Effect of Packaging Fillers Materials on the Quality of Papaya Fruit (Carica papaya L.)

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Abstract. Papaya is classified as a high economic value commodities, however it is perishable, easy to lose weight due to its thin skin and soft flesh and has a short shelf-life. Generally, the papaya transportation process in Indonesia is only conducted using a simple packaging method such as using papers or baskets to avoid wound on the fruit. Therefore, packaging improvement would provide a great advantage for papaya trading. This study aimed to determine the effect on papaya quality while packaged in different packaging fillers materials during land transportation using simulation. The results showed that the highest percentage of weight loss, mechanical damage and hardness after simulation at frequency of 1.5 Hz and 3 HZ were 6.74%; 71.48%; 4.23 gr/mm and 7%; 97.16%, 4.17 gr/mm respectively in RST3 treatment (plastic basket of straw filler in 5 hours simulation), while the lowest percentage after simulation at frequency of 1.5 Hz and 3 Hz were 0.14%; 30.95%; 2.86 gr/mm and 0.17%; 26.18%; 2.56 gr/mm respectively in NPT1 treatment (newspaper filling material in 1 hour simulation). The best packaging to reduce quality degradation in papaya using transportation simulation at the frequency of 1.5 Hz and 3 Hz was the plastic basket with newspaper filler.

1. Introduction
Papaya (Carica papaya L.) is one of the commercial plants with a high economic value and wide market opportunities ranging from traditional markets to supermarkets and even foreign countries. Papaya plants have considerable production potential in Indonesia. However, papaya is perishable, easy to lose weight due to its thin skin and soft flesh and has a short shelf-life. The occurred damage on the fruit skin could be the entrance of microorganisms into the fruit which will increase the respiration rate and decrease the shelf life. The damage (stress) experienced by fruit commodities can be caused by physical, chemical and biological factors.

Transportation process of papaya fruit from producer to consumer is conducted using a very simple packaging design, such as sacks and bamboo basket. Consequently, packaging improvement will provide great advantages for papaya fruit marketing due to the ability to reduce the degradation rate of papaya during transportation. In export market, papaya is wrapped in polyurethane foam to keep papaya from bruises after collisions during transportation, then wrapped in cartons and arranged where the fruit base is under. On the other hand, for local market each papaya fruit is wrapped using newspapers then packed in bamboo baskets, plastic or wooden crates.

Damage Fruits during transportation is affected by the transported fruit type, packaging type, and preparation of packed fruit in the packaging, the transport distance and duration. Mechanical damage in papaya fruit could occur due to collisions during harvest and transportation. Most farmers do not use...
pads consequently the fruits directly contact to the ground especially at the bottom part. Papaya fruit has a thin skin surface and thin tissue which make it easily damaged while scratched and impacted. Mechanical collisions can cause bruising on the skin surface and the food tissues, which trigger a further damage due to the microorganism growth.

Studies about fruit packaging have been widely conducted including studied about the effect of packaging methods using paper, active paper and edible coating, on the characteristic of papaya MJ9 in ambient temperature storage [1], trends in fruit and vegetable packaging [2], and development in packaging of fresh fruit – shelf life perspective [3].

To reduce the damage level of papaya fruit during transportation, study of papaya fruit packaging using different fillers to protect the fruit from mechanical damage is required. The objective of this study was to determine the effect of papaya fruit quality in different packaging fillers materials during land transportation using transportation simulation.

2. Materials and Methods

2.1 Material and Apparatus
Papaya california varieties (size of 1-1.5 kg weight and ± 15 cm diameter) were obtained from Basilam Village, Wampu Subdistrict, Langkat Regency. The ingredients for fillers were newspaper, dried banana leaves and dried rice straw. Apparatus used in this study were vibration table for the transportation simulation, penetrometer for fruit hardness measurement, stopwatch for simulation length calculation, scale for weight measurement and plastic basket as packaging container.

2.2 Analysis Method
This research were using the complete randomized design 2 factorial method, which were filler material type consist of newspaper (NS), dried banana leave (BL), and dried rice straw (RS), in three different simulation time which were 1 hour (T1), 3 hours (T2), and 5 hours (T3) with 3 repetitions respectively.

Research procedure that was conducted including determining the used papaya in size of 1-1.5 kg and average diameter of ± 15 cm, then observing the papaya quality (weight loss, mechanical damage and hardness), continue by arranging papaya horizontally into the package using different fillers, namely NP for plastic filler, BL for dried banana leaves filler plastic basket, and RS for rice straw filler plastic basket, then papaya fruit was arranged regularly in the package with a full capacity of ± 19 kg on each package, the ready package then set on the transportation simulator vibration table and simulated in 1, 3 and 5 hours respectively using frequency of 1.5 Hz and 3 Hz with 3 times repetition. After that, observing the papaya fruit quality (weight loss, mechanical damage, hardness) and data processing.

2.3 Research Parameter
This research were using four parameters including porosity, weight loss, mechanical damage and hardness. Weight loss measurement was conducted before papaya was entered in to the package and after the transport simulation. In addition, mechanical damage level measurement was conducted by analyzing the damage visually, namely scratches and bruises. Hardness test was also carried out before and after transportation using penetrometer on three points including the base, tip and center part of papaya on each package.

3. Results and Discussion
Porosity or pore space is the volume of all pores in an intact volume expressed in percent (%). Porosity data for each treatment can be seen in Table 1 which shows that papaya porosity in plastic basket package using newspaper, banana leaves and rice straw as filler material was 37.5%; 38.4% and 34%, respectively. The empty space inside the package caused friction that accelerated mechanical damage. According to [4], damage caused by shocked was caused by an unfinished loading and uneven packaging during transport (high number of empty space between papaya caused frictions in the transported package). The usual damage was bruised, skin peeled and broken.
Table 1. Data of porosity on each treatment

| Material Filler | Mass density (gr/cm$^3$) | Particle density (gr/cm$^3$) | Porosity (%) |
|-----------------|--------------------------|------------------------------|--------------|
| Newspaper (NP)  | 0.45                     | 0.72                         | 37.5         |
| Banana leaves (BL) | 0.45                    | 0.73                         | 38.4         |
| Rice straw (RS) | 0.44                     | 0.66                         | 34.0         |

Weight loss measurement on papaya was conducted after the transportation simulation. The weight loss data before and after simulation can be seen in Table 2. Papaya weight was decreased in each treatment due to transpiration and respiration factors. The transpiration process occurred after the fruit was picked and causing the water content in papaya decreased continuously. On the other hand, the respiration process was occurred when the fruit was simulated using frequency of 1.5 Hz and 3 Hz which caused frictions between papaya and the package which resulted in increase of injuries.

Table 2. Data of weight loss and mechanical damage percentage

| Frequency | Treatment | Initial Weight (gram) | Simulated Weight (gram) | Percentage of Mechanical Damage (%) |
|-----------|-----------|------------------------|-------------------------|-------------------------------------|
| 1.5 Hz    | NPT1      | 19.22                  | 19.19                   | 30.95                               |
|           | NPT2      | 19.28                  | 19.06                   | 35.71                               |
|           | NPT3      | 19.63                  | 18.75                   | 49.91                               |
|           | BLT1      | 19.52                  | 19.48                   | 40.47                               |
|           | BLT2      | 19.85                  | 19.50                   | 49.91                               |
|           | BLT3      | 19.63                  | 18.57                   | 64.28                               |
|           | RST1      | 19.41                  | 19.33                   | 47.53                               |
|           | RST2      | 19.57                  | 18.96                   | 49.91                               |
|           | RST3      | 19.49                  | 17.95                   | 71.48                               |
| 3 Hz      | NPT1      | 19.64                  | 19.51                   | 26.18                               |
|           | NPT2      | 19.57                  | 19.32                   | 42.57                               |
|           | NPT3      | 19.27                  | 18.66                   | 52.38                               |
|           | BLT1      | 19.31                  | 19.26                   | 57.14                               |
|           | BLT2      | 19.51                  | 19.06                   | 64.28                               |
|           | BLT3      | 19.13                  | 17.97                   | 76.18                               |
|           | RST1      | 19.63                  | 19.53                   | 73.86                               |
|           | RST2      | 19.67                  | 19.05                   | 85.77                               |
|           | RST3      | 19.34                  | 17.98                   | 97.61                               |

Description : NPT1 = 1 hour simulation (filler material: newspaper) ; NPT2 = 3 hours simulation (filler material: newspaper) ; NPT3 = 5 hours simulation (filler material: newspaper) ; BLT1 = 1 hour simulation (filler material: banana leaves) ; BLT2 = 3 hours simulation (filler material: banana leaves) ; BLT3 = 5 hours simulation (filler material: banana leaves) ; RST1 = 1 hour simulation (filler material: rice straw) ; RST2 = 3 hours simulation (filler material: rice straw) ; RST3 = 5 hours simulation (filler material: rice straw)

Table 2 showed that the highest percentage of weight loss after simulated using both frequency of 1.5 Hz and 3 Hz was RST3 using rice straw as filler material simulated for 5 hours. On the other hand, the lowest percentage was NPT1 which used newspaper as filler material and simulated for an hour.
Based on analysis of variance result indicated that the factor of filler type and simulation duration give a real effect to the weight loss of the fruit weight. In addition, the interaction between factor of filler type and simulation duration also have real effect on each treatment.

**Figure 1.** Bruises because of mechanical damage on various filler material at 1.5 Hz Frequency

**Figure 2.** Scratches because of mechanical damage on various filler material at 1.5 Hz Frequency

**Figure 3.** Bruises because of mechanical damage on various filler material at 3 Hz Frequency
The usual mechanical damage including scratches, broken s, and bruises. The percentage of mechanical damage caused by mechanical damage could be seen visually by looking directly at the physical condition of papaya fruit after simulated using different treatments of filler material, time of simulation, and frequency. The percentage data of mechanical damage to papaya fruit can be seen in Table 2. The highest percentage of mechanical damage such as bruises and broken in the frequency of 1.5 Hz and 3 Hz was RST3 which

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure4.png}
\caption{Scratches because of mechanical damage on various filler material at 3 Hz Frequency}
\end{figure}

\begin{table}[h]
\centering
\caption{Data of Papaya Hardness Level}
\begin{tabular}{llcccc}
\hline
Treatment & Papaya Position in Basket & Initial Hardness (gr/mm) & Simulated Hardness (gr/mm) \\
 & & 1.5 Hz & 3 Hz & 1.5 Hz & 3 Hz \\
\hline
NPT1 & Top & 5.12 & 4.64 & 4.23 & 4.17 \\
 & Bottom & 5.22 & 4.58 & 4.08 & 3.83 \\
NPT2 & Top & 5.62 & 5.54 & 4.11 & 3.71 \\
 & Bottom & 5.47 & 5.47 & 3.99 & 4.08 \\
NPT3 & Top & 5.15 & 5.00 & 3.96 & 3.78 \\
 & Bottom & 5.08 & 4.96 & 3.91 & 3.64 \\
BLT1 & Top & 5.02 & 4.82 & 3.78 & 3.91 \\
 & Bottom & 4.78 & 4.36 & 3.37 & 3.47 \\
BLT2 & Top & 4.33 & 4.44 & 3.52 & 3.53 \\
 & Bottom & 4.71 & 4.71 & 3.66 & 3.35 \\
BLT3 & Top & 4.88 & 4.89 & 3.56 & 3.69 \\
 & Bottom & 4.64 & 4.77 & 3.44 & 3.37 \\
RST1 & Top & 4.57 & 4.67 & 3.64 & 3.28 \\
 & Bottom & 5.10 & 5.27 & 3.59 & 3.40 \\
RST2 & Top & 5.29 & 5.39 & 3.38 & 3.38 \\
 & Bottom & 5.02 & 5.10 & 3.47 & 3.09 \\
RST3 & Top & 4.76 & 4.76 & 3.01 & 2.85 \\
 & Bottom & 5.24 & 4.69 & 2.86 & 2.56 \\
\hline
\end{tabular}
\end{table}

Description :NPT1 = 1 hour simulation (filler material: newspaper) ; NPT2 = 3 hours simulation (filler material: newspaper) ; NPT3 = 5 hours simulation (filler material: newspaper) ; BLT1 = 1 hour simulation (filler material: banana leaves) ; BLT2 = 3 hours simulation (filler material: banana leaves) ; BLT3 = 5 hours simulation (filler material: banana leaves) ; RST1 = 1 hour simulation (filler material: rice straw) ; RST2 = 3 hours simulation (filler material: rice straw) ; RST3 = 5 hours simulation (filler material: rice straw)
was 71.48% and 97.61% respectively. In contrast, the lowest percentage of mechanical damage in both frequency was NPT1 which were 30.95% and 26.18% respectively. Therefore, it could be concluded that newspaper as filler material was the best for papaya packaging, since newspaper is a soft material and could reduce impact between papayas or between papaya and the packaging wall.

Mechanical damage could be occured in harvesting stage, packaging, handling or transporting stage [5]. The mechanical damage could disrupt a normal biochemical reactions resulting a change of colour, odor and flavor, as well as a rapid decay. Papaya as perishable fruit have several properties like short durability, easily decomposes and easily to lose weight, so that a special attention is needed to handle it. The occurred mechanical damage in each treatment could be seen in Figures 1 to 4. The mechanical damage to papaya fruit occurred due to collisions between the fruit, the packing walls or the pressure from each fruit. Resistance to mechanical damage was determined by the shape of the epidermal cell structure, the type and the large of the base tissue and the arrangement of the carrier file system. The bruises occurred as a reaction to the pressure load from the engine vibration, the friction between products and the friction between products with the packaging. This pressure caused the cell wall to constrict, so that the water inside the cell was pushed out as a result of the tissue becoming a bruised.

Hardness is a determinant of papaya fruit freshness, a softer fruit showed a lower freshness. Transformation of papaya hardness could be seen in Table 3. The highest hardness after simulated using both frequency of 1.5 Hz and 3 Hz were 4.23 gr/mm and 4.17 gr/mm respectively in NPT1 treatment on top position in the basket. In contrast, the lowest hardness were 2.86 gr/mm and 2.56 gr/mm respectively in RST3 treatment on bottom position in the basket.

Based on Table 3, the best packaging was plastic basket with newspaper as filler material. Hardness testing was conducted by giving a compressive force to material in this case papaya. Decrease of hardness influenced by occurred weight loss and mechanical damage level. Papaya hardness was influenced by several factors including compressive force, vibration and transportation time, packaging type and filler. High compressive force during transportation caused a small papaya density inside the package which caused increase of porosity that would increase mechanical damage on papaya fruit which decreased the hardness [6]. Papaya in the bottom position on packaging arrangement would receive more compression and caused a lower hardness level.

Result for simulation using both frequency of 1.5 Hz and 3 Hz based on the analysis of variance testing showed that filler material factors was significantly different toward papaya hardness. On the other hand, the simulation length and the interaction between two factors did not show any significant difference.

4. Conclusion
After simulation with frequency of 1.5 Hz and 3 Hz, the highest percentage of weight loss and mechanical damage was in RST3 treatment, and the lowest was percentage of weight loss was in NPT1 treatment. In addition, the highest hardness was in NPT1 at the top side of packaging arrangement and the lowest hardness was in RST3 at the bottom side of packaging arrangement. The best packaging to reduce quality degradation in papaya using transportation simulation with the frequency of 1.5 Hz and 3 Hz was plastic baskets with newspaper as filler material.

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