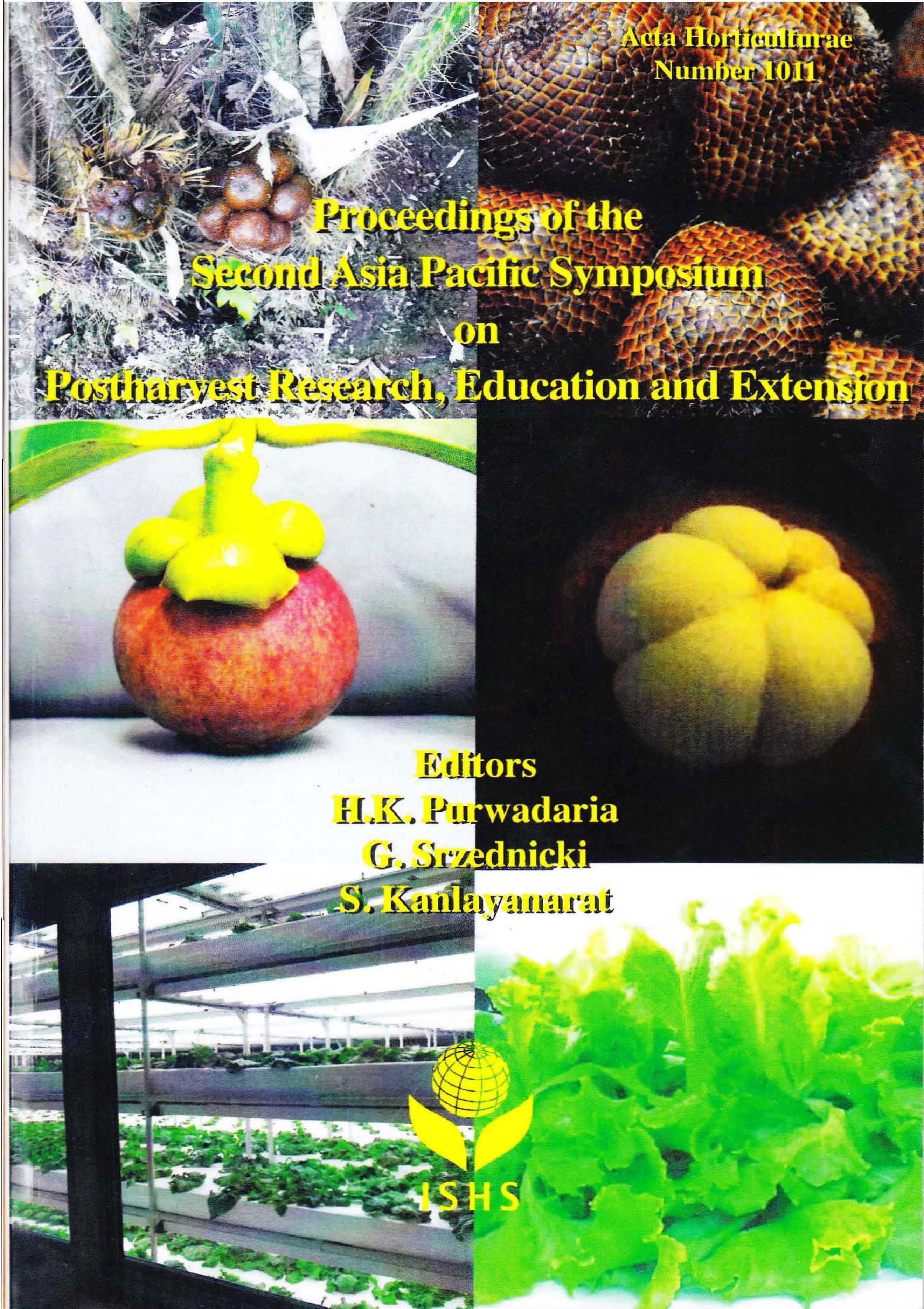
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Application of Semi-Cutting and Waxing in Low Temperature Storage of Mangosteen

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Keywords: mangosteen, semi-cutting, waxing, peel hardening

Abstract

Peel hardening of mangosteen fruit is one of the problems in low temperature storage and it makes it difficult to open them before consumption. One attempt to solve this problem is the application of semi-cutting treatment before storage of the fruits. Semi-cutting application requires a combination with waxing and cold storage to prevent faster quality deterioration because it provides a way for microorganisms to enter the fruits, and increases the respiration as well. Waxing helps to cover the pores, and especially in this case, the cut opening, of mangosteen fruit and cold storage helps to slow down the respiration and metabolism. The purpose of this research is to study the effect of semi-cutting treatment in combinations with waxing treatment to increase shelf life, and provides easier opening of the fruits at the end of long storage. Treatment of semi-cutting was conducted on two depths, 3 and 5 mm whereas waxing treatment was conducted with 2 concentrations, 6 and 10%. Mangosteen fruit which has been semi-cut and waxed was stored at 8 and 27°C for 60 days. It was observed that application of semi-cutting 5 mm and waxing 6% in mangosteen fruit stored at 8°C provided easy opening until 33 days of storage while maintaining fruit quality, which is the best result compared with other treatments, because the treatment was able to reduce the peel hardening.

INTRODUCTION

Mangosteen (*Garcinia mangostana* L.) is one of many exotic fruits from tropical areas including Indonesia. Demand for mangosteens in Indonesia continues to be high every year, both from local and export market. Quality of harvested mangosteen should be maintained, or even improved, whenever possible, through the application of postharvest handling. Low temperature storage is one of the technologies that is widely used in postharvest handling of fresh products. Low temperature is able to prolong shelf life of fresh products by decreasing physiological activity of the product such as respiration, transpiration, and ethylene production as well as inhibiting mould development during storage. However, some problems associated with low temperature storage of mangosteen such as green colour on stem and calyx turning them into brown, and peel hardening that makes it difficult to open the fruit for consumption after long-term storage (Sjaifullah et al., 1998). According to Qanytah (2004), peel hardening happens during low temperature storage and is a serious problem for mangosteens because their thick peel can be very hard to open if it loses water through transpiration process. In some cases, the stored fruits are impossible to open without any tool at the end of storage.

One attempt to overcome this problem is through the application of semi-cutting, which is done by half-cutting mangosteen peel along its equator line to facilitate easy opening even after the peel gets dry and hard. However, peel cutting, even only a part or maximum half of its depth, causes injury that creates a path for microorganisms to enter the fruit and start deterioration processes. To minimize the effect of semi-cutting, fruit will be coated using a natural wax. Waxing is very important for fruits and vegetabl especially when small injuries are present on the surface of the products. Waxing prever fruits and vegetables from excessive water loss through respiration and evaporati happening during storage. The aim of this research was to find out how well semi-cutti facilitates opening of mangosteen fruits after long storage period and how effective waxing prevents quality deterioration processes by microorganisms.

MATERIALS AND METHODS

Mangosteen fruits used in the experiment were those harvested in the second sta maturity level. Second stage maturity level in mangosteen can be recognized through pe surface that started to change its color from yellow to red. The fruits were harvested frc a farmer's orchard in Karacak village, Leuwiliang sub-district, Bogor District, West Ja Other materials used in the experiment were bee wax emulsion, distilled water and oth chemicals used in laboratory analysis. The equipment used were a cold store, a compu controlled electronic universal testing machine, a constant temperature oven, chromameter, a hand refractometer, an analytic balance, and other utensils.

The preliminary experiment was conducted to determine how deep t mangosteens need to be cut for facilitating easy opening when the peel gets dry and ha By measuring peel thickness from about 40 fruits, the minimum, maximum, and avera peel depth were obtained. These data then were used to determine the optimum depth semi-cutting, not too shallow because it will have no effect to opening force, and not t deep because it will cause breakage to the fruits during handling and storage.

In the main experiment, 1200 pieces of second stage maturity mangosteen fru were selected and used. The fruits were selected from the same harvest time to be fr from defects, injuries, and diseases contamination, with the size ranges from 5.5 to 6.0 c in diameter and from 80 to 100 g in weight. The fruits were divided into three groups, be semi-cut with 3 mm depth, semi-cut with 5 mm depth, and without semi-cutting. T samples then were soaked into natural bee wax. Each group was soaked into 6 and 1C bee wax emulsion concentration for 60 s. Each different treatment was then divided ir two groups, one group to be stored at 8°C and the other at room temperature (27°C Observations were conducted for eight weeks with the observation schedule was start on day-0 and then continued to day-6, 12, 18, 23, 28, 33, 37, 41, 45, 48, 51, 54, 56, 5 and day-60 during the storage period. In the observation, 96 fruits were observed for ea treatment. Sample weight loss, peel hardness, peel moisture content, total soluble sol and fruit flesh colour were measured.

RESULTS AND DISCUSSION

From the preliminary experiment, the minimum and maximum thickness mangosteen peel were 3.86 and 8.10 mm with an average thickness of 5.91 mm. Based this observation, semi-cutting was then determined as a treatment in two different dept to observe the effect, 3 and 5 mm depth from the peel surface. During the 60-day peri of storage, some quality attributes of fresh mangosteen were observed, and the results a discussed below.

Weight loss is one of important factors that contribute to quality change horticultural products. Fruits lost their weight because of some water inside the fruits gc out through respiration and evaporation. Water loss also happens during the ripeni process, since this process generates heat that makes the evaporation rate even higher, a this can be an indicator to physico-chemical changes that affect fruit quality (Sihombi 2010). Weight loss increases with storage time, and the higher the storage temperatu the bigger is the weight loss. In the experiment conducted within the current study, at t end of storage (day-60), the highest average weight loss was 74.05%, observed in t fruits stored at room temperature (around 27°C), while the lowest average was 13.89 observed in the fruits stored at 8°C. At 8°C storage temperature as seen in Figure 1a, t range of average weight loss for all treatments are 13.89-23.48% after 60 days stora Among them, the highest weight loss (23.48%) was experienced by mangosteen w

5 mm depth semi-cutting and soaked in 6% bee wax emulsion, while the lowest (13.89%) one observed from the fruits without semi-cutting and soaked in 10% bee wax emulsion. Change of weight loss for mangosteen stored at room temperature is shown in Figure 1b.

Weight loss of mangosteen after long period storage is associated with the loss of water through respiration that generates heat to evaporate some water, especially water in the peel which is close to the surface, and evaporation due to high storage temperature and low humidity. So, change in moisture content during storage was also investigated. From the obtained results, it is understood that the highest moisture content (high in freshness) after 60 days storage was observed from fruits stored at 8°C without semi-cutting and 10% bee wax emulsion, which was 59.64%. The lowest moisture content (low in freshness) was observed from fruits stored at room temperature with 5 mm depth semi-cutting and 6% bee wax emulsion, which was 11.43%. The data show that low temperature storage slows down water loss through evaporation from fruits surface, while semi-cutting treatment fastens the rate of water loss as it was predicted, and finally, wax coating slows down the rate of water loss and improves the surface protection. The changes in moisture content of mangosteen peel are shown in Figure 2a and b. It is clearly noticed that at 8°C, moisture content decreased in slower rate if compared with the rate of those stored at room temperature.

The results show that 5 mm depth semi-cutting caused higher rate of water loss because the rate of evaporation increased as some part of fruit surfaces was damaged, for storage at all temperatures. Semi-cutting caused damage of epidermal layer of the mangosteen peel, which is an outer protection layer for the fruit, where cuticle plays an important role in water evaporation. The cuticle was damaged and caused water evaporation in that part. According to Muchtadi et al. (2010), gas exchange, water loss, pathogenic, infiltration of chemical substances, heat resistance, mechanically injuries, evaporation of essential oils and other changes begin from peel surface.

The results also show that fruits stored at 8°C in all treatments, experienced lower increase in peel hardness during the storage as compared to those stored at higher temperature. The lowest increase in peel hardness (0.562 kN) observed from mangosteen stored at 8°C with 5 mm depth semi-cutting and 6% bee wax emulsion coating. The highest increase in peel hardness (2.072 kN) was observed in fruits stored at room temperature without semi-cutting and with 10% bee wax emulsion coating (Fig. 3a and b). It can also be mentioned here that, when the fruits are stored at 8°C, the increase of peel hardness started on day-48, however the increase in hardness happened earlier (on day-33) when they were stored at room temperature.

Another quality attribute that was affected by chemical changes in the fruit during storage period is total soluble solid (TSS) which contributes to taste of mangosteen, a specific combination of sweet and sour (Muchtadi et al., 2010). From a measurement on day-0, TSS of the fruits was found to be around 17.5-19.0°Brix for all treatments. During the storage period, TSS have gradually decreased with time, and samples that were stored at 8°C showed smaller decrease in TSS compared to these stored at room temperature, as shown in Figure 4. Among the treatments, the highest TTS value after 60 days storage (lowest rate of quality deterioration in TSS content) was observed in samples stored at 8°C with 5 mm depth semi-cutting and 10% wax emulsion coating, with final TSS value of 18.00°Brix, while the lowest TSS value (lowest rate of quality deterioration in TSS content) was observed in samples stored at 8°C with 3 mm depth semi-cutting and 10% wax emulsion coating, with final TSS value of 14.44°Brix. In general, TSS values were gradually decreased during storage period as shown in Figure 4a and b.

Determining if the flesh is damaged due to improper storage can be done by pressing mangosteen peel. The damaged flesh tends to be harder than the normal one so we can know it when we press it by our fingers, and when we open the fruit, the flesh has transparent colour instead of white in normal flesh, and its texture changed from soft into hard like an ice flake (Suyanti and Setyadjit, 2007). According to Suyanti and Setyadjit (2007), change in fruit flesh is reflected by change of peel characteristics, in this case increase of peel hardness. Bright white colour flesh at beginning of storage period turned into dull white colour at the end of storage. During storage at 8°C for 60 days, tl lightness (L*) value of fruit flesh tends to decrease, while chroma values (a* and b*) tei to increase, indicating there was a chemical reaction within the flesh. The highe lightness value was observed from mangosteen stored at 8°C, 5 mm depth semi-cuttin and 10% bee wax emulsion. However, the same treatment also gave highest value f green to red colour change (a*) and blue to yellow color change (b*). During storage room temperature, the change in lightness and chroma took place even faster, and most fruits stored at room temperature experienced severe deterioration so they were n suitable for eating. For this reason, the data for the samples stored at room temperatu were recorded only until day-18.

As can be seen in Tables 1 and 2, semi-cutting tends to prevent peel fro becoming very hard so it can facilitates easy opening after long period storage at lo temperature. This phenomenon was measured using a universal testing machine to recoi the force that was needed to open the fruits.

CONCLUSIONS

Semi-cutting treatment can contribute to easier opening (need smaller force open the fruit) after long storage at low temperature, however semi-cut peel affects tl rate of deterioration of some quality parameters such as weight loss, moisture content ar flesh colour. At 8°C storage semi-cutting can slow down peel hardness development unt day-37 of storage, while at room temperature it can only keep good quality fruits unt day-18.

A combination of 5 mm depth semi-cutting with 6% bee wax emulsion was four to best contribute to easier opening while preserving quality attributes by reducing weigl loss and maintaining moisture content and flesh colour. With 5 mm depth semi-cuttir and 6% bee wax coating, mangosteen was still easy to open with 0.189 kN force aft 33 days storage at low temperature.

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Tables

Table 1. Quality attributes of mangosteen on day-37 when stored at 8°C.

Treatment		Force	Peel MC	TSS	Change of flesh color		
Semi-cutting	Waxing	(kN)	(%)	(°Brix)	ΔL*	Δa*	Δb*
3 mm	6%	0.46	58.98	17.53	-6.05	1.97	-0.37
3 mm	10%	0.42	54.21	18.07	-5.00	0.06	-1.07
5 mm	6%	0.27	60.18	19.30	10.47	-1.05	-2.37
5 mm	10%	0.37	54.23	18.00	-7.76	0.77	-2.52
Without	6%	0.35	59.64	17.97	-3.30	2.18	-3.19
Without	10%	0.29	52.06	18.20	5.96	-0.20	-2.98

Table 2. Quality attributes of mangosteen on day-18 when stored at 27°C.

Treatment		Force	Peel MC	TSS	Change of flesh color		
Semi-cutting	Waxing	(kN)	(%)	(°Brix)	ΔL*	Δa*	Δb*
3 mm	6%	0.73	42.67	17.07	-15.68	3.89	0.94
3 mm	10%	0.77	46.67	12.77	-23.08	3.62	-2.16
5 mm	6%	0.62	52.67	14.92	-24.58	3.57	-3.63
5 mm	10%	0.57	51.61	12.23	-25.05	1.01	-3.70
Without	6%	0.83	45.32	14.68	-12.32	1.22	-3.41
Without	10%	0.57	37.10	18.10	-19.86	2.82	1.47

Figures

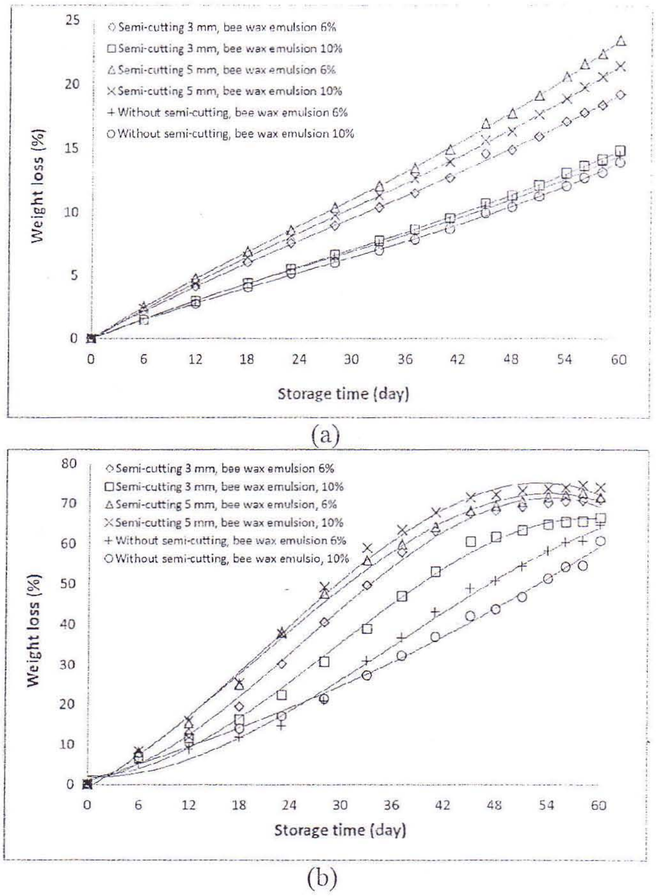


Fig. 1. Weight loss on mangosteen stored for 60 days at 8°C (a) and at 27°C (b).

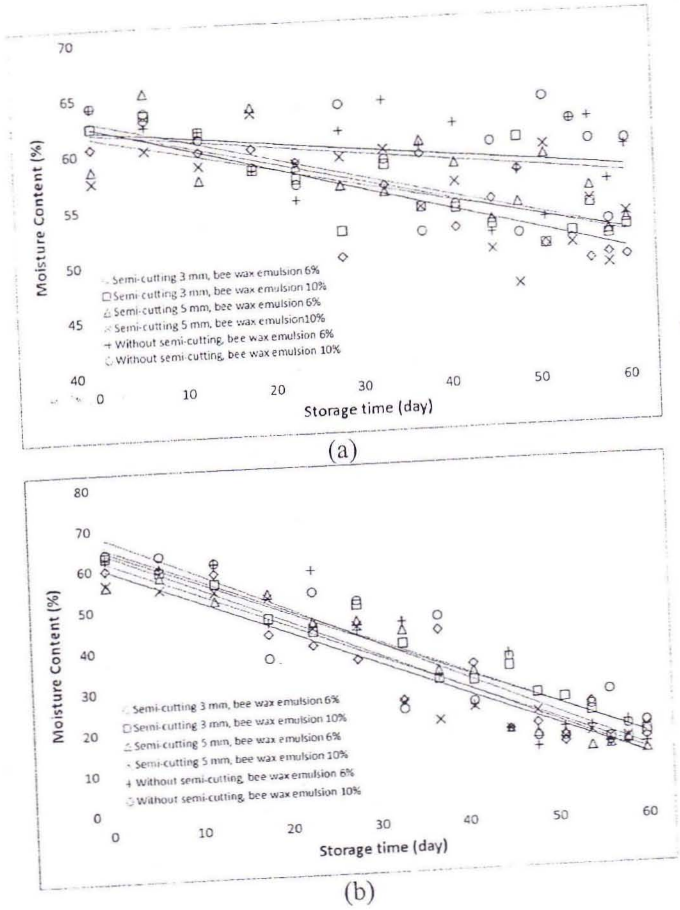
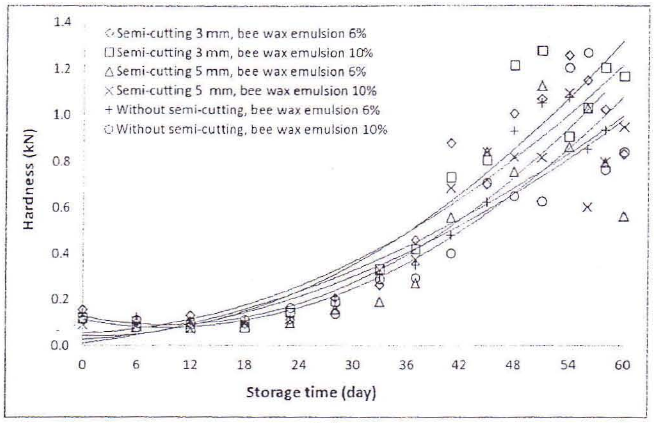
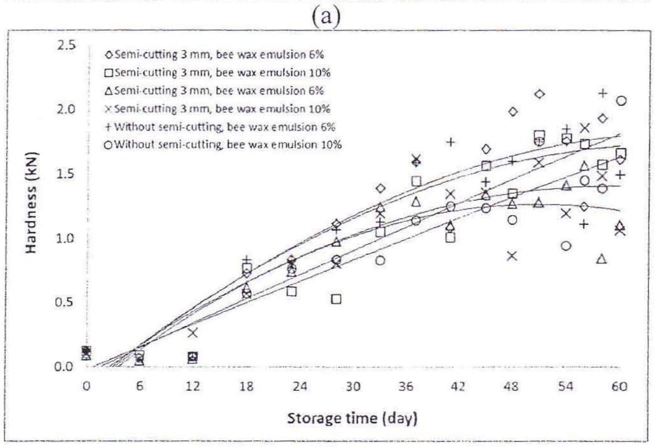


Fig. 2. Change in moisture content for mangosteen stored at 8°C (a) and at 27°C (b).



(a)



(b)

Fig. 3. Change in peel hardness for mangosteen stored at 8°C (a) and at 27°C (b).

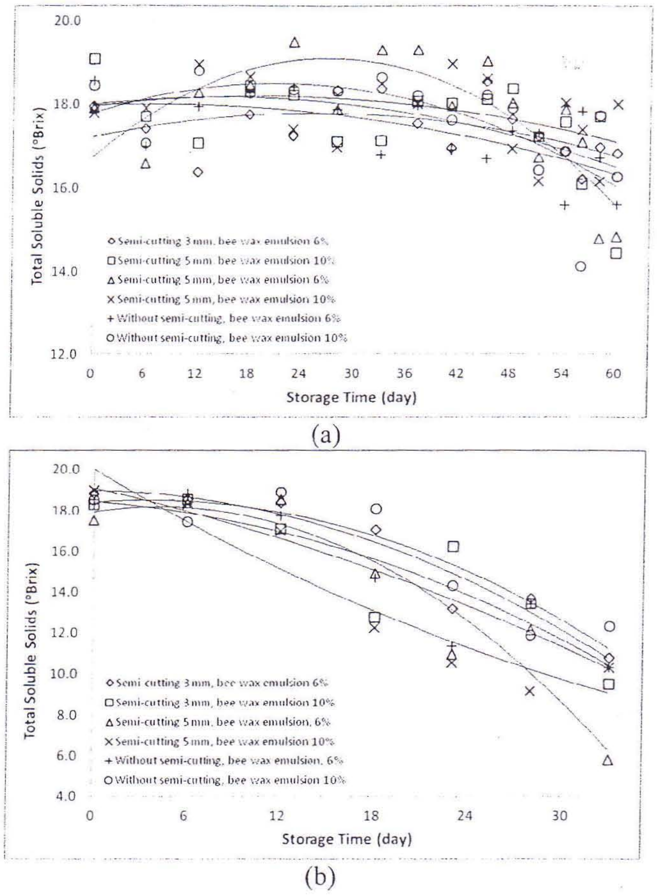


Fig. 4. Change in TSS value for mangosteen stored at 8°C (a) and at 27°C (b).