

POST-HARVEST HANDLING IN THE DRAGON FRUIT SUPPLY CHAIN

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Abstract Demand for dragon fruit is increasing every year. But to maintain and determine the quality of good dragon fruit, it is necessary to have information about the process of handling post-harvest when distributing dragon fruit ranging from farmers to consumers. Therefore, this study aims to examine the post-harvest handling process of dragon fruit in the dragon fruit supply chain cycle in Banyuwangi Regency. This study uses qualitative descriptive methods, where the main data sources used from direct field surveys. The supply chain of dragon fruit begins with the farmers-industrial/traditional market (Banyuwangi, Jakarta, Surabaya, Tangerang, Cikopo, Solo, Medan, and Riau). The post-harvest process carried out is grading based on size/weight and level of fruit defects, packaging using wooden crates, and the distribution process to the industry/market using a closed truck. Whereas in the industrial stage, post-harvest handling is done by cleaning, storing, and processing it into processed products.

Keywords: Dragon fruit, Post-harvest handling, Supply Chain.

1. Introduction

Dragon fruit belongs to the type of cactus plant and comes from America. Dragon fruits that are generally cultivated include red, white, and yellow dragon fruits [2]. Dragon fruit contains bioactive compounds that are beneficial to the body including antioxidants, minerals (calcium, phosphorus, iron, and so on), and vitamins (B1, B2, B3, and C) [6]. In addition, dragon fruit also has beta-carotene compounds. Even so, in the process of storing fresh dragon fruit, it cannot be stored for a long enough time. This is because dragon fruit has a high water content (83-90%), whereas the normal shelf life of dragon fruit is 7-10 days at room temperature, so advanced handling processes need to be considered both in the storage process to the dragon fruit supply chain process to maintain the nutritional content of dragon fruit [13, 24].

Consumer demand for the supply of dragon fruit every year has increased, considering that public awareness of the nutritional needs of fruits is quite important.

the supply of quality dragon fruit for consumers is also a problem in itself.

This is due to the unclear dragon fruit supply chain and the post-harvest handling processes during the distribution of dragon fruit that is not appropriate, both from farmers to markets [23]. The supply chain is an activity that discusses the flow of goods, money, and information to customers. The supply chain is also a process that regulates all activities starting from the procurement of goods, production planning, the process of converting goods, as well as the process of shipping products through the distribution system. In other words, the supply chain is the process of distributing products from harvested products to the market [21]. Problems in the supply chain can be solved by the *Supply Chain Management* (SCM) method, namely the process and information from the integration of activities ranging from the production of raw materials, the process of adding value to goods, the process of storing goods, and the process of shipping goods [14]. In addition, in a good SCM process, you will also pay attention to the post-harvest handling process of the product. Post-harvest handling of horticultural products in Indonesia can be considered still not considered, where the level

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However, as in other agricultural commodities,

of product damage can reach 25%. So, there is a need for post-harvest handling both in the distribution process to storage, where the information will be needed by consumers [7]. Post-harvest damage to horticultural products can be caused by moisture content, the activity of enzymes and microorganisms, mechanical damage, sensitivity to ethylene, and so on. Damage to horticultural products can generally occur faster if the post-harvest handling is not good. Hence, the importance of paying attention to post-harvest handlers is very necessary to get quality products [4].

Therefore, this study will examine how the supply chain process and post-harvest handling processes are carried out on dragon fruit products sourced from Banyuwangi Regency. This study uses qualitative descriptive methods to produce conclusions on the supply chain process and post-harvest handling of dragon fruit carried out. With this research, it is hoped that it can provide references to how the dragon fruit supply chain process/line from Banyuwangi Regency, as well as how the post-harvest handling process given to dragon fruit products in each supply chain line until before the product is received by consumers.

2. Methods

This research was conducted in Banyuwangi Regency, precisely in three areas that were the object of observation, namely Pesanggaran District and Purwoharjo District. The data collection and collection process are carried out from June 2022 to August 2022.

Data collection in this study was carried out using a qualitative descriptive method by conducting a direct survey of several dragon fruit agri-industry actors within the scope of the dragon fruit supply chain line in Banyuwangi Regency as the primary data source. The object of the survey comes from farmers as a source of supply of dragon fruit raw materials to market participants. The method of data collection through interviews with several lists of questions, including personal identity, varieties of dragon fruit grown, production land area, cultivation and care processes, cultivation and harvesting time, production results, distribution channels/supply chains, post-harvest handling, and sales processes.

The qualitative descriptive method is used by seeking systematic, actual, and accurate

data collection according to the facts that occur in the field [10]. The stages in this study include:

- a. Data collection, primary data were obtained from field surveys directly and secondary data were obtained from supporting references related to this study.
- b. Data reduction is carried out to sort out the main data needed in the analysis process to find patterns and review the supply chain and post-harvest handling carried out.
- c. Data presentation and analysis are carried out based on the main data to analyse the entire pattern of supply chain processes and post-harvest handling carried out on each supply chain line in this study.
- d. Drawing conclusions is carried out by drawing conclusions based on the results of the analysis that has been carried out, namely how the dragon fruit supply chain process sourced from Banyuwangi Regency and how the post-harvest handling process on each dragon fruit supply chain line is currently ongoing and tentative.

3. Results and discussion

3.1 Dragon Fruit Farming Conditions of Banyuwangi Regency

The process of planting, caring for, and harvesting dragon fruit in Banyuwangi Regency in general still uses conventional/mechanical methods. However, in some places in the process of cultivating dragon fruit, there has also been mechanization of cultivation carried out by utilizing artificial light by adding lighting from yellow LED lights to help the process of photosynthesis of plants to regulate the time of dragon fruit production. Another study also mentioned that the addition of lamps in the dragon fruit cultivation process is also very significantly influential on the number of fresh young dragon flowers and fruits, where the most effective lamp is the yellow color lamp [20]. In addition, based on other scientific articles, it is also stated that dragon fruit is a plant that is quite sensitive to the presence of irradiation in the process of plant growth and development [17].

In addition, harvesting is commonly carried out using cutting shears by slightly cutting the dragon fruit stem near the fruit stalk without damaging the fruit stalk. Dragon fruit is generally harvested when it is approaching the age of 60 days with an estimated weight of dragon fruit has reached 400-700 grams, and the harvesting process is carried out when the

weather conditions are quite favorable / moderately good. The technical manual for dragon fruit cultivation by the West Java Agricultural Technology Assessment Center also states that dragon fruit is harvested when it has reached the age of 50-55 days, weight is estimated to reach 400-600 grams, and harvested if the weather conditions are sunny to avoid damage due to pathogens when storage due to exposure to rainwater or also dew [15].

The production of dragon fruit in Banyuwangi Regency in 1 hectare can generally produce 8-9 tons of dragon fruit in one harvest, whereas in 1 year it can harvest up to 4-5 harvests. The result of this production is none

other than the influence of adding lighting from the lamp, irrigation, and proper fertilization, as well as the application of the *Gibbro* technique, namely spraying liquids containing the hormone gibberellin on the fruit to stimulate the dragon fruit enlargement process. Increasing the yield of dragon fruit production can be done in various ways, including by applying *Gibbro* (gibberellin hormone) and providing sufficient irradiation using light bulbs in each dragon fruit plant at night [22]. Data from observations and interviews about the dragon fruit supply chain in Banyuwangi Regency can be seen in Table 1

Table 1. Dragon fruit supply chain survey data, Banyuwangi district

Name of Respondent	District	Description	Land (m2)	Production/ Harvest (ton)	Target Market	Delivered by
Suyati	Purwoharjo	Collector	-	3-5	Jakarta, Surabaya, Solo	Closed truck
Sukarno	Pesanggaran	Farmer	1.250	1	Collector/Market	Pick up
Mustaqim	Pesanggaran	Farmer and collector	15.000	12	Jakarta, Tangerang, Surabaya, Cikopo	Closed truck
Imam	Pesanggaran	Farmer	10.000	8-9	Collector/Market	Pick up
Yono	Pesanggaran	Farmer	2.500	2	Collector/Market	Pick up
Nur	Pesanggaran	Farmer	2.500	2	Collector/Market	Pick up
Gono	Pesanggaran	Farmer	2.500	2	Collector/Market	Pick up
Ismail	Pesanggaran	Farmer and collector	1.025	1	Jakarta, Surabaya, Medan, Riau	Closed truck
M. Husain	Pesanggaran	Farmer and collector	5.000	4	Jakarta, Surabaya, Tangerang	Closed truck

Based on the data obtained when conducting field surveys, in general, dragon fruit in Banyuwangi Regency is distributed and sold outside the region and even outside the island of Java, such as Jakarta, Surabaya, Tangerang, Cikopo, Solo, Medan, and Riau (Table 1). The largest dragon fruit production area in Banyuwangi in 2018 was in Pesanggaran and Purwoharjo districts. Pesanggaran district has an area of 465 ha with the total amount of production of 470 ton [5]. While Purwoharjo district has an area of 3,306 ha with the total amount of production of 3.306 ton, respectively [5]. The total area of dragon fruit production in 2020 in the Banyuwangi district is 3,786 with the total amount of production of 82.544 ton [9]. Although based on the data presented, shows that the total area of agricultural land and the total amount of production in Pesanggaran District are smaller than in Purwoharjo District,

the data is taken from secondary data on field conditions in 2018 taken by data from the Central Statistics Agency of Banyuwangi Regency in 2019. The results of the field survey obtained show that the growth of production land and the amount of production in Pesanggaran District has currently grown very rapidly and has made Pesanggaran District one of the largest dragon fruit producing areas in Banyuwangi Regency. This also makes Pesanggaran District a dragon fruit production center in Banyuwangi Regency, both in terms of the production of dragon fruit raw materials and the production of processed dragon fruit. The Banyuwangi government has also stated that the dragon fruit production centers in Banyuwangi Regency are located in Pesanggaran District, Purwoharjo District, Bangorejo District, Siliragung District, Tegaldlimo District, Cluring District, Srono District, and Siliragung District [9].

3.2 Dragon Fruit Supply Chain Conditions of Banyuwangi Regency

The dragon fruit that has been harvested by farmers is then collected/sold to the dragon fruit collectors in their respective areas. Generally, each farmer has their own collector, and 1 collector handles 50-60 dragon fruit farmers. Then the dragon fruit from the collector will be directly distributed to markets that require the supply of dragon fruit, where most of the dragon fruit is still distributed outside the Banyuwangi area and still in the java island area,

but there are also those distributed outside Java Island (Figure 1). This is because the selling price for dragon fruit marketing outside Banyuwangi is higher than the local dragon fruit marketing in Banyuwangi Regency, especially when it is not dragon fruit season, so the majority of dragon fruit collectors prefer to distribute their dragon fruit outside the Banyuwangi area. A flowchart of the dragon fruit supply chain transportation process inside and outside the Banyuwangi area can be seen in Figure 2.

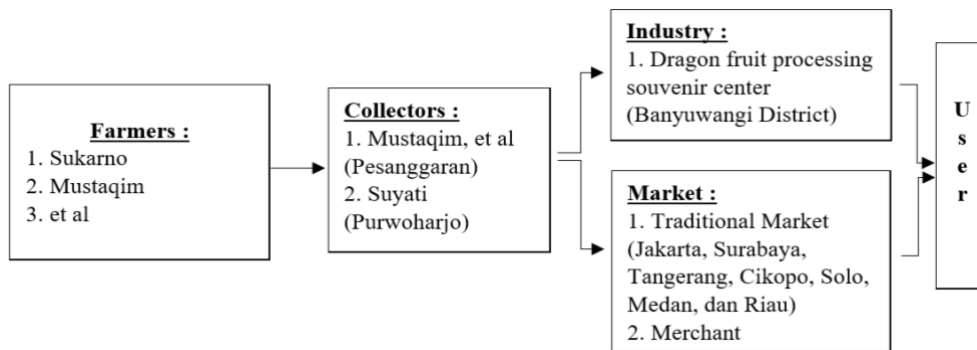


Fig. 1. Dragon fruit supply chain from farmers to users/consumers

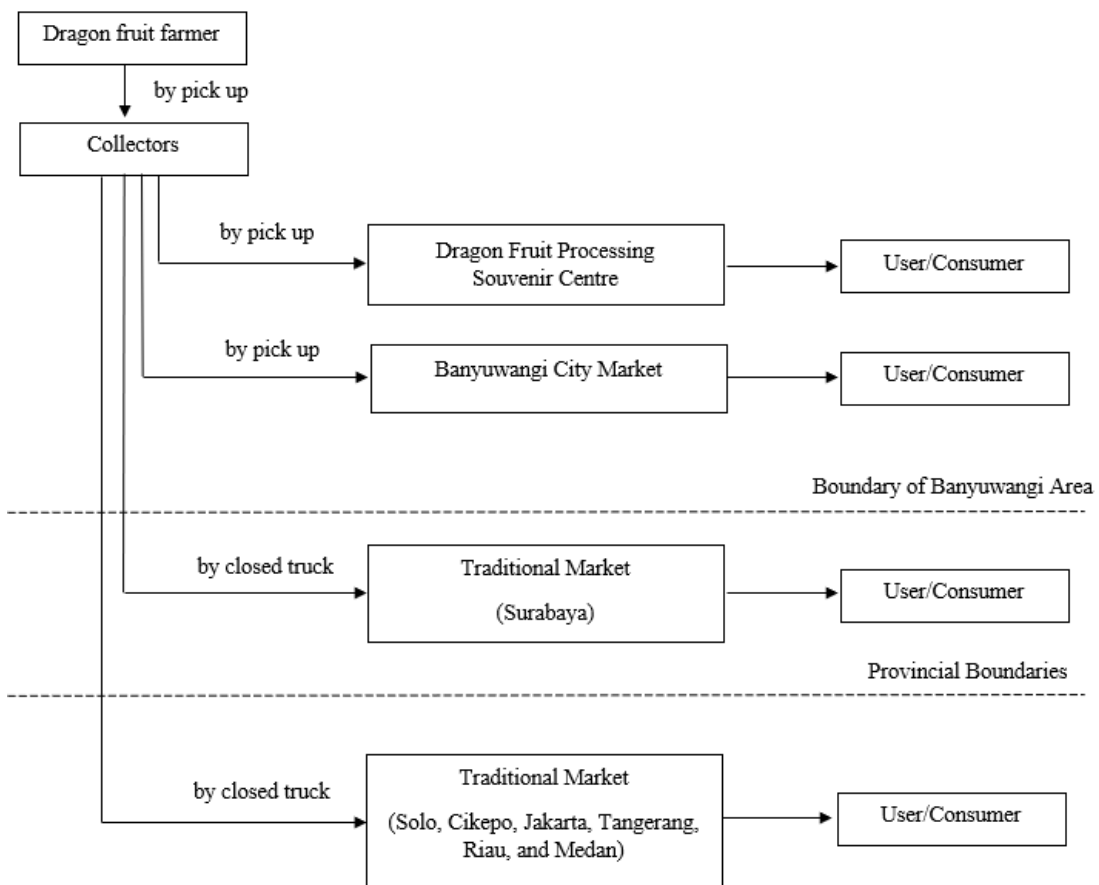


Fig. 2. Flowchart of the dragon fruit supply chain transportation process inside and outside the Banyuwangi area

The price of dragon fruit itself when it is not in season is generally from farmers to collectors is sold for 18-21 thousand rupiah/kg for grade A, 9-11 thousand rupiah/kg for grade B, and 3-5 thousand rupiah/kg for grade C (Table 2). Then based on the data obtained from collectors who send dragon fruit to the destination market, which is a difference of 3-4 thousand rupiah/kg more expensive than farmers to collectors, which is around 23-25 thousand rupiah/kg for grade A and so on for other grades

(Table 2). Meanwhile, dragon fruit from the market when sold to consumers reaches 25-33 thousand rupiah/kg. The price of dragon fruit when it is not in season is relatively higher when compared to the normal selling price of dragon fruit during its season. The price of dragon fruit during the off-season is more expensive by about 2-3 times the normal price during the season when the market demand for dragon fruit has also increased [22].

Table 2. Survey data on the number of shipments, purchase prices, and selling prices of Dragon Fruit from Collectors, Banyuwangi Regency

No.	Location	Collectors	Delivery Amount/ Day (ton)	Purchase Price from Farmers (Thousand Rupiah/Kg)	Selling Price (Thousand Rupiah/ kg)
1.	Pesanggaran Subdistrict	Mustaqim	3-5	A= 19-21 B= 9-11 C= 3-5	A= 22-25 B= 12-15 C= 6-9
2.		Ismail	0.75 – 1.25	A= 18-20 B= 9-11 C= 3-5	A= 23-25 B= 12-15 C= 6-9
3.		M. Husain	3	A= 18-21 B= 9-11 C= 3-5	A= 23-25 B= 12-15 C= 6-9
4.	Purwoharjo Subdistrict	Suyati	3-5	A= 18-20 B= 9-11 C= 3-5	A= 23-25 B= 12-15 C= 7-9

When it is not dragon fruit season, the collectors prefer to distribute and sell dragon fruit outside the Banyuwangi area. This is because, due to the scarcity of dragon fruit, the selling price of dragon fruit outside the region is relatively higher. Only a small portion of dragon fruit is sold in Banyuwangi Regency. A small part of the dragon fruit production sold in Banyuwangi City is generally intended for the dragon fruit processing industry, especially in several places as centers for processed dragon fruit souvenirs. Even from the survey results that have been carried out, only 1 dragon fruit seller was found in Banyuwangi Regency, especially in the Red Island Beach tourist area. Dragon fruit sold from collectors to industry or local markets is generally dragon fruit with grades B and C. The selling price from collectors to industry and markets in Banyuwangi Regency is also only 1-2 thousand rupiah/kg more expensive than the selling price of farmers to collectors.

Meanwhile, in the process of distributing dragon fruit outside the area, generally the collectors use shipping services in Banyuwangi specifically for agricultural products. Shipments

outside the area, it is carried out using a closed truck, where the fruit to be distributed has been packed in wooden crates with a base of the crate using wastepaper. In terms of shipping costs, generally, these costs will be borne by the dragon fruit orderer and the shipping costs themselves are relative (depending on the shipping distance). Meanwhile, the process of distributing local dragon fruit, Banyuwangi Regency is generally carried out by the dragon fruit orderer himself with a private vehicle owned. Therefore, the selling price outside the Banyuwangi area and Banyuwangi local area is quite different, where the operational costs in local distribution are smaller than the distribution of dragon fruit outside the area, and this is greatly influenced because Banyuwangi itself is a dragon fruit production center. The longer the distribution process and the more operational stages of distributing goods can increase the selling price of goods, and vice versa [12].

3.3 Dragon Fruit Post-Harvest Handling Conditions on Each Supply Chain Line

Based on the existing dragon fruit supply

chain path in Banyuwangi Regency, each of them has a different post-harvest dragon fruit handler. In general, based on data from field surveys obtained post-harvest handling for dragons, the following are as follows:

a. Dragon Fruit Post-Harvest Handling in the Dragon Fruit Farmer Stage.

Post-harvest handling of dragon fruit in the farmer stage starts from the post-harvest process to the process of transporting from the field to the collector. Based on the data obtained, after the dragon fruit is picked/harvested, the dragon fruit is collected in a dry and shady place. Dragon fruit should not be placed in a dirty, humid, watery, or too hot place. This is to keep the dragon fruit from insect and animal disturbances, dirt, water, and temperatures that are too extreme to keep the fruit in good shape. In addition, it is also to maintain the quality of the dragon fruit during the storage process remains good and can be stored longer. This is because dragon fruit, which is an agricultural product, is very vulnerable to damage due to pathogens, water, and so on so the dragon fruit quickly suffers damage (rot, and so on). The environmental conditions of the dragon fruit will greatly affect its quality of the dragon fruit, especially if the dragon fruit will later be stored. The main problems related to the quality of dragon fruit include microbes and pathogens, temperature, water, and water loss problems [18, 23].

While fruit laying and distribution of fruit to dragon fruit collectors must also be done carefully because dragon fruit of fruit that is prone to impact damage. Generally, in the process of distributing dragon fruit to the collector, the collector will take the dragon fruit to the farmer directly to the farmer's land area using a pick-up vehicle. Dragon fruit that has been picked from the field is taken to a pick-up vehicle using a one-wheeled trolley with a maximum of one trolley of 15-20 kg. The use of this trolley aims to make it easier for farmers to carry dragon fruit and to avoid damage due to impact. This is if you don't use a trolley, another alternative for farmers in transporting dragon fruit is to use plastic tubs or sacks. If the

transportation of dragon fruit using a plastic tub is still quite possible, it is not possible not to suffer damage, but if it is transported using sacks, it will be very likely to suffer damage, especially the fruit at the bottom due to excessive cooking. In addition to the damage due to environmental factors, dragon fruit is also a fruit that is very vulnerable to mechanical damage [18, 23].

b. Dragon Fruit Post-Harvest Handling in the Dragon Fruit Collection Stage.

The dragon fruit received from the farmer is then directly carried out in the grading process. The grading process is carried out based on the size/weight and level of disability manually (visible vision of the human eye). In the grading process, dragon fruit is sorted into 3 grades (Table 3), where dragon fruit with a size/weight of ≥ 400 grams is included in grades A and B, and dragon fruit with a size/weight of < 400 grams is included in grade C. Because the sizes of grades A and B are relatively similar, so what distinguishes between grades A and B is the degree of disability of dragon fruit. The defect in the intended dragon fruit is due to the presence of smallpox on the skin of the dragon fruit, where based on the survey that has been carried out that the presence of smallpox in the dragon fruit can be caused because the fertilization process of the dragon fruit is exposed to water from rain and dew. Abdurrosyid also mentioned that smallpox that occurs in dragon fruit can be caused by the presence of water from quite high rainfall, so dragon fruit plants absorb water that is quite high [1]. Then in the research conducted by Anugrahandy that sorting/grading is important to determine the classification of a commodity based on the quality of the same type of the commodity. However, the process of sorting manually by utilizing human sensory senses has many disadvantages if it is on a large enough scale and time is less efficient because it is long enough. Therefore, the sorting/grading process will be very effective and efficient if it can be done using tools/machines [3]

Table 3. Dragon fruit grade

No.	Grade	Size/Weight (Grams)	Disabled
1.	A	< 400	Nothing/a little
2.	B	≥ 400	Pretty much
3.	C	≥ 400	Nothing—a lot

After the grading process is carried out, the dragon fruit is weighed based on their respective grades to determine the total cost to be paid to the farmer who sells the dragon fruit. Then the dragon fruit is directly included in the packaging process using a wooden crate, with a maximum of 1 wooden chest containing 20-30 kg of dragon fruit according to their respective grades. On the sides of the wooden crate both the bottom, sides, and top are given a layer of wastepaper (old newspaper) to reduce the impact of the dragon fruit on the chest. It is as previously mentioned that dragon fruit is a fruit that is very vulnerable to damage due to impact/pressure (mechanical damage). In addition, the use of wooden crates and the maximum restriction of dragon fruit that can be accommodated in 1 crate can also reduce mechanical damage on the way. This is because shipping is carried out by using a delivery service, namely trucks, so using crates and limiting the capacity in the crate will greatly reduce the level of damage to dragon fruit during the shipping process, both damage due to the pressure of the fruit pile and damage due to shocks/impacts during the trip. In addition, in the delivery process, the trucks used also use special cover trucks for the delivery of agricultural products. It aims to reduce the damage of dragon fruit due to water content loss due to the scorching heat of the sun, reduce damage due to rainwater, and reduce damage due to various pathogens and microbes. The pathogens and microbes in question, for example, come from farm animals if the trucks used for the delivery of agricultural products are also used for the delivery of farm animals, and so on. If these factors cannot be avoided, they will be able to damage the quality of the dragon fruit, just as the dragon fruit is bruised due to pressure/impact, quickly damaged, and so on. As previously outlined, to maintain the quality of dragon fruit products, you must avoid the main causes that can result in damage to the fruit such as pathogens and microbes, extreme temperatures, water, and the causes of mechanical damage [18, 23]. In this delivery process, based on the data obtained, the damage rate during the shipping journey so far has only reached $\leq 5\%$ until the dragon fruit reaches its destination. Meanwhile, the level of damage to general agricultural products can reach 25% which can be influenced by various environmental and mechanical factors [7]. Therefore, the post-harvest handling provided from the collector to the delivery

process can be considered quite good.

- c. Dragon Fruit Post-Harvest Handling in the Dragon Fruit Industry and Market Merchants Stage.

At this stage, the main post-harvest handling is generally carried out cleaning and storage. In the industrial stage, because the dragon fruit processing industry in the Banyuwangi area is a small-scale industry (SMEs and/or MSMEs), the post-harvest handling carried out includes cleaning dragon fruit and then directly entering the processing process. Processed dragon fruit made in the industry includes dodol/ jenang, fruit juice, pastries, wet cakes, noodles, sauces, and crackers/chips. The process of processing dragon fruit into processed products aims to increase the economic value of the product. In addition to carrying out the cleaning, sorting/grading, storage, and distribution processes, the economic value of an agricultural product can be improved by diversifying the product into other forms, for example, processed products [8, 11, 16, 19]. Meanwhile, if the dragon fruit that has been accommodated is not all processable, then the dragon fruit will be stored and processed in the future. The storage process carried out is also still quite simple, which is only placed in a special plastic basket for fruit and stored in a dry place and in room conditions. This is because the dragon fruit will be directly processed in the next 1-2 days, so it has not suffered any significant damage. A study [25] mentioned that dragon fruit can still be stored at room temperature for up to 7 days even though in terms of the content of compounds contained in it has undergone many changes (quality decline) [25].

In addition, the post-harvest handling process at the market merchant stage is basically not much different when compared to the post-harvest handling carried out in the industry, which includes cleaning and storing dragon fruit. Based on the survey data obtained, the dragon fruit cleaning process was carried out using a clean dry cloth. This cleaning aims to clean the dragon fruit from the dirt that sticks to the dragon fruit, both the dirt carried from the farmland to the dirt that sticks during the dragon fruit distribution process. This dragon fruit cleaning has a lot to do with the quality and durability of the dragon fruit during storage. This has also been stated in [26] that cleaning

agricultural products can maintain product quality, maintain product shelf life, and increase product selling prices [26]. Meanwhile, the dragon fruit storage process carried out at the market trader stage is generally stored in a clean, dry, and closed place. The storage treatment aims to maintain the quality and maintain the shelf life of dragon fruit from non-mechanical damage, for example, dragon fruit rots quickly due to exposure to pathogens, microbes, and water, and dragon fruit withers quickly due to high temperatures so that it experiences considerable water content loss continuously as previously described.

4. Conclusion

Based on the data obtained and the results of the analysis that has been carried out, the results of this study can be concluded as follows:

- a. The dragon fruit supply chain in Banyuwangi Regency generally starts from farmers, then is distributed/sold to collectors in each region. A small part of the dragon fruit accommodated by the collector is then sold to industries, especially the local dragon fruit processing industry in Banyuwangi Regency and to small dragon fruit vendors in Banyuwangi Regency. Meanwhile, most of the dragon fruit accommodated by collectors is distributed to markets outside the region, which include Jakarta, Surabaya, Tangerang, Cikopo, Solo, Medan, and Riau.
- b. The process of handling dragon fruit on each dragon fruit supply chain line of Banyuwangi Regency is generally at the stage of farmers only paying attention to the place where the dragon fruit is collected and the distribution process to collectors. Then the collector's stage, several post-harvest handling processes are carried out including grading (grades A, B, and C) based on the size/weight and level of fruit defects with manual methods (human sensory sense), packaging processes using wooden crates, and distribution processes to industries/markets using special delivery services for agricultural products and closed trucks. Meanwhile, in the industrial stage, post-harvest handling is carried out by cleaning, storing, and processing dragon fruit into processed products. As well as at the stage of market traders, the post-harvest handling carried out includes the cleaning

and storage process. All the post-harvest handling processes of the dragon fruit, whether in the farmers, collectors, industry, or market, aim to maintain the quality of the dragon fruit from mechanical and non-mechanical damage, maintain the shelf life of the dragon fruit, and increase the economic value of the dragon fruit.

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