J. Trop. Agric. and Fd. Sc. 28(1)(2000): 87–94

Quality of minimally processed jackfruit stored at different temperatures

(Penilaian mutu nangka yang diproses secara minimum pada suhu penyimpanan yang berbeza)

M. N. Latifah*, A. R. Abd. Shukor*, I. Ab. Aziz*, M. Habsah*, Y. Talib*, K. M. Rahman* and H. Jabir*

Key words: minimally processed, jackfruit, rate of respiration, physical and chemical changes

Abstrak

Mutu ulas nangka kultivar Madu yang diproses secara minimum dikaji semasa disimpan pada suhu 2, 10 dan 25 °C. Ulas nangka yang disimpan pada suhu 2 °C dinilai pada setiap minggu, manakala sampel yang disimpan pada 10 °C dan 25 °C dinilai dua hari sekali. Penilaian mutu merangkumi perubahan fizikal, kimia dan kadar pernafasan. Mutu ulas nangka masih baik apabila suhu persekitaran dikekalkan pada aras yang rendah (0 °C). Kehilangan berat hanya 0.9% selepas 2 hari penyimpanan pada 25 °C, dan 0.02–0.12% selepas 6 hari pada 10 °C. Pada 2 °C, kehilangan berat kekal rendah (0.02–0.06%) sepanjang 3 minggu penyimpanan. Tiada perbezaan yang ketara pada perubahan warna (nilai *L, a* dan *b*) dengan tempoh dan suhu penyimpanan. Nilai pH meningkat bagi ulas nangka yang di simpan pada 25 °C dan 2 °C, manakala trend penurunan ditunjukkan pada nilai TSS dan kandungan gula pada ketiga-tiga suhu penyimpanan (25, 10 dan 2 °C). Kadar pernafasan ulas nangka yang disimpan pada 25 °C menunjukkan peningkatan yang mendadak pada hari ke-2. Pada suhu 10 °C, trend peningkatan hanya dapat dikesan selepas 4 hari. Kadar pernafasan ulas nangka yang disimpan pada 2 °C kekal rendah sepanjang tempoh 3 minggu penyimpanan.

Abstract

Quality of minimally processed jackfruit cv. Madu was evaluated during storage at 25, 10 and 2 °C. The jackfruit pulp stored at 2 °C was evaluated on weekly basis, whereas samples stored at 10 °C and 25 °C were evaluated on alternate days. Quality observation was based on physical and chemical changes and rate of respiration. The quality of minimally processed jackfruit remained good when the surrounding temperature was maintained at low level (0 °C). The weight loss was only 0.9% after 2 days at 25 °C, and 0.02–0.12% after 6 days at 10 °C. At 2 °C, the weight loss remained low (0.02–0.06%) throughout the 3 weeks storage period. There was no significant change in the colour (*L, a* and *b* values) between duration and storage temperatures. The pH value of minimally processed jackfruit stored at 25 °C and 2 °C increased, whereas, the TSS and total sugar of minimally processed jackfruit stored at the three storage temperatures (25, 10 and

*Horticulture Research Centre, MARDI Headquarters, P. O. Box 12301, 50774 Kuala Lumpur, Malaysia
Authors' full names: Latifah Mohd Nor, Abd. Shukor Abd. Rahman, Ab. Aziz Ibrahim, Habsah Mohamed, Talib Yacob, Rahman K. Moidu and Jabir Husin

2 °C) showed a decreasing trend. Minimally processed jackfruit stored at 25 °C showed an abrupt increase in the rate of respiration after day 2. At 10 °C, the increasing trend was noticeable only after day 4 onwards. Rate of respiration of minimally processed jackfruit stored at 2 °C remained low during the 3 weeks storage period.

Introduction

Minimally processed products are more perishable than the intact products because they have been subjected to severe physical stress, such as peeling, cutting, slicing, trimming and removal of protective cells (Watada et al. 1996). The preparation of minimally processed products entails physical wounding of the tissue which causes an increase in the rate of respiration and ethylene production (Saltveit 1996). The increased surface area of minimally processed products exposed to the atmosphere after cutting allows oxygen to diffuse into the interior cells more rapidly. These will hasten the metabolic activity and senescence process (Zagory 1996).

Temperature management is the key to success in any minimal processing operation. Failure to maintain temperature control before, during and after processing results in significant losses of product shelf life and overall quality (James and Kader 1996). At low temperature, the respiratory metabolism and other metabolic reactions are reduced. These will conserve the plants store of carbohydrate, acid and moisture (Zagory 1996). Metabolic reactions in fruits and vegetables are reduced about two to three times for each 10 °C reduction in temperature (Jeffrey 1995).

The shelf-life of some fruits and vegetables, primarily of tropical or subtropical origin, can be limited by chilling injury, a disorder induced by low (0–12 °C) but non-freezing temperatures. The extent of chilling injury is influenced by temperature, duration of exposure to a given temperature, and chilling sensitivity of the particular fruit or vegetable. The symptoms of chilling injury may not be evident while produce is held at chilling temperatures, but they become apparent after transfer to higher temperature (Wang 1989). The susceptibility to chilling injury sometimes may only manifested in whole or unprocessed produce (Reyes 1997) as been observed during storage of pineapple at 8 °C (Abdullah and Rohaya 1983), papaya at 10 °C (Latifah et al. 1994) and durian at 15 °C (Siriphanich 1993). There was no chilling injury reported in minimally processed pineapple (Powrie et al. 1990; Latifah et al. 1998b; 2000), durian (Latifah et al. 1997a; 1997b) during storage at 2 °C and papaya and melon stored at 4 °C (O'Connors et al. 1994).

This study attempts to evaluate the quality changes of minimally processed jackfruit stored at different temperatures. Quality evaluation was based on the physical, chemical changes and the rate of respiration. Temperature surrounding the products was also monitored to relate with quality.

Materials and methods

Jackfruit *(Artocarpus* cv. Madu) harvested at commercial maturity was obtained from FELDA farm at Bukit Cerakah, Shah Alam, Selangor. Upon arrival at MARDI laboratory at Serdang, Selangor, the fruit was sprayed with water to remove the extraneous matter and dipped in 100 ppm chlorinated water for 10 minutes. The fruit was then air dried and temporary stored for ripening at ambient temperature of 28 °C and 65–70% relative humidity. The fruit ripened after 3 days. At that time, the skin was slightly soft and the smell was more pronounced. The ripened fruit was again dipped in 100 ppm chlorinated water before being placed at 2 °C for 24 h. The purpose of keeping the fruits at 2 °C was to ensure the fruit pulp temperature attained a temperature of 2 °C.

This helped to overcome the difficulties in separating the fruit pulp from the longitudinal and the epidermal cells, and also the latex problem during cutting the fruit. The cutting and packing operations of the minimally processed jackfruit were conducted in a controlled room at 20 °C. The seed was removed from the individual fruit pulp to prevent from sprouting and bitter taste during storage (unpublished data).

The individual fruit pulps were trimmed at both ends and randomly selected for packing in polypropylene container with ‘‘clip-on “ lid (10 cm x 5 cm x 17 cm). Three pieces of water absorbent (Trade name *Supersob*) were placed in the polypropylene container and each pack contained 7–8 fruit pulp. Each pack had an average net weight of 300 g. The strong smell of jackfruit was controlled by wrapping the individual pack with polyethylene bag (thickness 0.04 mm).

The individual container was further placed in an insulated box (36 cm x 49 cm x 37 cm) which was lined with thermal freeze. The use of thermal freeze was based on the study conducted earlier (Latifah et al. 1998a). Nine insulated boxes were used in the study. Each insulated box contained 20 packs of jackfruit pulp. The insulated boxes were stored overnight at 2 °C to ensure that the fruit pulp attained temperature of 2 °C. Following that, the insulated boxes were divided into three lots. The first lot was stored at 2 °C, second lot at 10 °C and the third lot at 25 °C. Temperature of 25 °C was chosen to simulate the condition at wet market, 10 °C at dry market, and 2 °C for ideal storage and market distribution.

Samples stored at 2 °C were evaluated on a weekly basis while those stored at 10 °C and 25 °C were evaluated on alternate days. Ten packs of the jackfruit pulp were used as replication for each evaluation time.

Physical changes

The weight loss of the jackfruit pulp was taken by measuring the difference in weight before and after storage. Weight loss was reported in percentage. Colour was determined using colour meter (Chromameter model 300, Osaka Japan) by measuring the values of *L*, *a* and *b*.

Chemical changes

The minimally processed jackfruit pulp were analysed for pH value using an Origon digital pH meter (model SA 520) and the total soluble solids by using a refractometer (model Atago Digital DBX-5). Total sugars were analysed by the method of Lane and Eynon (AOAC 1975).

Temperature

Changes in temperature in the insulated boxes were measured 3 times daily (9.00 am, 12 noon and 4.00 pm). Temperature probes were inserted in the insulated boxes at 3 points: top, middle and bottom. Cole Palmer temperature probes (model 8529-00) were used for the temperature measurement.

Rate of respiration and ethylene production

Minimally processed jackfruit (6 fruit pulp with the average weight of 300 g) were placed in a 0.5 L glass jar which was continuously aerated with humidified air at a flow rate of 1 L/100 g fruit per hour. The measurements of gases for each storage temperature was replicated 4 times. Respiration rate was measured by the rate of carbon dioxide liberated by the jackfruit pulp. One mL of respired air from the head space was injected into a Varian 1420 thermal conductivity detector gas chromatograph fitted with a 1500 mm x 3 mm stainless steel column packed with Porapak R of size 80–100 mesh. The carrier gas was helium flowing at 30 mL/min and the column temperature was 35 °C.

For ethylene measurement, 1 mL of respired air was injected into a Varian 1440 flame ionization detector gas chromatograph fitted with a 1800 mm x 3 mm stainless steel column packed with Porapak T of size 100–200 mesh. The carrier gas was nitrogen flowing at 30 mL/min and the column oven temperature was 100 °C.

Measurements of respiration and ethylene production were taken daily until the fruit pulp showed signs of quality defects, such as watery, off-odour, or colour changes.

Statistical analysis

Analysis of variance and Duncan's Multiple Range Test were performed on the data (Gomez and Gomez 1984).

Results and discussion

The storage temperature of the product was found to have a direct relationship with the freshness of the jackfruit pulps. Temperature not only affects the rate of respiration, but also the rate of gas diffusion. However, the effect on respiration is much more pronounced. As temperature increases the concentration of oxygen in tissue decreases and the concentration of carbon dioxide increases (Saltveit 1996).

The initial surrounding temperature of the packed minimally processed jackfruit was maintained at 0 °C. The surrounding temperature influenced the in-package temperature of minimally processed jackfruit, and this consequently affected the storage life. Sample stored at 25 °C showed a sudden increase of 15 °C on day 2, whereas at 10 °C the temperature remained 0 °C until day 4 and started to increase only on day 5 and 6, achieving a temperature of 8 °C *(Figure 1*). Similar trend of temperature change was also observed when evaluating the effectiveness of thermal freeze packing for shelf life extension of minimally processed jackfruit (Latifah et al. 1998a). At 2 °C, the temperature remained low (0–1 °C) throughout the 3 weeks storage period *(Figure 1*). The lower temperature attained in the thermal freeze packing contributed to lower weight loss and maintenance of freshness, aroma, texture and chemical compositions (Latifah et al. 1998b).

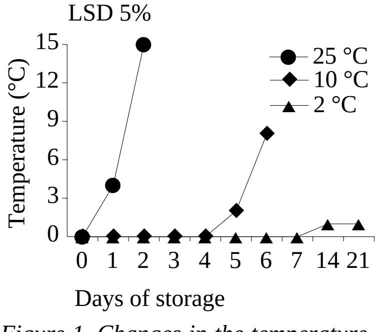

Figure 1. Changes in the temperature surrounding the minimally processed jackfruit stored at 25, 10 and 2 °C

The temperature recommendation for maintaining quality of minimally processed products differs from those recommended for whole/intact fruits. Peeled fruits can tolerate lower temperature (Siriphnich 1993). For whole tropical fruits, minimum storage temperatures for whole fruits are 10–15 °C, below which chilling injury symptom usually develops (Siriphanich 1993). Whole jackfruit stored at 5 °C showed a serious formation of browning blemishes which was a chilling injury symptoms after 2 weeks of storage (unpublished data). However, in this study, no chilling injury was observed to the minimally processed jackfruit stored either at 10 °C or 2 °C.

One serious problem associated with high in-package humidity is condensation on the film that is driven by temperature oscillations during storage and handling in modified atmosphere packages. The amount of condensate formed is related to the difference in temperature inside and outside the package, the void volume of package, and, to some extent, the nature of the polymeric film (Ben-Yehoshua 1985). In this study, the condensate is being reduced to a minimum by the combined use of water absorbent and thermal freeze which created a lower in-package humidity and minimize the development of high temperature of the jackfruit.

The weight loss of minimally processed jackfruit was very low at all storage temperatures; 25 °C (0.9%), 10 °C (0.02–0.12%) and 2 °C (0.02–0.06%) *(Figure 2).* Reducing water loss is one of the most important aspects related to modified atmosphere packing of minimally processed products. Water loss reduces the saleable weight and can reduce senescence of the product (Grierson and Wardowski 1978). Plant tissues are in equilibrium with an atmosphere at the same temperature and a RH of 99% to 99.5% (Burton 1982). Any reduction of water vapour pressure in the atmosphere below that in the tissue, results in water loss. Minimal processed products are subjected to fast dessication due to increased surface area and exposed moist inner tissue (Reyes 1997). The use of polymeric packaging film which is highly permeable to water vapour is normally used to retain the moisture inside the package and within the product.

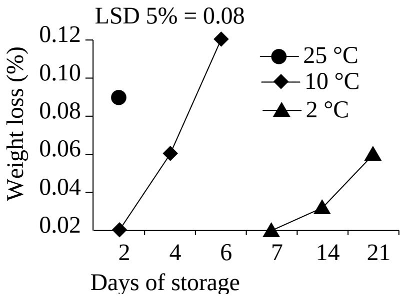

Figure 2. Weight loss of minimally processed jackfruit stored at 2, 10 and 25 °C

Table 1. Changes in the *L, a* and *b* values of minimally processed jackfruit stored at different temperatures and storage period

Duration of storage	*L* value	*a* value	*b* value
Day 0	70.95abc	–3.48c	+50.37a
25 °C			
Day 2	70.68abc	–5.57ab	+50.79a
10 °C			
Day 2	73.33ab	–4.75abc	+49.87a
Day 4	69.73bc	–4.10bc	+50.21a
Day 6	69.54bc	–5.76a	+52.87a
2 °C			
Day 7	75.263a	–3.43c	+50.94a
Day 14	69.54bc	–4.27abc	+51.4a
Day 21	73.5ab	–5.14ab	+51.40a

Each value is the mean value from 20 jackfruit pulps. Means with the same letters within column are not significantly different at 5% level according to DMRT

Slight discolouration was observed in the minimally processed jackfruit stored at 25, 10 and 2 °C as shown by the changes in *L, a* and *b* values *(Table 1).* However, no significant difference was shown between temperatures and duration of storage. A gradual decreasing trend was only observed in the *L* value of minimally processed jackfruit stored at 10 °C *(Table 1).* Discolouration normally occurs at the cut surface of minimally processed products as a result of the disruption of compartmentation that occurs when cells are broken, allowing substrates and oxidases to come in contact (Rolle and Chism 1987). Browning occurs when the products of phenylpropanoid metabolism, such as various phenolic and possibly other substrates (e.g. anthocyanin) are oxidised in reactions catalysed by phenolases such as polyphenoloxidase (PPO) or peroxidase (Hanson and Havir 1979).

The pH declined rapidly from day 4 to day 6 for minimally processed jackfruit stored at 10 °C *(Figure 3*). But those stored at 25 °C and 2 °C increased with duration of storage *(Figure 3).* These are probably related to the value of total soluble solids (TSS) *(Figure 3)* and total sugars *(Figure 3).*

The TSS and total sugar value of minimally processed jackfruit decreased during storage at 25, 10 and 2 °C. After two days storage at 25 °C, the change in TSS was 32% to 29% and the total sugar change was 22% to 19%. At 10 °C, the TSS decreased on day 2 (30%), but later increased on day 6 (31%). The total sugar also showed similar increasing trend towards the end of storage period. However, at 2 °C the decreasing trends of TSS and total sugar value were more obvious with longer storage period *(Figure 3).* The decreasing trend is probably related to sugar being used as respiratory substrate (Seymour et al. 1993).

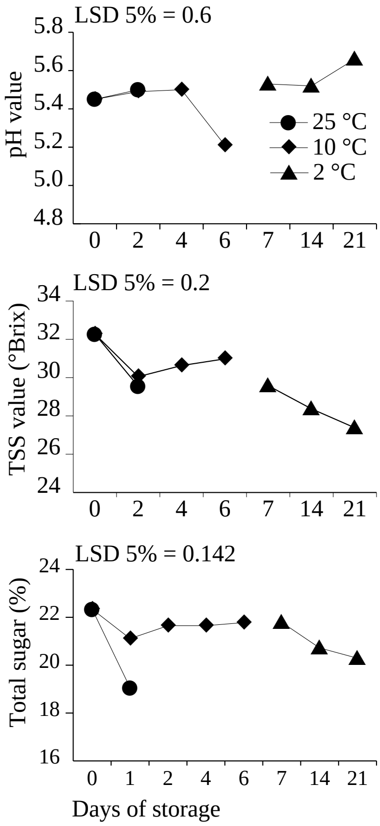

Figure 3. Changes in the values of pH, TSS and total sugar of minimally processed jackfruit stored at 25, 10 and 2°C

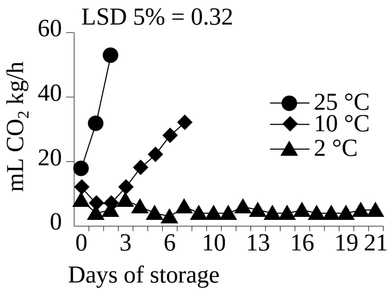

Figure 4. Respiration rate of minimally processed jackfruit stored at 25, 10 and 2 °C

Sugar/acid ratios are often used as an index of consumer acceptability and quality in fruits. Both sugars and acids are found largely sequestered within the vacuole, and form a major contribution to the overall flavour of fruit (Tucker and Grierson 1987). Acids can affect flavour directly and are also important in processing, since they affect the formation of off-flavour and the gelling properties of pectin. Acid also regulate cellular pH and may influence the appearance of fruit pigments within tissues (Seymour et al. 1993). In general, the levels of acid are indicated by the product pH. The pH declined during fruit ripening, presumably due to their utilization as respiratory substrates (Ulrich 1970).

An abrupt increase in the rate of respiration was observed after two days for minimally processed jackfruit stored at 25 °C. Whereas at 10 °C, the rate of respiration showed an increase only after day 4 onwards. The rate of respiration of minimally processed jackfruit stored at 2 °C remained constant throughout the 3 weeks storage period *(Figure 4).* Higher respiration rates indicate rapid metabolic activities and deterioration rates resulting in loss of sugar and other components that determine flavour quality (Marita 1996) These were in agreement with the values of pH, TSS and total sugar *(Figure 3).*

Rolle and Chism (1987) reported that the increase in the rate of respiration reflected the defence mechanism being triggered by the wounding tissue of the minimally processed product. The defence mechanism includes the synthesis of new compounds that serves as antimicrobial agents, the lignification of the cells adjacent to the wound, and the formation of new cell layers to heal the wound.

Maintaining the rate of respiration at low level is significantly important in minimally processed products. The CO_2 liberated as a result of respiration process is stimulated to furnish not only energy, but also in molecules to synthesise the needed repair compound of the minimally processed products. The substrates used in these reactions are often the compounds that prized components of quality; e.g., sugars and organic acids. The reduction and interconversion of these compounds during metabolism can significantly reduce quality (Salveit 1996).

The increase in the rate of respiration of minimally processed tissues is thought to be a consequence of elevated ethylene which stimulates respiration (Bretcht 1996). Starch breakdown is enhanced and both the tricarboxylic acid cycle and electron transport chain are activated (Laties 1978). Wounded plant tissue as a result of cutting/ slicing induces elevated ethylene production rates sometimes within a few minutes (Bretcht 1996). Probably this phenomenon had occurred to the minimally processed jackfruit as no ethylene production was detected at the three storage temperatures. In this study, the climacteric peak could have occurred during preparation time, as no ethylene was detected from the minimally processed jackfruit stored at 25, 10 and 2 °C (*Figure 4).*

Conclusion

Temperature management is a key issue in maintaining the fresh quality of minimally processed jackfruit. Failure to maintain temperature often results in significant reduction of the product shelf life and overall quality. Combined use of polypropylene container, polyethylene wrapper and thermal freeze packing effective for handling and marketing minimally processed jackfruit. The packing system had contributed to minimal weight loss, colour and chemical changes and also the respiration rate for 2 days at 25 °C, 6 days at 10 °C and 3 weeks at 2 °C. The quality of minimally processed jackfruit declined significantly with the increase in the surrounding storage temperature of the package.

Acknowledgements

The authors wish to acknowledge the valuable assistance of Ms Fariza Mat Lazid in carrying out the research. This project was jointly funded by MARDI, a grant from the National Integrated Research in Priority Areas (IRPA) program (HR-06-03-02) and AusAid (Australia) for research grant through the AAECP-111 project.

References

Abdullah, H. and Rohaya, A. (1983). The development of black heart disease in Mauritius pineapple during storage at low temperature. *MARDI Res. Bull.* ***11(3):*** 309–19

Abeles, F. B., Morgan, P. W. and Salveit, M. E. (1992). *Ethylene in plant biology* 2nd ed. San Diego: Academic

AOAC (1975). *Method of analysis.* 12th ed. Washington, D.C. :Association of Official Analytical Chemists

Ben-Yehoshua, S. (1985). Individual seal-packaging of fruits and vegetables in plastic film – A new postharvest technique. *HortScience* **20**: 32–7

Brecht, J. K. (1996). Physiology of lightly processed fruits and vegetables. *HortSci.* ***30 (1)***: 18–22

Burton, W. G. (1982). *Post-harvest physiology of food crops.* London: Longman

Cantwell, M. (1996). *Frech-cut-products (section 4): maintaining quality and safety.* USA: Univ. California Davis

Gomez, K. A. and Gomez, A. A. (1984). *Statistical procedures for agricultural research* 2nd ed., 680 p. New York: Willey

Grierson, W. and Wardowski, W. F. (1978). Relative humidity effects on the postharvest life of fruits and vegetables. *HortScience* ***13***: 570–4

Hanson, K. R. and Havir, E. A. (1979). An introduction to the enzymology of phenylpropanoid biosynthesis In *The biochemistry of plant phenolic* (Swain, T., Harbone, J. B. and Sumere, C. F., ed) p. 91–138

James, R. G. and Kader, A. A. (1996). *Fresh-Cut Products (section 14): Maintaining quality and safety.* USA: Univ. California Davis

Jeffrey, K. B. (1995). Physiology of lightly processed fruits and vegetables. *HortSci.* ***30 (1):*** 18–22

Latifah, M. N., Ali, Z. M. and Lazan, H. (1994). Effect of storage temperature of ethylene metabolism of papaya. *Proc. 19th Malaysian Biochem. Soc. Conf.* Bangi, Selangor. p. 143–6

Latifah, M. N., Talib, Y. and Abd Rahman, K. M. (1997a). Suitable storage temperature for minimally processed durian. *30th National Convention of the AIFST.* Perth, Australia

—— (1997b). Modified atmosphere packing for minimally processed durian. Poster (No. 14) presented at the Asian Food Technology ’97 Oct. 1997, Kuala Lumpur. Organizer: MARDI

Latifah, M. N., Ab Aziz, I., M., Talib, Y. and Abd Rahman, K. M. (1998a). Thermal freeze packing for shelf life extension of minimally processed jackfruit. Proc. *9th Malaysian Society of Plant Physiology Conference*, 1–2 Sept. 1998, Bangi, Selangor, p. 116–9

—— (1998b). Quality evaluation of minimally processed pineapple stored at holding temperature (10 °C) after subsequent storage at low temperature (2 °C), Proc. *9th Malaysian Society of Plant Physiology Conference*, 1–2 Sept. 1998, Bangi, Selangor, p. 147–50

Latifah, M. N., Abdullah, H., Mohd Selamat, M., Habsah, M., Talib, Y. Abd Rahman, K. M. and H. Jabir (2000). Shelf life of minimally processed pineapple *J. Trop. Agric. and Fd. Sci*. ***28(1):*** 75–85

Laties, G. G. (1978). The development and control of respiratory pathways in wounded slices of plant storage organs *Biochemistry of wounded tissues* (Kahl, G., ed.) p. 421–66. Berlin: Walter deGruyier & Co.

Marita, C. (1996). *Fresh-Cut Products (section 4): Maintaining quality and safety.* USA: Univ. California Davis

O'Connor-Shaw, R. E., Roberts, R., Ford, A. L. and Nottingham, S. M. (1994). Shelf-life of minimally processed honeydew, kiwifruit, papaya, pineapple and cantalouupe. *J. Food Sci.* ***59***: 1202–15

Powrie, W. D., Chia, R., Wu, H. and Skura, B. J. (1990). Preservation of cut and segmented fresh fruit pieces. US Patent #4, 895, 729

Reyes, V. G. (1997). Factors limiting shelf life and quality of minimally processed fruits and vegetables. Paper presented at the AAECP-111: QASAF project workshop on minimal processing of tropical fruits, 21–23 Oct. 1997, Kuala Lumpur Organizer: MARDI and Palmere Pty. Ltd. (Aust)

Rolle, R. S. and Chism, G. W. (1987). Physiological consequences of minimally processed fruits and vegetables. *J. Food. Qual.* ***10***: 157–77

Salveit, M. E. (1996*). Fresh-cut products biology: Maintaining quality and safety.* USA: Univ. California Davis

Seymour, G. B., Taylor, J. E. and Tucker, G. A. (1993). *Biochemistry of fruit ripening.* London: Chapman & Hall, London.

Siriphanich, J. (1993). Minimally processing of tropical fruits. *Proc. ACIAR. Postharvest handling of tropical fruits* ***50***: 127–8

Tucker, G. A. and Grierson, W. (1987). Fruit ripening. In *The Biochemistry of Plants – A comprehensive treatise,* (Davies, D. D., ed.) p. 265–318. Academic Press

Ulrich, R. (1970). Organic acids. In *The Biochemistry of fruits and their products* (Hulme, A., ed) p 89–118. Academic Press

Wang, C. Y. (1989). Chilling injury of fruits and vegetables. *Food Review International* ***5(2):*** 209–36

Watada, A. E., Abe, K. and Yamauchi, N. (1990). Physiology activities of partially processed fruits and vegetables. *Food Technol. XX*: 116, 118, 120–2

Watada, A. E., Nathanee, P. K. and Minott, D. A. (1996). Factors affecting quality of fresh-cut horticultural products. *Postharvest Biology and Technology* ***9***: 115–25

Zagory, D. (1996). Fresh-Cut Products (section 13): *Maintaining quality and safety*. USA: Univ. California Davis

Accepted for publication on 12 July 2000