Packaging Design of the Mangosteen for Local Transportation

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ABSTRACT

Mangosteen is one of the tropical fruit that is quite popular in Indonesia. Economically, the fruit has grew to be a potential export comodity. However, the most significant obstacle faced up by the fruit is it's damaged during transportation. The damage that accurs in the transportation process reaches to 20%. The level of damage can be significantly reduced with the use of a proper and comprehensive packaging. This research was aimed to introduce by an appropriate packaging technology especially applied for local transportation of mangosteen. This research was conducted in three stages: measurement of physical and mechanical properties of mangosteen (stage I); planning and designing packaging (stage II); testing packaging for transportation by using the simulator equals 477 km of transportation using trucks (stage III). Packaging used is designed for capacity of 8 kg and 15 kg with the two patterns arrangement of mangosteen inside package, that is FCC (face center cubic) and jumble (bulky).

Mangosteen used in this research was the quality I, with the caracteristics are: 61mm-63 mm diameter, 120 grams individual weight, and 6.53 kgf bioyield with 5.2 mm deformation. From those data of mangosteen physical and mechanical, the packaging was designed : 388 mm x 204 mm x 204 mm for the 8-kg; 388 mm x 294 mm x 244mm for the 15-kg capacity, using FCC pattern. Whereas when using jumble patterns, each of above dimension only enough for the capacity of 5.4 kg and 10.2 kg. Packaging materials used were corugated board (BC flute).

The magnitude physical damage of Mangosteen after transportation was between 1.1% - 7.9%. Type of damage on the fcc pattern was dented, and on jumble pattern was broken petals of fruit. Although the physical damage of the mangosteen on FCC pattern was higher than jumble pattern, but the damage was not on the skin tissue, which means that the damage only on the surface of the fruit. This can be seen from the decreasing rate of respiration and low weight decrease compared to the pattern of Jumble in 10 days after transportation. The rate of respiration and low weight decreasing of Mangosteen indicated that storage period is expected long.

***Keywords** : Mangosteen, packaging, trasnportation*

1. INTRODUCTION

Transportation is an important link in the mangosteen agribusiness activities. In the process of transportation, fresh mangosteen damage can be caused by environmental risks and physical risks. Physical risk cause mechanical damage (Peleg, 1985). Mechanical damage that occurs in agricultural products during transport can reach 32%-47%. Products that experienced mechanical damage will be more vulnerable to physiological and biological damage (Satuhu, 2004).

Physical risk can be minimized by the use of appropriate packaging and good handling. Accuracy packaging done through planning and design with due regard to the environment and handling during transportation and post-harvest physiological properties Mangosteen. The research aims to do the planning and design of packaging for local transportation Mangosteen using corrugated board that has bigger opportunity to be used for export packaging.

2. METHOD

2.1 Measurement of Physical and Mechanical Properties of Mangosteen

Fruit physical properties data required for packaging design is a form of geometry, the diameter and individual weight of fruit, mechanical properties data which is bioyeld and deformation values. Bioyield inform maksismum load of fruit which can be held without experiencing damage, deformation inform the Mangosteen which dented size can still be returned to original form.

2.2 Packaging Dimension Design

2.2.1 Calculate the Number of Fruits (N) in Packaging

$$N = \frac{Packaging\_Capacity\ (kg)}{Individual\_Weight\ (kg)} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (1)$$

2.2.2 Calculate Inside Dimensions of the Package

Arrangement of fruit in containers with non-symmetrical pattern

$$N = \frac{(KAxKBxKC)}{2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (2a)$$

Arrangement of fruit in containers with a symmetrical pattern

$$N = \frac{(KAxKBxKC+1)}{2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (2b)$$

Inside dimension

$$\left.\begin{aligned} Length\_Inside &= (1.41KA+0.59)xa \\ Width\_Inside &= (1.41KB+0.59)xb \\ High\_Inside &= (1.41KC+0.59)xb \end{aligned}\right\} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (3)$$

a : diameter mayor ; b : diameter minor

2.2.3 Calculating of Design Dimension (BC flute)

$$\left.\begin{aligned} \text{Length} &= \text{Length\_Inside} + 8 \\ \text{Width} &= \text{Width\_Inside} + 4 \\ \text{High} &= \text{High\_Inside} + 4 \\ \text{Flap} &= (\text{Length\_Inside} + 8)/2 \end{aligned}\right\} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (4)$$

2.2.4 Calculate of Compression Strength

$$P = 1.82xPmx\sqrt{hx\sqrt{Z}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (5)$$

2.2.5 Packaging Test in Protecting the Mangosteen whithin Transportation Process

The test is conducted by using the simulator of vibrating table with the average frequency of 3.50 Hz and average amplitude of 4.61 cm for 3 hours which is the equivalent of transportation using trucks as far as 477 km. The variables treatment were the capacity and the pattern of arragement of Mangosteen inside package. The capacity of package were 8 kg and 15 kg, with arrangement of FCC and jumble pattern. Mangosteen was packed with patterns jumble, wrapped by stereo foam net for individual fruit. Mangosteen quality parameters measured after the transport were visual physical damage, the rate of respiration, and weight lost.

3. RESULTS AND DISCUSSION

3.1 Physical and Mechanical Properties of Mangosteen

Mangosteen geometry is the ball, because the diameter ratio of major and minor approaches the value 1 (1.01), so only need one diameter data. Mangosteen used in the research was the quality I, with the diameter range from 61-63 mm with a uniformity level of 98%; the average weight of individual fruit was 120 grams with the 95% level of uniformity. The uniformity of the fruit was crucial factor in the arragement of fruit packaging with FCC pattern. Bioyield Mangosteen was 6.53 kgf and deformation was 5.2 mm. The form of the Mangosteen damage when a load was greater than bioyield is fragment out in Figure 1.

Figure 1 Form of the Mangosteen fruit damage when a load greater than bioyield

3.2 Plan and Design Packaging

3.2.1 Packaging Plan

Packaging is planned using the method of handling normally carried by human. Based on market observations two models will be planed for a capacity of 8 kg and 15 kg. Transportation was planned to use truck transportation to the variable distance representing the distance between the centers of production to the distribution centers or shipping center for export purposes.

3.3 Designing Packaging

3.3.1 Inside Dimension

The length, width and height of the package was calculated by equation 3. With combination of the value of KA, KB and KC had maximum space efficiency. Results for the inside dimension were presented in Table 1.

Tabel 1 Inside dimension of packaging

Parameters		Capacity	
		8 Kg	15 Kg
Number of fruits in package		64	120
The amount of fruit in a row (Fruit)	Length direction (KA)	8	8
	Width direction (KB)	4	6
	High direction (KC)	4	5
Inside dimension (mm)	Length (A)	371	371
	Width (B)	195	283
	High (C)	197	238
Volume(cm^3)	Fruit in package	8181.2	15339.8
	Packaging	13126.8	23384.4
Packing density (%)		62	65.6

3.3.2 Dimensional Design

Using equation 4, calculation of design dimensions for each capacities was presented in Table 2.

Table 2 Design dimensions for the 8-kg capacity and the 15 kg capacity

Packing Capacity	Length (mm)	Width (mm)	High (mm)	Flap (mm)
8 Kg	388	204	204	104
15 Kg	388	294	244	144

With the consideration that the Mangosteen requires adequate circulation inside the package, there for the packaging was made some ventilation. The ventilation made was ventilation circle wich that total area 3% of the total surface of the packaging. Packaging design are presented in Figure 2.

Figur 2 Packaging for 8 kg and 15 kg capacity

3.3.3 Compression Strength of Packaging

By having the design dimensions of packaging, calculatation of the perimeter of the package were done. The data used to calculate the compression strength were equation 5. To validate the results of testing was conducted by compression test using a Universal testing mechine. Comparison between the calculation and test results are presented in Table 3.

Tabel 3 Comparison between the calculated and test Compresion Strength

Capacity	Result of Calculation	Result of Test	Accuracy
8 kg	201.01	204.00	98.5%
15 kg	216.47	256.00	85,2%

The results above show that equation 5 can be used to estimate the compression strength of packaging with 90% accuracy level.

3. 4 Transportion Test using a Simulator

3.4.1 Arrangement of Fruit in Package

According to the results of the design, up to 8 kg capacity, as many as 64 Mangosteen were arranged : 8 fruits at length direction, 4 friut at wide direction, and the 4 fruit at high direction (4 layers). Whereas capacity up to 15 kg, as many as 120 Mangosteen were arranged: 8 fruit at length direction, 6 friut at wide direction, and the 5 fruit at high direction (5 layers). The FCC arrangement pattern of the capacity of 15 kg is presented in Figure 3.

Figure 3 FCC arrangement pattern of the capacity of 15 kg

This research were compared two fruit arragement models for packaging, the FCC model and jumble (bulky). The Comparison of packaging capacity results of the two pattern designs are presented in Table 4.

Tabel 4 Comparison of packaging capacity for FCC pattern and jumble

Packaging Dimension (mm)	FCC pattern	jumble pattern
388 x 204 x 204	8 kg (64 fruit)	5.4 kg (44 fruit)
388 x 294 x 244	15 kg (120 fruit)	10.2 kg (80 fruit)

The results in Table 4 shows that the amount of fruit that can be packaged with the pattern of fcc was 30% more than the fruit was packed using jumble patterns in the same package dimensions.

3.5 Changes in the Quality of Post-Transport

Changes of the quality of post-transport Mangosteen show that the packaging had capability in protecting and maintaining the quality of Mangosteen.

3.5.1 Physical Damage

Mangosteen is considered of damaged if found dent, broken petals of fruit, shaft broke, and broken skins. The level of total physical damage in the Mangosteen that are packed with fcc pattern (3% -7%) was larger than jumble pattern (1% -3%). The type of the most damage in fcc pattern was dented, while at the jumble was broken petals of the fruit. The low physical damage on the jumble pattern, caused by the mangosteen wrapped with stereo foam net while the fcc pattern was not done. This treatment showed that the additional treatment with a wrapping of stereo foam net would provide more effective protection.

3.5.2 The Rate of Respiration

The rate of respiration of fruit is a good indication of the fruit store ability. A high rate of respiration is usually accompanied by a short-life storage (Pantastico, 1986). Respiration rate of post-transport Mangosteen are presented in Table 5.

Table 5 Respiration rate of each treatment

Treatment	Respiration Rate of CO_2 (ml/kg hour)	Respiration Rate of O_2 (ml/kg jam)
FCC pattern (8 kg)	29.484	68.984
Jumble pattern (5.4 kg)	31.007	69.561
FCC pattern (15 kg)	26.302	66.737
Jumble pattern (10.2 kg)	29.032	67.519

From these data show that the rate of respiration mangosteen with fcc pattern are lower than the jumble. This indicates that the physical damage of mangosteen are not caused to the damage of the skin tissue of fruit. While the Jumble patterns show that the rate of respiration was higher. It is possible frequent collision between fruit in the package that lead to tissue damage, although physically not appearance.

3.5.3. Lost Weight

Lost weight on agricultural products is very harmful, because the commodities is sold by weight. In addition, lost weight affects the physical appearance, texture, and nutritional values. The amount of weight lost during the 10-day mangosteen post-transport is presented in Table 6.

Tabel 6 Mangosteen weight lost per day during 10 days post-transport

Treatment	Lost Wight per Day (%)
FCC pattern (8 kg)	1.09
Jumble pattern (5.4 kg)	1.20
FCC pattern (15 kg)	1.05
Jumble pattern (10.2 kg)	1.11

The data in above table indicate that the pattern of mutually support the relationship between respiration rate and the rate of lost weight. The FCC pattern better results eventhough the physical damage visually higher than arrangement jumbel pattern. This means that the fcc pattern could be selected as the better pattern of Mangosteen in the packaging arrangement to reduce the physical damage coused by wraping net stereo foam on each individual fruit. Capacity of 8 kg or 15 kg was not significantly affect the level of damage, therefore both capacities couldn be chosen according to market demand.

4. CONCLUSION

1. Packaging made from corrugated board with flute BC, comprehensive enough for local transportation package that was developed for export purposes.

2. Pattern mangosteen efficient arrangement is fcc pattern (30% more than jumble in the same package dimensions)

3. Packaging capacity of 8 kg and 15 kg showed no significant difference in terms of decreased quality of mangosteen after transportion, meaning the two capacities can be selected in accordance with market needs. Packaging dimensions (with fcc pattern) for the 8-kg capacity is: 388 mm x 204 mm x 204 mm anf for 15 kg capacity is: 388 mm x 294 mm x 244 mm

4. To reduce the physical damage can be done by wraping of stereo foam net each individual fruit.

5. ACKNOWLEDGEMENT

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