Kasetsart J. (Nat. Sci. Suppl.) Vol. 25, : 119-125 (1991)

Postharvest Physiology of Durian Pulp and Husk

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ABSTRACT

Pulp and Husk of mature (110±3 days after anthesis) 'Chanee' durians were separated from the whole fruit, and measured for their respiration and ethylene production. It was found that most of the activities occurred in the husk. Rate of respiration and ethylene production of the husk at the peak were 550 mg CO_2/kg.hr. and 170 µl/kg.hr., about 5 and 100 folds respectively, to that of the pulp. Other ripening processes, such as softening and starch conversion to sugar in the pulp continued to proceed after separation from the fruit, but the rate depended on the atmospheric composition surrounding the pulp. At 5°C, whole durian showed chilling symptom, as husk discoloration, within 3 weeks or only one week when the fruit was transferred to room temperature. At this temperature the pulp inside also ripened abnormally. However, ripening processes of the pulp, already separated from the fruit, continued upto the eight weeks, and slight chilling injury showed up after the fourth week at 5°C.

INTRODUCTION

Buying and selling durian pulp (with seed) is becoming more popular in Thailand. Durian is a big fruit weight normally 2-3 kg, which makes it quite expensive for a consumer to buy the whole fruit. The fruit is also difficult to dehusk, particularly at the stage when durian is not yet fully mature. Thai consumers prefer durian at this stage which has quite firm flesh, mild odor, but already tested sweet. Durian is also the most difficult fruit to judge, by the consumers, for its maturity as well as ripening stage. Buying the whole fruit means having a chance to get immature fruit for upto 30% (Jarimopas et al., 1987).

Durian for export also faces difficulty due to its low pulp to husk ratio (about 1:2) which makes transportation of durian very expensive. In addition, durian odor can cause quite annoying problem during shipment by airplane, along with the passengers. Many exporters choose to deal with frozen durian instead of the fresh one.

At the present time, exporting of durian pulp without its husk is being seriously considered. Praditduang (1986) reported that durian pulp could be stored at 4°C for upto 40 days, while the whole fruit could be stored at the same temperature for only 20 days. In other commodity, however, partially processed fruit or vegetables usually had shorter storage life than the intact ones due to the wound during the preparation. (Bolin et al., 1977; Ponting et al., 1972; Rosen and Kader, 1989).

Salunkhe and Desai (1984) reported that durian could be stored at 4-5°C for 5 weeks. However, Tongdee et al. (1990) reported that storage at 12°C or lower caused chilling injury. Works in our laboratory also found that durian must be kept at 15°C or higher to avoid chilling injury. Considering the report by Praditduang (1986), it is possible that the pulp which were seperated from the fruit might behave differently from that inside intact durian due to their different surrounding atmospheric conditions.

In this paper we reported the ripening characteristic of durian pulp and husk separately, including respiration, ethylene production, quality changes, and sensitivity to low temperature.

MATERIALS AND METHODS

Durian cultivar "Chanee" aged 110±3 days after anthesis were harvested from a commercial

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orchard in Klang district Rayong province and transported to Kamphaengsaen campus in the same day. All experiments were started in the next morning.

Experiment I. Respiration and Ethylene production. Each durian weight about 2.5 kg were kept in a 10 l metal container having air continuously flow through at about 1.8 l/min, in order to kept CO_2 concentration inside the container below 1%. A set of four durians (1 fruit = 1 replication) were kept inside these containers for 7 days. Other sets were kept for only 1,2 or 3 days, then the fruit were removed and dehusked to take out the pulp. The husk were put back to the containers, while the pulp were placed in glass jars, 4 l capacity, having air flow at 200 ml/min. Respiration and ethylene production were measured by measuring CO_2 and C_2H_4 from the air outlet of each container or jar using Claypool and Keefer (1942) method and by a GC (Shimadzu R1A) equipped with FID detector and Porapak Q column. All fruit were kept at 25-29°C.

Experiment II. Quality of durian pulp under different atmospheric condition. Durian pulp were suparated from the fruit and (a) kept in glass jars as in the first experiment, 400 g/jar; (b) placed on foam tray and wrapped with PVC stretch film, 20 µm thick; (c) as in b plus 5 g of pasteur of paris tablets soaked with saturated $KMnO_4$; (d) as in b and contained 2 ml of 1,000 ppm ethephon, dropped on a piece of tissue paper. 100 ppm C_2H_4 was obtained at the beginning of the experiment. Intact durians were used as a control (e). All treatments have 4 replications (4 jars or packages) and were kept at 25-29°C.

Concentration of CO_2 and C_2H_4 in the atmosphere surrounding durian pulp were checked by TCD and FID GCs having silica gel and porapak Q column, respectively. The gas samples were draw directly from the air outlet (treatment a) or from the package by inserting needle through the plastic film and sealed with scotch tape afterward (treatment b-d) or by drawing gas sample from the whole fruit under water, by insert the needle into the empty space around the pulp. Durian pulp were evaluated for firmness using a firmness tester with 5 mm diameter plunger head; starch content by the AOAC's method (1984); soluble solids content (SS) by blending one part of the pulp with 3 parts of water, centrifuged and read the SS of the solution with a hand refractometer then calculated for the soluble solids content of the pulp.

Experiment III. Storage at 5°C. Intact fruit or durian pulp separated from the fruit were held at 5 ±1°C. A number of durians were taken out to room temperature (25-29°C) every week for upto 8 weeks. Half of them was evaluated immediately after removal, the other half was checked 3 days after. They were evaluated for appearance and other quality changes similar to that in experiment II.

RESULTS

Experiment I

Respiration and ethylene production of durian were that of the climacteric type (Fig. 1a). Peaks were about 450 mg CO_2/kg.hr. and 36 µl C_2H_4/kg.hr., respectively. Once durian were dehusked, it was found that the husk and the pulp bahaved differently. For respiration, the husk had about the same rate as in the whole fruit or a little higher (Fig. 1b-d). The rate was about 2-5 times to that of the pulp, which tended to decline continuously.

Durian that were dehusked after one day in storage (two days after harvested) were discarded on the fifth day due to the appearance of fungus on the surface (Fig. 1b). These fruits were dehusked by knife, since the dehiscence zone along the suture at the middle of each locule had not yet been weaken, causing extensive wounding to both the husk and the pulp.

For ethylene production, if durian were dehusked after one day in storage, ethylene production of both the husk and the pulp were immediately much higher than the whole fruit before dehusking (Fig. 1b). Ethylene production continue to increase in the husk while that of the pulp reached the peak soon after dehusking and then decline. When durian were dehusked later on, the rate of ethylene production in the pulp remained at a very low level until the end of the experiment. However, ethylene production in the husk started up at about the same level as in intact fruit, reached the peak at about 170 µl C_2H_4/kg.hr. in about 3 days then declined (Fig. 1c-d).

Experiment II

CO_2 concentration in the whole fruit was about 2-4% during the first few days, similar to that found in the jar (Fig. 2a), then increased to about 8% and declined. Inside the foam tray, CO_2 accumulated to 9-11%, but in the package containing $KMnO_4$ CO_2 was only about 5% during the first 3 days before increased to 9% later on. With ethephon enclosed, however, CO_2 could not be detected on the first day, but increased to 6% on the third day and to about 9% on the fifth day.

Ethylene concentration inside durian fruit was about 2-3 ppm, while it was 2-5 ppm in the jar (Fig. 2b). Inside foam tray ethylene was 2 ppm on the first day, increased to 6 ppm on the third day then declined to 1 ppm at the end of the experiment. With ethephon, ethylene dropped from about 100 ppm at the beginning to 60 ppm after one day, then dropped to 17 and 4 ppm after 3 and 5 days, respectively.

Firmness of the durian pulp in intact fruit declined with time from 4.2 kgf. after 1 day in storage to about 1 kgf. after 3 days in storage (Fig. 3a). Durian pulp in the jar softened very fast and it was terminated due to fungal appearance. For those in foam tray wrapped with PVC film the softening was delayed. The use of $KMnO_4$ could delay the process a little further. However, ethephon which generated 100 ppm of ethylene inside the package on the first day did not enhance ripening or overcame the effect of wrapping.

Soluble solids content of the pulp of intact fruit was 17% on the first day in storage and continued to increase to 27% on the seventh day (Fig. 3b). Soluble solids of the pulp in the jar was about the same as that in intact fruit. This increase in soluble solids content was delayed in durian pulp packed in the foam tray.

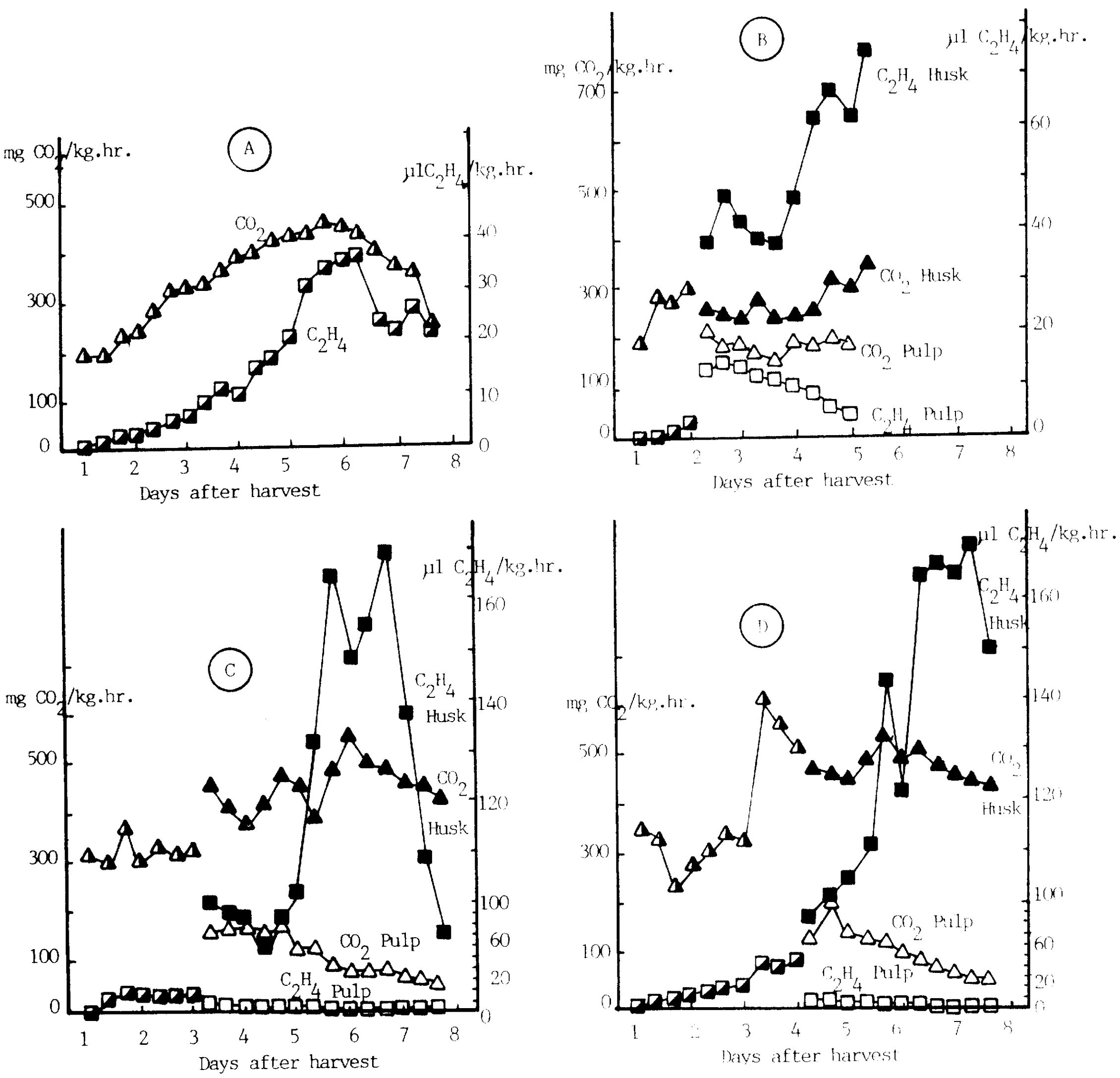

Figure 1 **Respiration and ethylene production of "Chanee" durian : A = whole fruit (▲,◪) B,C and D = pulp (△,□) and husk (▲,■) separated from the whole fruit on the second, third and fourth day after harvest, respectively**

$KMnO_4$ could also delay the increase in soluble solids content for the first 3 days, but after that the level was closed to that without $KMnO_4$. Treatment with ethephon, however, cannot enhance the increased in soluble solids. Starch content declined during the storage in concomitant with the increase in soluble solids (data not shown).

Experiment III

Ripening of the durian pulp intact fruit and that separated from the fruit behaved differently under storage at low temperature. Chilling was observed on the husk of durian fruit after only a few days at 5°C. After one week thegroove between spines has already became black all over the fruit. After 3 weeks the

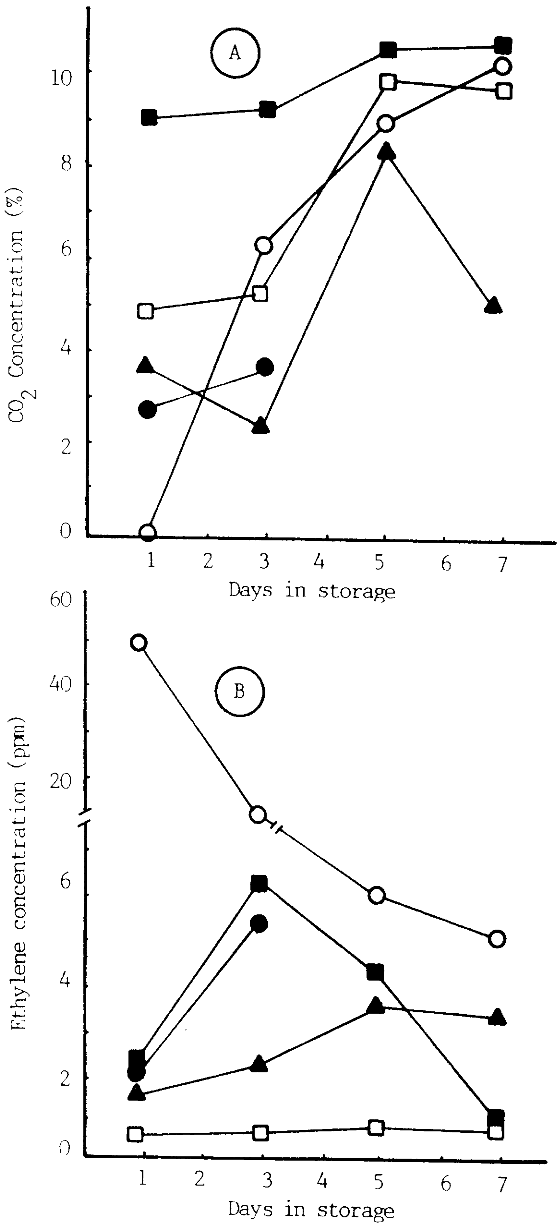

Figure 2 CO_2 (A) and C_2H_4 (B) concentrations in intact durian (▲)
in jar containing durian pulp (●)
in foam tray containing durian pulp (■)
in foam tray + pulp + $KMnO_4$ (□)
and in foam tray + pulp + ethephon (○)

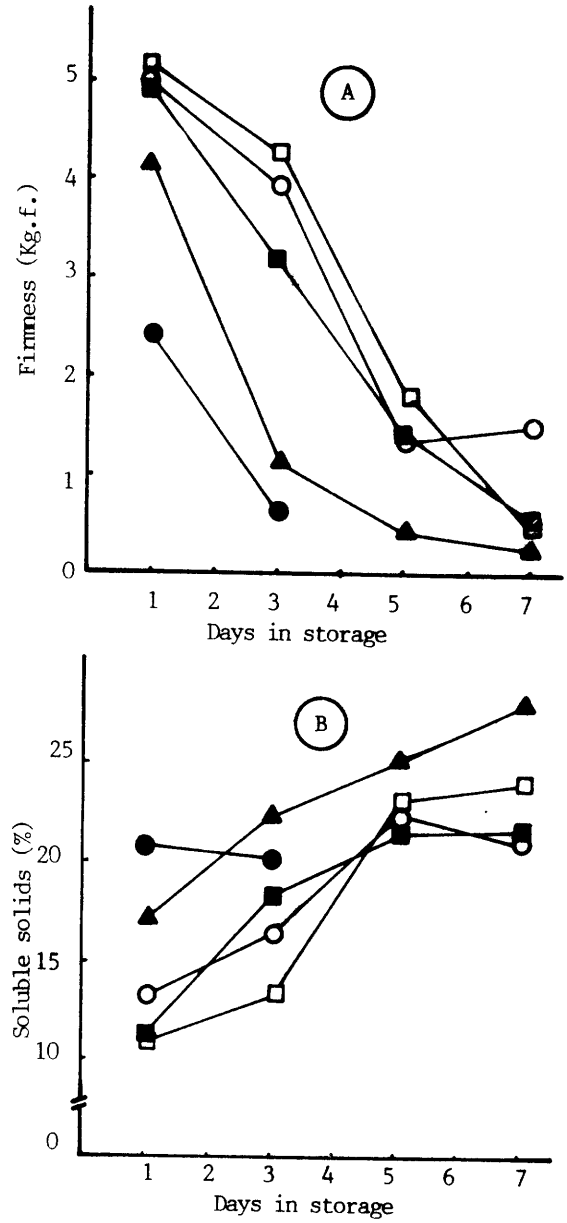

Figure 3 Firmness (A) and soluble solids content (B) of durian pulp from intact fruit (▲),
of pulp stored in jars (●),
of pulp in foam tray (■),
of pulp in foam tray + $KMnO_4$ (□),
and of pulp in foam tray + ethephon (○).

whole surface were brown or black particularly once removed to room temperature. For the pulp, chilling symptom could be found at the base of each seed where it attached to the fruit axis. This was also found in separated pulp, but only after 4 weeks of storage.

Firmness of durian pulp at the begining of the experiment was 3.4 kgf. and dropped to 0.6 kgf. after

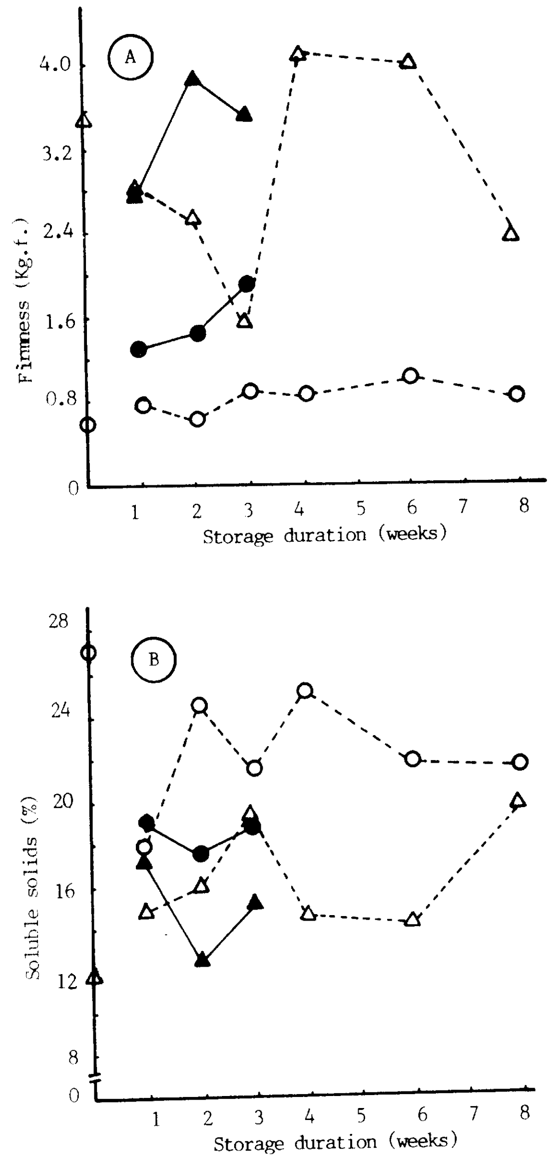

Figure 4 Firmness (A) and soluble solids content (B) of durian pulp, from whole fruit (dark marks) or from pulp only (blank marks), stored at 5°C. The measurements were made immediately at the end of the storage periods (▲,△), or 3 days after transferred to room temperature (●,○).

3 days at room temperature (Fig. 4a) At 5°C storage, durian firmness remained high, if measured immediately after removal to room temperature. However, 3 days after the removal, the firmness reduced to 1.2-1.6 kgf., which was still higher than that found in the control intact fruits after harvest. Firmness of the pulp which was removed from the fruit dropped during the first 3 weeks then increased before dropped down again. Once transfered to room temperature and evaluated 3 days later, the firmness dropped to the level similar to that of the control fruit.

Soluble solids of durian at harvest was 12% and increased to 27% after 3 days at room temperature (Fig. 4b). Soluble solids content of the pulp in intact fruit was around 12-18% during storage at 5°C, and increased to 18-19% when transfered to room temperature for 3 days. In contrast, soluble solids of the pulp which was separated from the fruit increased from 14-19% during storage at 5°C to 21-25% after 3 days at room temperature, closed to the level of the control fruit.

DISCUSSION

Rates of respiration and ethylene production clearly showed that durian was a climateric fruit, in agreement with that reported earlier by Tongdee et al. (1990). The rates also varied with cultivars, Monthong, another important cultivar in Thailand, had only about half the activity of Chanee cultivar reported in this experiment. The ripening processes of Monthong were also much slower (Booncherm, 1989). Chanee at the harvesting stage of 110 days, as in this experiment, was ready to be consumed by Thai consumer at about 3 days after harvest which coincided with the peak of ethylene and respiration of the pulp. However, the husk turned yellow and dehisced at around the 6 days after harvest, which was also coincided with the peak of C_2H_4 and CO_2 production in the husk. At this stage the pulp had already become very soft and had a very strong odor. Consumption at this stage is preferred by many consumers in Malaysia, Singapore and the Phillipines.

The higher respiration and ethylene production rates found in the husk than in the pulp was not only because of wounding, resulting from the separation of the pulp from the husk. The reason behind this argument was that two days after harvest the durian was still quite difficult to open, a knife was used to cut it open. The pulp was also needed be cut to separate it from the axis of the fruit. But, later on opening became easy due to the development of the dehiscence zone along the suture in the middle of each locule and along the fruit axis. Knife was used at minimum and the pulp can be removed quite easily. Thus, durians dehusked earlier should have higher respiration and ethylene production rates than those dehusked later, but the opposite was found.

Judging from the data obtained, it was likely that CO_2 and C_2H_4 production peaks were reached first in the pulp. It was, therefore possible that ripening of the husk was stimulated by C_2H_4 from the pulp. This information could be used to explain the broad peak of durian respiration and ethylene production shown in Fig. 1. Nevertheless, although the husk had quite a strong structure, ripening processes developed later and it was not the tissue that would be consumed, care must still be taken for the husk. Because, if the husk was damaged or induced to ripen, it could provide quite a high heat load and a lot of ethylene which could shorten the shelf life of durian further. From the physiological point of view, storage of only durian pulp looked more promising than the whole fruit.

Ripening process of the pulp separated from the fruit continue as if it were intact. In fact the process seem to proceed even faster judging from the rate of softening of the pulp in the jar. This may be due to suitable atmospheric condition surrounding the pulp, having higher O_2 and lower CO_2. The experiment also showed that ripening of the separated pulp can be manipulated by modifying atmospheric condition. CO_2 concentration around 10% created by respiratory activity of the pulp inside the plastic wrap clearly delay the ripening process, eventhough there was about 5 ppm of ethylene presented. When $KMnO_4$ was used, the ripening was delayed particularly the softening process, but sugar accumulation was less influenced.

Use of ethephon however was not successful eventhough ethylene was generated in large quantity. This may be due to other component release from ethephon, which might interfere with the ripening process. In addition, CO_2 inside the package was not found on the first day indicating that other reaction besides the breakdown of ethephon might occur.

Although it was shown here that ripening of the separated pulp could be manipulated and hence the pulp could be stored longer than the whole fruit, difficulty still existed. Durian pulp used in the second experiment were forcibly taken out from the fruit with knife when the pulp began to ripen. This process damage the pulp, and might induce ethylene production. If the fruit was left longer until it was easier to open, the ripening processes of the pulp would probably far to advance to delay the ripening by atmosphere manipulation.

Another problem interfere with the successfulness of the storage of durian pulp was contamination by fungi. Normally fungal growth could be found on the base of the seperated pulp where it used to attach to the fruit axis, but not on the surface of the pulp itself. This was obviously because the tissue at the base were damaged during dehusking. Infection by microorganism could occur easily. On the other hand, the surface of the pulp was covered with cuticle of the pulp's epidermis. Nevertheless, atmospheric condition of about 10% CO_2 achieved inside the foam tray could control the fungal growth sucessfully.

The result from the last experiment indicated that the pulp was more tolerant to low temperature than the whole fruit or the husk itself. It could be due to the difference in membrane composition or the metabolic activity of the two tissues. From the first experiment, the pulp had lower respiratory activity. Once chilling injury occurred, toxin which could be produced should be less than the from the more active tissue, and consequently less symptom developed. High level of CO_2 was reported to help alleviate chillinginjury in some tissues, but aggravate it in the others (Kader et al., 1989). Thus the level of CO_2 surrounding the pulp could not explain why the pulp in intact fruit fail to ripen eventhough the fruit was later removed th room temperature and kept for more than 3 days.

It was concluded that durian pulp had lower metabolic activities than the husk. The ripening process of the pulp could proceed eventhough it was removed from the intact fruit. The pulp was also less susceptible to chilling injury than the husk, and could be stored at low temperature longer than the whole fruit.

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