The effect of packaging and storage method on Snake fruit 
(Salacca edulis Rainw.) quality

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Abstract. Snake Fruit (Salacca edulis) var. Pondoh is one of potential commodities in Yogyakarta, Indonesia. It has fluctuated price in farmers level. During the peak of harvest season, the price dropped because of the increase of supply in market. The solutions are needed at farmer’s level to prolong the fruit’s lifetime. One possible solution is treatment to maintain the product quality through good packaging and good storage. The aim of this study was to investigate the effect of room temperature, RH treatment and packaging method on salak pondoh quality during storage. Salak pondoh were packed into four different packaging: a stem of bunch, single fruit, single fruit in plastic (PP), and single fruit in vacuum plastic. Samples from all four packaging were stored in four treatments: ambient room, humidified room, cold storage, and cold-humidified room. The quality parameters were weight loss, moisture content, TDS (brix %), and fruits stress. ANOVA was used for statistical analysis. The result showed that packaging and storage method significantly affect the moisture content, weight losses, and brix. Combination of vacuum packaging and cold storage preservation could keep the moisture content, reduce the weight losses, and prohibited the respiration process that could change the TDS (brix %) value.

1. Introduction
Snake fruit (Salacca edulis) var. Pondoh is one of potential commodities in Yogyakarta, Indonesia. It has a worldwide recognised as authentic fruit from Indonesian. Meanwhile it is excellent commodities to export [1]. It can be harvested and consumed in all season, especially in the peak season, which is in November-January. Production of snake fruit in Indonesia achieved about 965,205 tonnes in 2015 [2]. Unfortunately, it has fluctuated price in farmers level. When it harvested in the peak season, the price dropped that caused by large number of supplies in the market [3]. The farmers need a solution to prolong the fruits lifetime, so it still can be sold after the peak season.

So far, the farmers processed snake fruit traditionally. Innovation in postharvest treatment is needed to maintain the product quality. Some researches have been conducted to preserve snake fruit using modified atmosphere (MA) [4,5], and proved that the temperature and storage method could affect the respiration rate and the quality of fruit. Therefore, the objectives of this research were to find out the effect of packaging and storage method to snake fruit quality during preservation and find the best
method to preserve the snake fruit product. It is hoped that the farmers can apply the technology for export activity, thus the profitable price can be obtained.

2. Materials and Method

2.1. Materials
Snake fruits were cultivars Salak Pondoh with commercial maturity obtained from “Salacca Tourism Village” Turi, Sleman, Yogyakarta, Indonesia. Every single snake fruit was packed into two methods, vacuum and non-vacuum with PP plastic, and a bunch of snake fruit without packaging as control.

2.2. Storage procedures
All of products were put in three different storage rooms, include humidified room, cold storage, and cold-humidified room. One sample was put in the ambient room as control. Humidified and cold-humidified room were made from plywood and covered by styrofoam. Humidified room has a RH treatment from atomized distilled water using high compressor. The humidity was controlled at minimum 90%. Cold-humidified room has a temperature and RH treatment from air conditioner and atomised distilled water. The temperature and humidity were controlled at minimum of 20-25°C and 90% respectively. Cold storage temperature was set in minimum of 18°C [6]

2.3. Property analysis
The initial data of weight loss, moisture content, brix, and fruit stress were collected before packed, and every day during storage. Moisture content was analysed using gravimetric method. Total dissolved solids/TDS (% brix) was measured using Atago hand refractometer capacity 0-85% [6]. Fruit stress, as physical parameters were measured using compress test equipment. Analysis of variance (ANOVA) was carried out using the SPSS 19.0 software. ANOVA tests were performed for all experiments at 95% confidence interval.

3. Results and Discussion
Each treatment given to the storage room greatly influences the atmospheric conditions inside, especially in temperature and relative humidity. Table 1 showed the average temperature and RH during storage. The ambient room has a high temperature in the afternoon, which the average temperature and RH were 26.95°C and 77.8% respectively. Humidified room has a highest RH in 93.5% and the temperature was higher than ambient. The lowest cold storage temperature reaches at 18.08 °C and the RH was higher than ambient. While cold-humidified room temperature and RH were 21.48 °C and 91.03%, respectively.

| Room          | Average Temperature (°C) | Average RH (%) |
|---------------|--------------------------|----------------|
| Ambient       | 26.95                    | 77.8           |
| Humidified    | 29.94                    | 93.5           |
| Cold Storage  | 18.08                    | 87.5           |
| Cold-Humidified | 21.48                     | 91.03          |

Each room condition has a different influence on fruit appearance and quality. Figure 1 shows the effect of different packaging and storage method on storage period. Preservation, which conducted in cold storage, has a longest lifetime in all packaging treatment. Storage process in cold storage occurred for 36 days, 37 days, and 41 days for the bunches, plastic and vacuum respectively. The shortest period of snake fruit preservation were 19 day for plastic packaging in ambient room and bunches in cold-humidified room. Vacuum packaging method had the longest period in almost all storage conditions. It is caused by some factors, depending on room conditions and packaging methods.
Figure 1. Storage period of snake fruit on different packaging and room treatment

Bunches of snake fruit became soft and moldy in the second week, thus some damaged snake fruits were separated from the bunches. Snake fruit on plastic packaging had mold spots and slightly watery. The snake fruit packed on vacuum had a little bit mold spot, which grew in the fourth week. Based on products appearances, snake fruit in humidified room defected faster than other room storage conditions. High humidity and temperature cause the number aerobic bacteria and molds increased markedly [7]. Otherwise, snake fruit stored in cold storage could not be grown by mold easily. Because the temperature is unfavourable to gray mold development. Therefore, cold storage effectively reduced mold in fruit for a few days [8]. Even the mold counts can be influenced by some factors, such as weather, time of the year, harvest conditions, and also the fruit moisture content [9]. Yeast and mold growth on fruits not only affected by storage method, but also because the products were collected from the field and were not sterilised, thus the mold naturally grew [10].

3.1. Moisture content and weight losses

Figure 2 and Figure 3 show weight losses and moisture content of snake fruit during storage in cold storage, cold-humidified room, ambient room, and humidified room respectively. All graphs show that snake fruit samples in each storage room got weight losses while the moisture content relatively constant. The highest weight losses occurred on bunches snake fruit, especially in ambient room (around 135g), followed by humidified room (~100g), cold storage (~76g), and cold-humidified room (~65g). The bunches snake fruit were unprotected by the packaging, so the fruit surface directly contacts with the surrounding environment. Evaporation occurred in the fruit surface which determined by difference of vapour pressure in the surface and in the surrounding [11]. The moisture content of snake fruit in plastic and vacuum packaging were relatively low. The packaging and storage methods significantly affect the water content of snake fruit (p<0.05). Snake fruit with plastic and vacuum packaging, which preserved on cold storage had the lowest weight losses and could keep the moisture content. It is in agreement with the literature that weight losses equal with the length of storage and it affected by temperature, humidity and method of storage [12].
Figure 2. Weight losses of snake fruits in cold storage (CS), cold-humidified room (CH), ambient room, and humidified room (hum)

Figure 3. Snake fruits moisture content in cold storage (CS), cold-humidified room (CH), ambient room, and humidified room (hum)

3.2. Brix
Brix content of snake fruit for all packaging and storage methods were shown in Figure 4. Almost all of graphs show increasing trend for brix contents. It means that total dissolved solid which assumed as
sugar content in the snake fruit have raised. It was caused by the chemical process of the breakdown of starch compound into sucrose reduction. Decay on snake fruit into a rotten one caused brix content decline. The fluctuation value of brix content is caused by different snake fruit condition as the sample. The packaging and storage methods significantly affect the brix content of snake fruit (p<0.05). Sucrose was the highest sugar content in fresh snake fruit, followed by glucose and fructose [13].

![Graphs showing brix content changes over time.](image)

**Figure 4.** The brix content of snake fruits in (a) cold storage, (b) cold-humidified room, (c) ambient room, and (d) humidified room.

Snake fruit with PP plastic packaging in ambient room has the highest brix value. On the other hand, sample in vacuum packaging with cold storage preservation has the lowest brix value. High-temperature affects the chemical process of starch compound breakdown running faster. Low temperature influenced the respiration process, so it can inhibit the enzyme activity and chemical reaction. The rate of chemical and biological reaction in fruit that stored in cool condition could decrease half time if each temperature drops 10°C [14].

MAP with PP packaging can delay the fruit ripening period at least 6 days. This is caused by a reduction in respiration which causes slowing of softening and various changes in composition such as
TDS (brix%), which are related with ripening. When compared to fruit stored without packaging, TDS (brix%) values can indicate higher respiration and ripening rates. Hence, some fruit quality parameters such as weight loss, firmness, TDS (brix%) were significantly influenced by polyethylene packaging during the storage period [15].

3.3. Fruit stress
Stress test was assumed to represent the texture quality of snake fruit. Figure 5 shows the snake fruit stress during storage. The pattern of stress fruit indicates an increase in the beginning week 3, and then decreased until the end of storage. The respiration process affected the physiological properties of snake fruit, so high respiration rate affected the decay to start faster than the fruit texture quality changed. The fluctuated value of stress was caused by different conditions of snake fruits. The packaging method significantly affects the stress of snake fruit (p<0.05), but storage method did not influence the stress value.

Most of bunches samples had high stress values. The results of the stress measurement indicate the quality of fruit texture during storage. The high stress value means that the sample had better quality of the texture parameters of fruit. Food preservation processes affect the structural and biochemical composition of the cell wall. During the post-harvest process, turgor pressure and crispness are lost due
to a decreased in the structural integrity of the cell [16].

4. Conclusions
Moisture content, weight losses and brix% were influenced by packaging and storage method. Texture quality of snake fruit which is represented by stress value was unaffected by packaging and storage method significantly. Combination of PP vacuum packaging and cold storage preservation can be applied to keep the moisture content, reduce the weight losses, and render the respiration process. Therefore, this method can delay the fruit ripening period for few days. The material of storage chamber required to be evaluated, that it can keep the condition in the chamber that have been adjusted.

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