommodities, perishable, and easy to shrink in weight which is about 20-50% [4]. Changes in the physiology ofnon-edible fruit parts such as the skin often determine consumer preferences, although edible parts are still suitable for consumption. The amount of non-edible is relatively high compared to the edible (mangosteen 63-75%, mango22-29%, rambutan 52-57%)and householdwaste contributors [5]. Therefore, it is necessary to handle good post-harvest so that when the fruit reaches the hands of consumers remain fresh quality as well as fresh-cut fruit.

Fresh-cut fruit is a product that has undergone processing levels such as stripping, cutting, slicing, washing, packing [6]. The need for the consumption of quality products (fresh, healthy, comfortable, safe, nutritious) and lack of preparationtime causes today's society to prefer fresh-cut products [7]. Some of the advantagesof fresh-cut products include: 1) presenting a variety of options in one package. 2) make it easier to assess the quality of products purchased, 3)lower volume, 4)cheaper transportcosts [4, 5].

Disadvantages withthe minimal process are that it is very easily damaged and its shelf lifeis shorter compared to whole fruit [7, 8], even though it has been stored at coldtemperatures. Minimal processes result in the softening of tissues so that the fruit undergoes physiological, pathological, and physical changes. Such damages include increased

respiration, ethylene production, unexpected metabolite production, degradation of sensory components,decreased fruit integrity, as well as microbial growth [9]. A decrease in quality and short shelf life of fresh-cut can decrease interest in consuming it.Therefore,alternative methods are needed to maintainquality, extending shelf life during handling, distribution, and sales. One such method is the use of cold temperatures,for which there is currently no information.The purpose of the study was to find out the effect of cold storage on the quality of fresh-cut mango, mangosteen, and rambutan fruit.

2. Materials and Methods

STUDY AREA
MATERIALS USED
SOURCE OF SEED OR FRUITS
EXPERIMENTAL DESIGN AND TREATMENTS
DATA COLLECTION
STATISTICAL ANALYSIS

The study area is the postharvest treatment of tropical fruit especially mango, mangosteen, and rambutan. Fruit used for fresh-cut fruit is mangosteen aged 105 days, sweet fragrant mango aged 105 days, and Rambutan Aceh aged120 days. The fruits were obtained from Panji Village Sukasada district of Buleleng regency Bali Province Indonesia. The chemicals are obtained at Bharataco Chemical stores in Denpasar. The research tools used are digital scales, refractometer (950,032 B-ATC, France), spectral colorimeter (CS-280, Zhejiang China), chiller (RSA, Indonesia), and texture analyzer (TA). XT *plus C*, UK), viscometer fluorimeter (NDJ8S, country), digital pH meter (HannaHI8424, Romania), oven (Germany, Memmert, drop pipette, volumetric pipette, cup glass, petri dish, measuring glass, Erlenmeyer, hockey stick, test tube, analytical balance sheet (Ohaus, USA), incubator (Memmert, Germany).

The experimental design used a one-factor randomized block design, namely the type of fruit, with three replications. Periodic observations of days 0, 3, 6, and 9. The study began with the characterization of whole fruit including pluck age, stadia maturity, skin color (visually), and texture (physically). Before the fruit is processed at least first precooling with the hydro cooling method and then lined. Testing the characteristics of fruit raw materials using mangosteen, mango, and rambutan that have been processed is minimal, by peeling and removing the skin and seeds. The stripping process uses a stainless-steel knife. Mangosteen fruit is left in the form of fused segments while mango fruit is cut into cubes 4cm x 4cm x 1.5cm (without seeds). Rambutan fruit is preprepared without skin, but the seeds are left. Fresh-cut fruit is analyzed and directly packaged in a plastic box equipped with 2 holes 0.5 cm in diameter on the lid. Fresh-cut fruit is stored at 7$\pm$1oC and characterizes physical and chemical changes during storage to 0, 3, 6, and 9 days.

Statistical analysis of the data was used analysis of variance to determine the significant variables using SPSS software (version 12; SPSS Inc.; Chicago, IL, USA) at a confidence level higher than 32 95% ($p < 0.05$). Differences between means were evaluated using the Duncan Multiple Range Test. All measurements were made in triplicate.

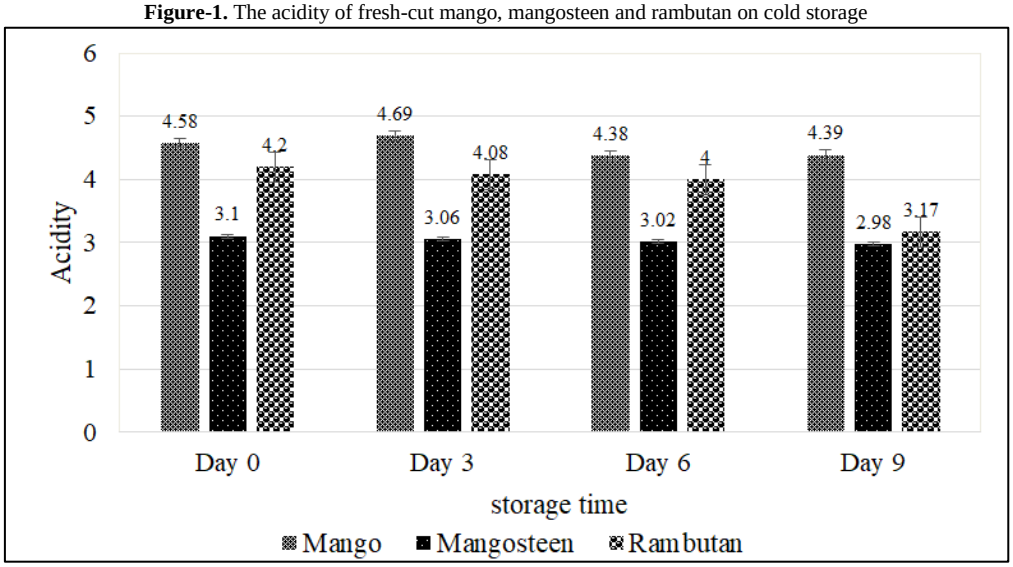
3. Result and Discusion

Visual criteria: Mango used as a raw material for fresh-cut fruit is Harumanis mango with a picking age of 105 days with stadia maturity stage 3 at the time of harvest and changed to stage 4 when processed minimally. Visual criteria ofmangoes include dark green skin and as if dusty,shouldersup, stalks notched into, roundmusts,the sweet fragrantsmell when the fruit is ripe andtasty to eat, yellow-orange fruitflesh, the level of defilement is lower than 15%, weighing between350-600 g.Mangosteen used in thisstudy is a fruit that is105daysold,with stadiamaturity stage 3 when harvesting andwhen processed at leasthas entered stage 4.Mangosteen criteria includeskinyellow-greenish with 50% pink spots spread on the skin of the fruit, fruit-shaped round like a depressed ball, the flesh of the fruit consists of 5-8 segments,fresh green petals, and fruit weight 130-180g. According to Palapol, *et al.* [10] the discoloration of mangosteen skin from green to black-purple after harvest can be used as a harvest index.Thecolor index of the mangosteen harvest for fresh-cut fruit starts inthe fruit with a pale green color,fruit with a color development of50% red on the fruit until the red is evenly distributed or stage 4, whichindicatesgood eating quality. In stages 5-6, the quality andripening of the fruit cannot be maintained or delayed because the harvested fruit has reached the optimal ripening stage.While mangosteen fruitis in stages 1-3 (palegreen to green red patches),mangosteen contains yellow latex spots in the skin thus reducing the acceptable quality during transport andstorage [11]. Rambutan is a tropical fruit that is favored by foreign people because the flesh of the fruit is sweet and juicy, and its nutritional value is high [12]. Rambutan fruit used as raw material fresh-cut fruit in this study is Acehnese variety fruit that is 120 days old with stadia maturity stage 5. The criteria of rambutan fruit include red skin evenly, round or oval-shaped fruit, long fruit hair, transparent white fruit flesh, fruit weight 20-30g. In line with the opinion [13]. That rambutan fruit is round or oval-shaped and has a yellow-red pericarp, long fruit hair, and transparent white aril. According to (Wall *et al*., 2011), rambutan fruit has a non-climacteric pattern, for consumption harvested when ripe and has a fresh external appearance.

Acidity: The degree of acidity (pH) is often an indication of changes that occur in the quality of the fruit. Fruits mostly have a low pH. The results showed fresh-cut mangoes have a pH range of 4.38-4.69 (Table 1). The pH value is affected by the number of organic acids in the fruit. Mango fruit is a climacteric fruit that still undergoes maturation during storage. The maturation process after harvest results in increased respiration, ethylene production, carbohydrate changes, or starch conversion into sugars, organic acids, fats, phenol, and volatile compounds [14].

The results showed the fresh-cut Mango fruithas a pH range of 2.98-3.10 (Table 1) and decreased during storagefor 9 days. Mangosteen has a very lowpH, in linewith opinions [15]. Mangosteen has a fairly high degree of acidity. Vitamin C fresh-cut mangosteen decreases during storage. Mangosteen vitamin C levels range from 1.14-2.78mg/100g. This is becausemangosteen fruit includes climacteric fruit that is still undergoing respiration, maturation, and overhaul of vitamin C during storage [16]. Based on morphological and physiological characteristics rambutan is a very easily damaged fruit, due to easily dehydrated and oxidized fruit hair, resulting in a dark and unwanted appearance that limits the marketing potential for fresh consumption [17]. The results showed fresh-cut rambutan fruit has a pH range of 3.17-4.20 (Table 1). Fresh-cut rambutan has a fairly sharp pH decrease. Increasing the number of organic acids decreases the pH value. In line with the opinion [18]. that the pH of fresh-cut rambutan decreases significantly during storage.

Figure-1. The acidity of fresh-cut mango, mangosteen and rambutan on cold storage



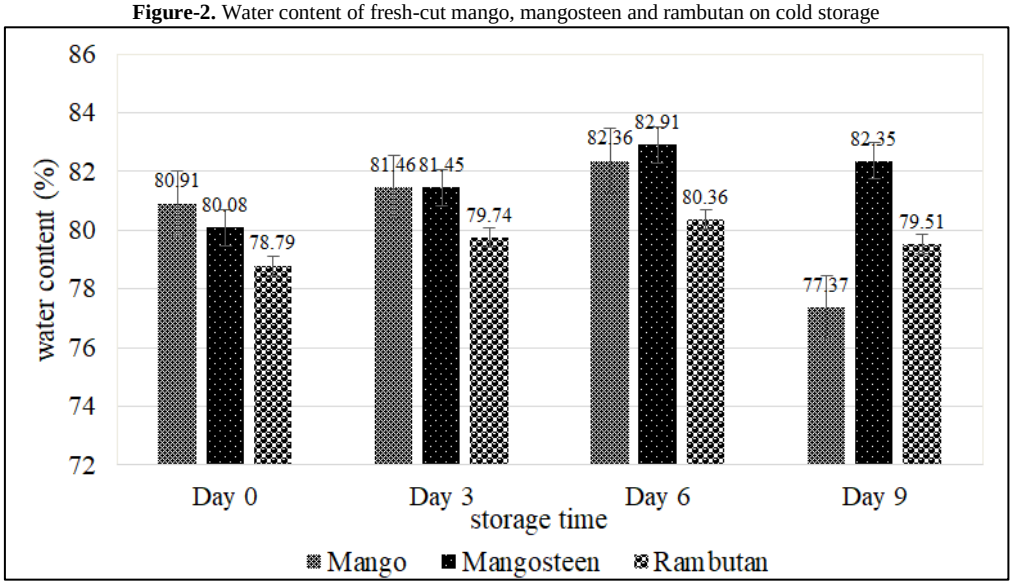
Vitamin C levels: Mango vitamin C levels58.58-82.37 mg /100g. Vitamin C fresh-cut mango fruitalthough increase on the 3rd day, but decreased again on day 9 (Table 1). Decreased vitamin C levels are caused by vitamin C degradation, Maillard reaction, and oxidation of anthraquinone [19]. Mangoes include climacteric fruits that are still undergoing respiration, maturation, and vitamin C production during storage [20]. Vitamin C of fresh-cut mangosteen tends to decrease during storage. Mangosteen vitamin C levels range from 1.14-2.78mg/100g. The mangosteen fruit is a climacteric fruit that is still undergoing respiration, ripening, and reshuffling of vitamin C during storage. Salinas-Roca, *et al.* [20]. Vitamin C fresh-cut rambutan fruit tends to decrease until day 9 (Table 1). Rambutan vitamin C levels range from 33.28-56.37 mg/100g. Changes in the levels of fresh-cut rambutan vitamin C are quite drastic, this is caused by the degradation of vitamin C, Maillard reaction, and oxidation of anthraquinone [21]. Rambutan fruits include non-climacteric fruits that no longer undergo maturation and vitamin C production during storage [20].

Table-1. Vitamin C content of fresh-cut mangoes, mangosteens and rambutans

Time of storage (day)	Fresh-cut Mango	Fresh-cut Mangosteen	Fresh-cut Rambutan
0	44.20	2.78	56.37
3	52.37	2.69	49.26
6	51.25	2.29	43.19
9	28.58	1.14	33.28

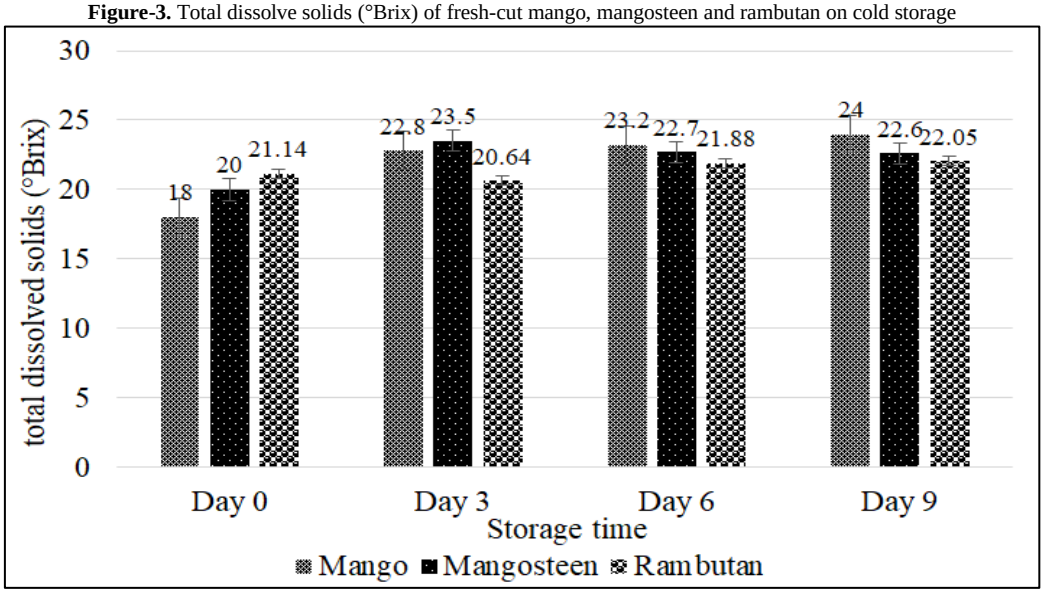
Water content: Kadar water greatly determines the quality of fruits. The average fresh-cut mango water contentincreases until the 6th day then decreases,seen in Table 1. Mango fresh-cut water content ranges from 77.37-82.36%. The minimal process of stripping and cutting leads to tissue softening that will induce faster respiration rates compared to whole tissues [22]. Respiration is the process by which organic matter (carbohydrates, proteins, fats, etc.) decompose into simpler end products and produces energy for their cell [6]. Fresh-cut mangosteen water content increased until the 6th day then decreased on day 9, its value was 80.08-82.91% (Table 1). In line with the opinion [23] mangosteen fruit water reservoir 82.6 ± 0.2%. Once the fruit is separated from the tree, the process of respiration continues to produce energy or the tissue will die causing the aging process of cells. In line with [24]. the increase in maturation rate and water loss is spurred by cutting and pruning. Shelf life and fresh-cut quality are reduced by a series of decay processes triggered by physical damage including water loss [14]. Fresh-cut rambutan water content increases until the 6th day then decrease (Table 1), its value between 78.79-80.36%. The minimal process by stripping induces the rate of respiration and spurs the speed of water loss compared to intact tissue [22]. Vithana, *et al.* [24] It also says that the rate of maturation and water loss is driven by cutting and pruning.

Figure-2. Water content of fresh-cut mango, mangosteen and rambutan on cold storage



Total dissolved solids: The older the fruit, there is an increase total sugar in the flesh of the fruit because of the hydrolysis of starch content into simple sweets. If the sugar content is more dominant than the acid content causes sweetness. The observations in Table 1 show the total dissolved solids in fresh-cut mangoes tend to increase, the value between 18.00-24.00°Brix. Gray-Goukh [25] states, the increase in risk in the total dissolved solids of the fruit coincides with the increase in sugar content in the fruit during ripening.The results of observations such as in Table 1 showthatthe total dissolved solids in fresh-cut mangosteen tend to increase until the 3rd day and then decrease. Total dissolved solids fresh-cut mangosteen 20.00-23.50°Brix. The increase in glucose levels is due to the hydrolysis of starch. At the end of storage, there is a decrease in glucose levels due to reduced starch hydrolysis while glucose is used as a respiration material that continues during the storage process [26]. Total dissolved solids in fresh-cut rambutan 20.40-22.05°Brix, the increase is not as sharp as mango and mangosteen. According to Gray-Goukh [25] the increase in the total °Brix of dissolved solids of the fruit coincides with the increase in the sugar content in the fruit during ripening. Total dissolved solids of rambutan fruit during storage did not undergo significant changes [4].

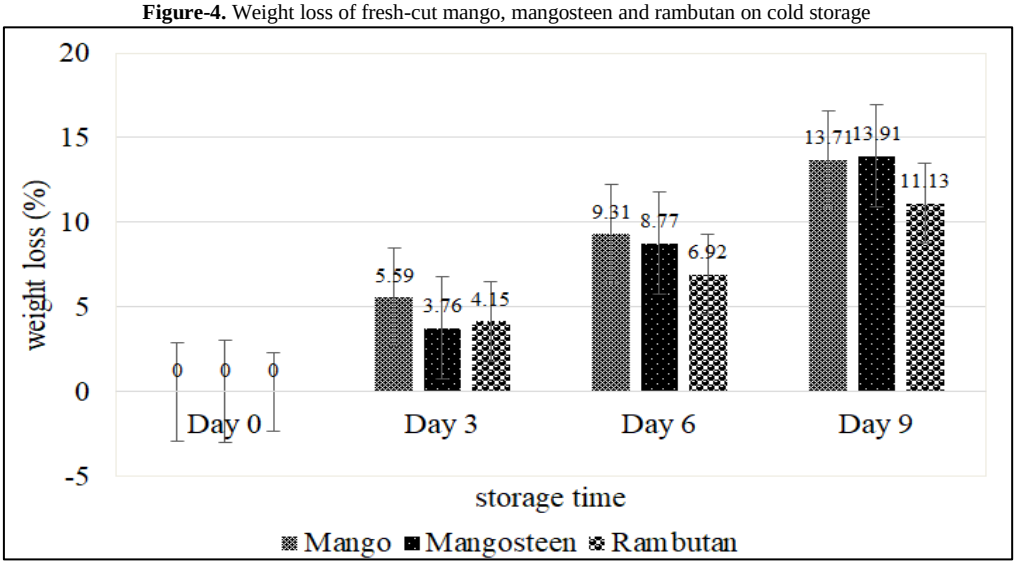
Figure-3. Total dissolve solids (°Brix) of fresh-cut mango, mangosteen and rambutan on cold storage



Weight loss: The fresh-cut weight of the mango increases during storage. Based on observations such as seen in Table 1, the value of fresh-cut mango weights is 3.76-13.91%. The longer it is stored the fresh-cut weight of mangoes the greater. Some of the influences that can be observed in fruits during storage are weight loss, respiration rate, and shelf life. Tappi, *et al.* [14], states tissue softening leads to increased respiration rates, accelerated consumption of sugars, lipids, organic acids, and increases the production of ethylene which will induce maturation and cause weight shrinking. Fresh-cut mangosteen weights increased during storagewith a value between 5.59-13.71%. Water loss loses weight from the product, protopectin decreases in number and turns into water-soluble pectic acid. So the longer the storage, the primary wall, and the middle lamella will decrease in their solid structure or cause a decrease in fruit hardness and increase weight shrinking [27]. The weight loss of fresh-cut rambutan increases during storage as seen in Table 1. The weight loss of fresh-cutrambutan is between 4.15-11.13%. Tappi, *et al.* [14], states tissue softening causes an increase in respiration rates, causing accelerated consumption of sugars,

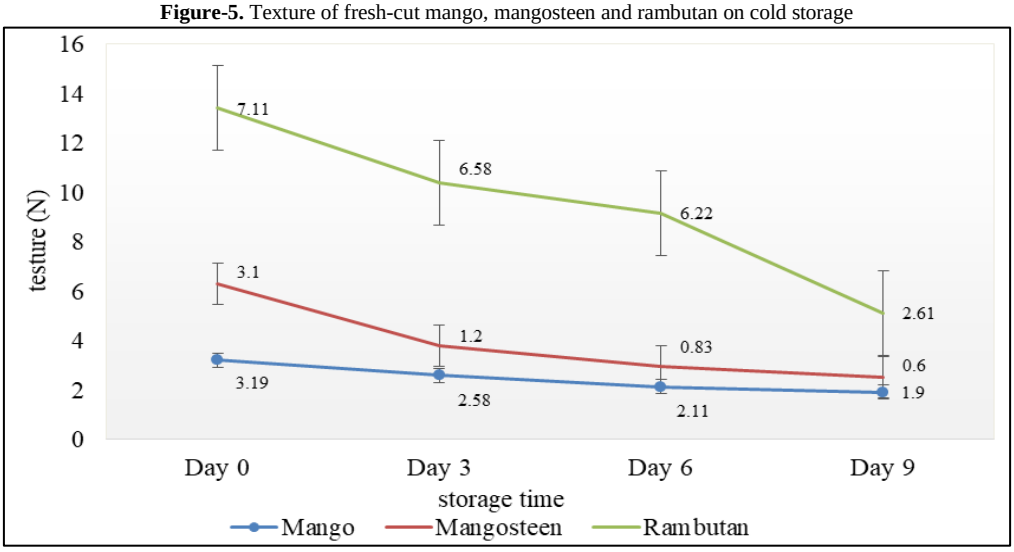
lipids, protopectin organic acids to decrease in number and turn into water-soluble pectic acid so that increasing storage leads to a decrease in fruit weight [27].

Figure-4. Weight loss of fresh-cut mango, mangosteen and rambutan on cold storage



Texture: The texture is a very important indicator of the fresh-cut quality of the fruit. The fresh-cut texture of mangoes during storage decreases. Table 1 showsthe fresh-cut texture value of mango 3.19-1.90 N. According to Deng, *et al.* [28] the process of ripening the fruit due to the process of degradation of pectin into protopectin causes the turgor pressure of the cell wall to decrease and causes the fruit to become soft. Sikora and Świeca [29] also stated that after harvesting the maturation process in mangoes results in increased respiration, ethylene production, changes in carbohydrate structure to be softer, degradation of chlorophyll, development of pigments through carotenoid biosynthetic. Changes in carbohydrates into sugars, organic acids, fats, phenol, and volatile compounds also occur, thus causing the ripening of the fruit by softening the texture towards the preferred quality. The fresh-cut texture of mangosteen during storage decreases, its value is 4.10-0.60 N (Table 1). The sensitiveness of the fruit to damage is caused by the speed of ripening and softening in storage, handling, and transportation. When the fruit is cut, peeled, or in any other way that causes injury, the tissue responds with increased respiration, consumption of sugars, lipids, organic acids, and the production of ethylene that will induce maturation and decrease obstinacy [30]. The fresh-cut texture of rambutan during storage also decreased. Table 1 shows rambutan fresh-cuttexture values7.11-2.61 N. According to Panahirad, *et al.* [31]. The rate of ripening and loss of water promoted by cutting and pruning especially accelerates the decline in the texture of fruits. Structures such as cell walls, middle lamella, and cell membranes undergo biochemical changes during maturation that lead to a loss of cohesion between cells resulting in softer and weaker structures. At the individual cellular level, water loss promotes the loss of cell turgor, causing the texture of fruits to become mushy due to the shrinking of cells in structure [29].

Figure-5. Texture of fresh-cut mango, mangosteen and rambutan on cold storage



Index browning: Fresh-cut fruit tanning occurs due to mechanical damage which is an early indicator of consumer acceptance of fresh produce. The shelf life and fresh-cut quality of the fruit are much reduced due to a series of enzymatic and non-enzymatic tanning processes [32]. The results showed an increase in the mango fresh-cut browning index after the 6th day of storage as seen in Table 1. This is because mangoes are a climacteric fruit,

which still undergoes biochemical changes after harvest [26]. The results of observations showed a sharp increase in the browning index in fresh-cut mangosteen after the 6th day (Table 1). This is because theerrors infresh-cut products such as stripping and cutting can cause chemical and biochemical changes that further cause quality damage. Such changes include increased respiration, ethylene production, discoloration, flavor, secondary metabolite formation [33]. The browning fresh-cut rambutan fruit index did not undergo significant changes (Table 1). This is because rambutan is a fruit with a non-climacteric pattern, not much biochemical change after harvest. Treatment in fresh-cut products such as stripping causes chemical and biochemical changes that further cause faster quality damage [34].

Figure-6. Browning index of fresh-cut mango, mangosteen and rambutan on cold storage

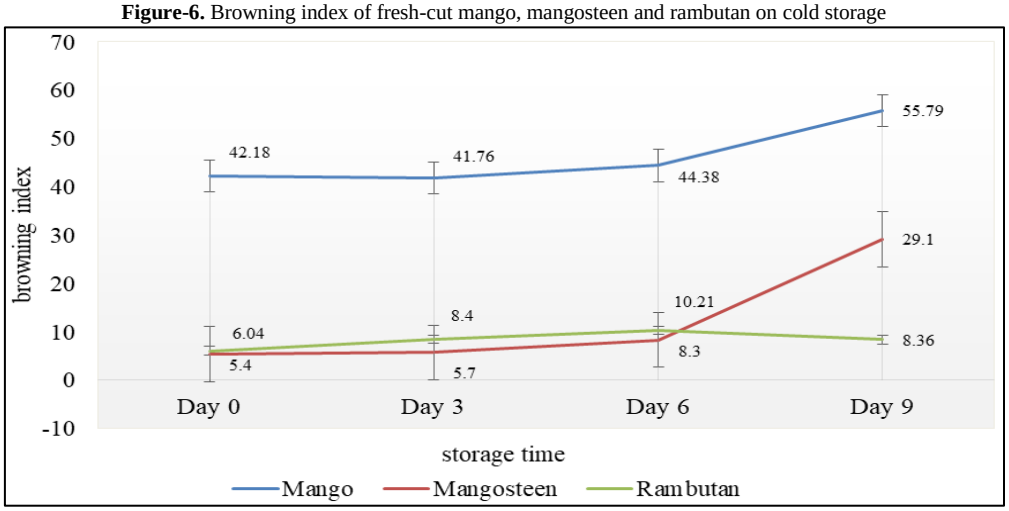


Figure-7. Fresh-cut mangosteen, mango and rambutan on cold stogare

4. Conclusion

The recommendation of this research is the removal of the skin followed by cutting the fruit as in manga, the shelf life at cold temperatures is shorter than without cutting, such as mangosteen and rambutan. Fresh-cut mango at cold storage only lasts 3 days, while mangosteen and rambutans last up to 6 days.

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