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Effect of packing methods on the quality of minimally processed green citrus cv. *limau madu*

(Kesan kaedah pembungkusan terhadap kualiti limau hijau kultivar limau madu diproses secara minimum)

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Key words: minimally processed, packing, quality, shelf life, green citrus

Abstract

Effect of packaging method on the quality of minimally processed (MP) green citrus cv. *limau madu* stored at 25 ºC was evaluated using insulated boxes lined with frozen gel (FG) and corrugated fibre board (CFB). Physical and biochemical changes were observed to relate with quality changes. Surrounding in-package temperature and relative humidity of the product was also recorded throughout the 3-day storage period. A decreasing trend in the weight loss was observed on the MP *limau madu* in FG packing, however, significant increase (p <0.05) to 0.32% was observed in CFB packing on day 3. The total soluble solids (TSS) in the FG packing was quite stable (12.5–13 °Brix) throughout the 3-day storage period. However, significant increase (p <0.05) in the TSS value (16 ºBrix) was observed in the CFB packing on day 1. There was no significant difference (p >0.05) in the pH and total titratable acids (TTA) value between the two packing systems throughout the 3-day storage period. However, for the acid ascorbic content, the significant difference was observed only on day 2. Lower inpackage temperature (0–3 ºC) and high relative humidity (100%) was observed surrounding the MP *limau madu* in the FG packing until day 2. Whereas the temperature in the CFB packing increased from 19–26 ºC with RH 55–85% from day 0 until the end of the storage period (day 3). Overall acceptability of MP *limau madu* in the FG packing was still good with the average score was 6.8 even after day 2, but overall acceptability score in the CFB packing was only 5 on day 0. MP *limau madu* in the CFB packing was not acceptable after day 1.

Introduction

The demand for minimally processed (MP) products has increased rapidly due to the increasing demand for healthy food and the limited time in preparing healthy meals. High quality product is a requisite for successful marketing of MP products. All MP products are perishable and demonstrate rapid postharvest quality degradation over time especially at ambient temperature (Shewfelt 1987). The MP produce is more perishable than the unprocessed fresh produce. Thus, production of high quality and convenience produce present a unique challenge for processors as undesirable physiological changes are the most crucial problems encountered.

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Suitable packaging system is needed for all minimally processed products. The package must protect and contain the product from the place and time of preparation to the point of consumption. It is necessary for the package to fulfil numerous functions such as retarding or preventing loss of product quality, providing protection against environmental contaminants, and facilitating transport, handling, storage and marketing.

Temperature abuse of MP product during distribution and retail display is of critical concern to processors. Temperature of a product has a direct relationship with the freshness and metabolic reactions of MP product (Bretch 1996) as the life span of MP products is controlled by product temperature. The integrity of the cold chain system from the supplier to the end-user is the critical component for achieving maximum shelf life, quality and food safety.

Minimal processing varies with the type of fruits and how the fruits are normally consumed. Suitability of fruits for minimal processing depends on many reasons. *Limau madu* is suitable to be minimally processed due to unique skin appearance i.e. having scanty dark spots and patches all over the skin, which causes great problem to get good market price for the fruit (Latifah et al. 2005). Despite the crude skin appearance, the quality of the fruitlets is good with 12–16 °Brix depending on the season and also agronomic practices (Latifah et al. 2005).

This study was to evaluate the effect of packaging method on the quality of MP *limau madu* during storage at 25 °C and RH 65–70%. The MP *limau madu* was packed in insulated boxes lined thermal freeze and corrugated fibreboard packing. Physical and chemical changes, sensory evaluation and surrounding inpackage temperature and relative humidity were monitored to relate with the product quality and shelf life.

Materials and methods

Green citrus cv. *limau madu* fruits at commercial maturity were obtained from a private farm at Yong Peng, Johor Bahru. *Limau madu* is considered commercially mature when the upper part of the fruit skin is soft with glossy appearance and easy to peel off (Ahmad Tarmizi and Pauziah 2005). Upon arrival at MARDI laboratory at Serdang, Selangor, the fruits were sorted and washed to remove the extraneous matter from the field. The skins were peeled, individual segments were segregated and the arils were removed.

Round polypropylene containers with 'clip-on lid' (250 ml) were used for packing. One piece of water absorbent (*Supersob*) was placed in the polypropylene container and each container/pack contained 10–12 fruitlets. Each pack had an average net weight of 100 g. The polypropylene containers were arranged in an insulated box (50 x 38 x 17.5 cm) which was layered with frozen gel (FG). Each insulated box can hold 18 containers. Control samples were placed in a corrugated fibreboard box (CFB) (40 x 32 cm). All samples were stored at 25 °C and RH 65–70%. Samples were observed daily for physical and chemical changes. Temperature measuring kit (*HOBO*) was placed at the centre of the insulated box and also in the CFB box.

Physical analysis

The weight loss of *limau madu* was taken by measuring the difference in the weight before and after storage. The weight loss recorded was based on the average of 10 packs of the MP *limau madu.*

The surrounding inpackage temperature and relative humidity were measured using *HOBO* Temp/RH logger. Temperature kit (*HOBO*) was placed at the centre of the three FG and CFB boxes. The graph plotted was based on the average from the *HOBO* readings.

Chemical analysis

The *limau madu* juice was obtained by squeezing the flesh using a kitchen blender with one pack represented a replicate. Chemical analysis was conducted in five replicates. Minimally processed *limau madu* juice was analysed for total soluble solids (TSS) by using a refractometer (Model Atago Digital DBX-5). The pH value was determined using an Orion digital pH meter (Model SA520). Total titratable acidity (TTA) was measured by titrating 0.1 N NaOH to an end point of pH 8.1. Ascorbic acid content was measured by titrating with 2,6 dichlorophenolindophenol (Ranganna 1977).

Sensory evaluation

A panel of 10 panellists evaluated the fruit for various attributes using 7-point hedonic scale (1 = very unacceptable, 2 = unacceptable, 3 = moderately unacceptable, 4 = neither good nor bad, 5 = moderately good, 6 = good and 7 = very good). For day 0, sensory evaluation was conducted after 6 h the packed MP *limau madu* were stored at 25 °C.

Statistical analysis

A complete randomized design was used for the experimental set up of the two packing treatments [frozen gel (FG) and corrugated box (CFB)] with three boxes used for samples replication on the evaluation day. Data were analysed using analysis of variance (ANOVA) (Steel and Torrie 1980) and the differences among the means from three replicates were determined for significance at $p < 0.05$ using Duncan multiple range test (SAS Inst. 1990).

Results and discussion

Significant increase in the weight loss (0.1–0.35%) was observed on the MP *limau madu* packed in CFB boxes throughout the 3-day storage at 25 ºC as indicated by the dryness of the fruitlets. However, a decreasing trend in the weight loss was observed on the MP *limau madu* packed in FG (*Figure 1*). This probably had contributed to the fresh appearance of the MP *limau madu* in the FG packing as compared to the MP *limau madu* in the CFB packing. A decreasing trend in the weight loss of MP *limau madu* (–0.25%) in FG packing was due to the effect of lower temperature in the insulated boxes as the FG still remained in the frozen form until day 2. However on day 3, the weight loss increased to –0.12% when the FG started to melt (*Figure 1*).

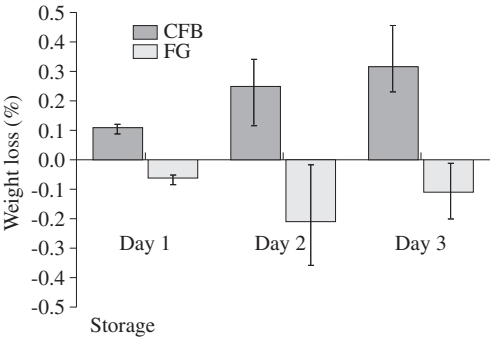

Figure 1. Weight loss of minimally processed limau madu packed in corrugated fibre board (CFB) and frozen gel (FG) during storage for 3 days at 25 ºC. The weight loss recorded was based on the average of 10 packs of the minimally processed limau madu

Similar observation was also observed in the study conducted for MP jackfruit, durian and pineapple (Latifah, Abd. Shukor et al. 1999; Latifah, Abdullah et al. 1999, 2000; Latifah, Abd. Shukor, Ab. Aziz et al. 2001; Latifah, Abd. Shukor, Abdullah et al. 2001). Water loss is often related with a reduction in the fresh weight of the produce which when sold on weight basis is often translated into a loss in value and undesirable quality changes (Kays 1991). Furthermore, water loss diminishes the firmness and associates with fresh appearance and is related to a stress that reduces postharvest life (Kader 1986).

The TSS value of MP *limau madu* in the FG packing was quite stable (12.5–13 °Brix) throughout the 3-day storage period at 25 °C. However, the

TSS value in the CFB packing increased on day 1 and later decreased on day 2 and 3 (*Figure 2*). The decreasing trend of the TSS value is often related to the components used as energy partly to carry on respiration and other metabolic functions (Shewfelt 1987).

The pH value increased significantly in the MP *limau madu* packed in CFB on day 2 (4.15) and day 3 (4.17). Whereas the pH value in FG increased only on day 3 (4.13) indicating that the pH value remained stable when the frozen gel remained in the frozen form *(Figure 2)*. Despite the change, no significant difference was observed in the pH values of MP *limau madu* in the FG and CFB packings throughout the 3-day storage period.

The TTA value, which is a quantitative measure of the organic acid, decreases with senescence process (Burton 1982). However, in this study the TTA value of the MP *limau madu* in both packings was quite stable even though significant difference between both packings system was shown on day 2 (*Figure 2*). Organic acids play an important role in the general metabolism of postharvest products.

The ascorbic acid content in FG packing on day 2 decreased significantly with higher value in the CFB packing. However, no significant difference ($p > 0.05$) was noted in both packaging methods (FG and CFB) on day 3 (*Figure 2*). Ascorbic acid is structurally one of the least complex vitamins found in plants. It is a lactone of sugar acid synthesized in plants from glucose or other simple carbohydrates (Kays 1991). Retention of ascorbic acid is often measured when evaluating post-harvest storage effect on nutrients. Loss of vitamin C is often reported to be greater with increasing storage temperature and duration (Burton 1982).

Environment temperature influenced the quality of MP *limau madu* as observed both in the FG and CFB packings. The temperature of inpackage atmosphere in the insulated boxes lined with frozen gel (FG)

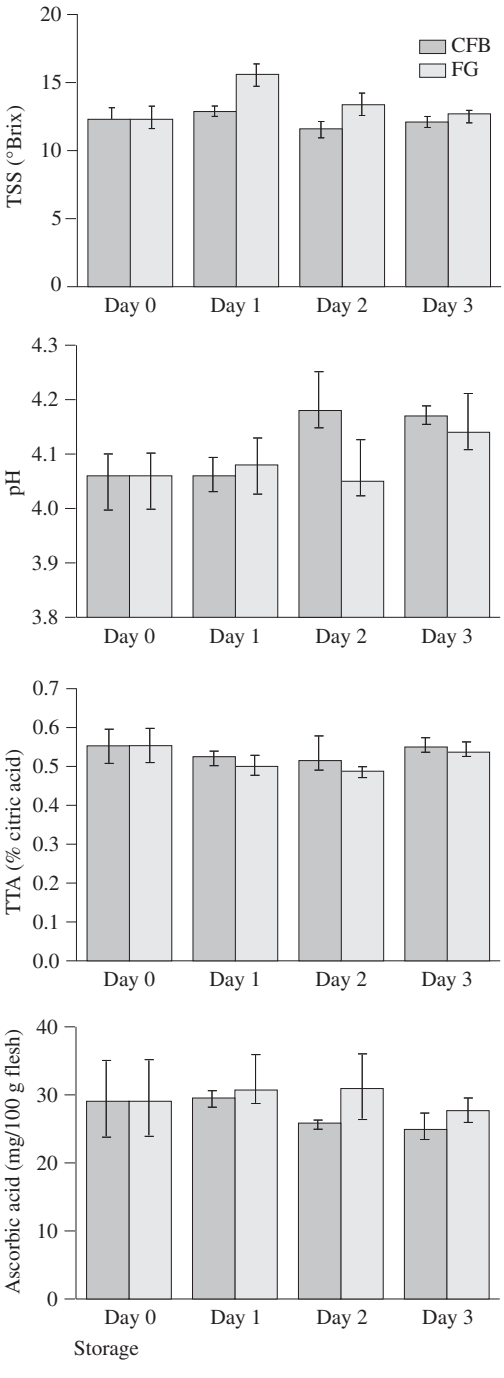

Figure 2. Changes in TSS, pH, TTA and ascorbic acid content of minimally processed limau madu packed using corrugated fibre board (CFB) and frozen gel (FG) during 3-day storage at 25 ºC. All changes were analysed based on the average of 5 packs of the minimally processed limau madu

remained at 0 ºC for 24 h. The temperature increased to 3 ºC after 60 h and reached 15 ºC after 72 h (day 3). Following that, the temperature increased progressively reaching 20 ºC after 78 h (*Figure 3*). At this stage, the thermal freeze was melted. Temperature in the control samples in the CFB packing fluctuated from 19–26 ºC. The relative humidity in FG packing remained stable at 100%, whereas in the CFB packing increased from 55–75% throughout the storage period. Temperature in the control samples in the CFB packing fluctuated from 19–26 ºC with RH 55–85% (*Figure 3*).

Changes in the temperature and relative humidity in both FG and CFB packings probably attributed to the decreasing trend in the weight loss in the FG packing and increasing trend in the weight loss in the CFB packing (*Figure 1*). The instability of the TSS value in the CFB packing was also probably related to the changes in the temperature and the relative humidity (*Figure 2*).

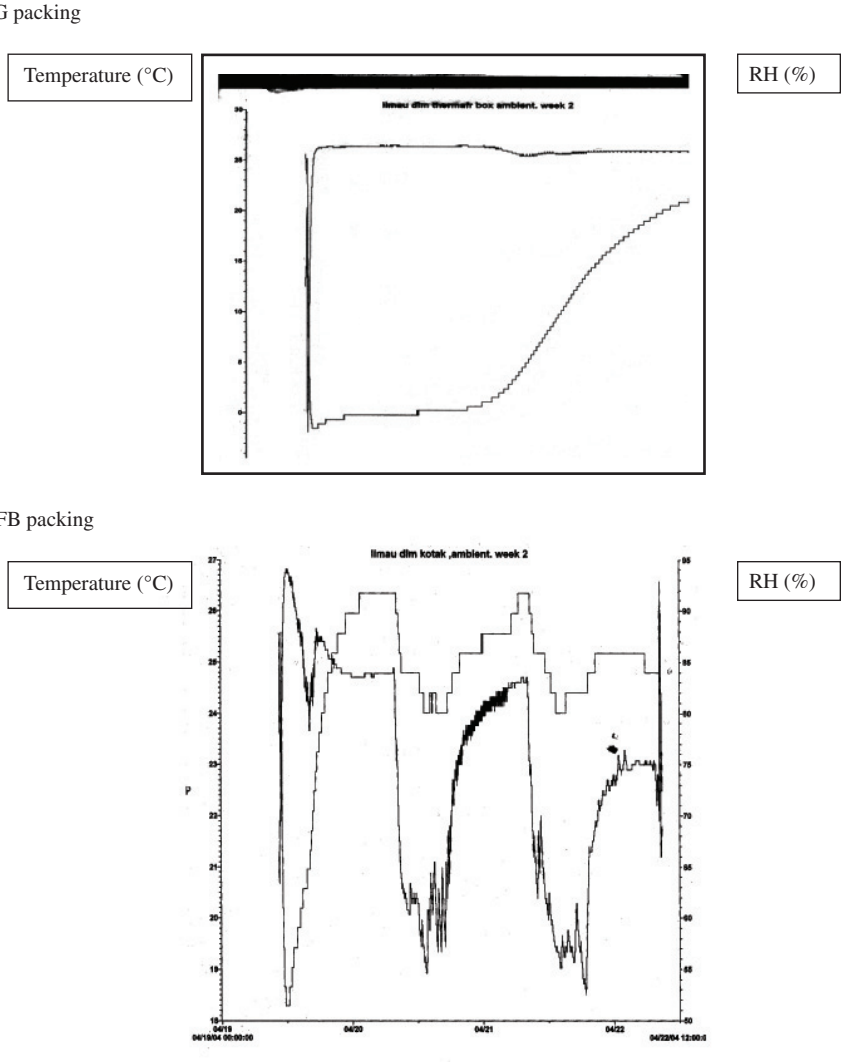

Figure 3. Changes in the temperature and relative humidity of minimally processed limau madu packed using frozen gel (FG) and corrugated fibreboard boxes (CFB) stored for 3 days at 25 ºC. The graph plotted was based on the average reading from 3 HOBO readings

Similar trend of temperature change was also observed when evaluating the effectiveness of thermal freeze packing for shelf life extension of minimally processed jackfruit, durian and pineapple as the quality remained good after 2 days at 25 ºC (Latifah, Abd. Shukor, Ab Aziz et al. 2001; Latifah, Abd. Shukor, Abdullah et al. 2001).

Overall acceptability of MP *limau madu* depends greatly on the packing system used. MP *limau madu* in FG packing was still acceptable until day 2 with higher score in taste and overall acceptability attributes *(Table 1).* Combined values of TSS (15.17 ºBrix) and pH (4.02) (*Figure 2*) had resulted in sweet-sour taste which probably had contributed to higher score given by the panel (*Table 1*). However on day 3, lower score was given especially on taste and aroma, which coincided with the reduced sweetness due to the decrease in the TSS (14.4 ºBrix) and pH (3.98) values (*Figure 2*). Overall acceptability score of MP *limau madu* in CFB packing was only 5 on day 0 (6 h after storage) and was totally rejected on day 1 onwards due to the unfavourable odour and softness of the fruitlet tissue.

Conclusion

Method of packaging influenced the quality of minimally processed *limau madu.* Insulated box lined with frozen gel is suitable for packing minimally processed *limau madu* as the sample was still acceptable even after day 2. Lower weight loss and slow metabolic changes contributed to the acceptability of the product. By using frozen gel packing, lower inpackage temperature (0–3 ºC) and high humidity (100%) can be achieved for two days at 25 ºC which indicated the sufficient time for market distribution and retailing of the product at open market. The lower inpackage temperature and high relative humidity achieved in the insulated boxes had contributed to the maintenance of good quality even after day 2.

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Table 1. Sensory evaluation of minimally processed limau madu stored at 25 ºC

Days of storage	Packing system	Colour	Texture	Taste	Aroma	Overall acceptability
Day 0	FG	6.6a	6.76a	6.8a	6.5a	6.8a
	CFB	6.5a	5.17c	5.17c	6.06c	5.0c
Day 1	FG	6.5a	6.67a	6.77a	6.56a	6.8a
	CFB	–	–	–	–	–
Day 2	FG	6.5a	6.57ab	6.71a	6.6a	6.77a
	CFB	–	–	–	–	–
Day 3	FG	6.5a	6.3b	6.b	6.4b	6.3b
	CFB	–	–	–	–	–

Each value is the mean value from 10 panellists. Mean values with the same letters within each column are not significantly different at 5% level according to DMRT (1 = Very unacceptable, 2 = Unacceptable, 3 = Moderately unacceptable, 4 = Neither good nor bad, 5 = Moderately good, 6 = Good)

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Abstrak

Kesan kaedah pembungkusan terhadap kualiti limau hijau kultivar limau madu yang diproses secara minimum (PM) dan disimpan pada 25 ºC telah dikaji menggunakan kotak penebat yang dilapisi bekuan gel (FG) dan kotak beralun ombak (CFB). Perubahan fizikal dan biokimia diperhatikan bagi mengaitkannya dengan perubahan kualiti. Suhu dan kelembapan relatif sekeliling produk juga direkod sepanjang 3 hari penyimpanan. Limau madu PM di dalam pembungkusan FG menunjukkan tren menurun pada kadar kehilangan air. Bagaimanapun, tren tersebut meningkat secara ketara (p <0.05) iaitu mencapai 0.32% pada hari 3 bagi CFB. Sepanjang 3 hari penyimpanan, nilai pepejal larut (TSS) bagi limau madu PM di dalam pembungkusan FG agak stabil (12.5–13 ºBrix), tetapi yang di dalam pembungkusan CFB meningkat secara ketara (p <0.05) (16 ºBrix) pada hari 1. Tiada perbezaan ketara (p <0.05) bagi nilai pH dan jumlah asid tertitrat (TTA) antara kedua-dua jenis pembungkusan sepanjang tempoh 3 hari penyimpanan. Bagaimanapun, nilai asid askorbik berbeza dengan ketara hanya pada hari 2. Suhu persekitaran yang rendah (0–3 ºC) dan RH yang tinggi (100%) diperhatikan pada limau madu PM di dalam pembungkusan FG pada hari 2. Manakala di dalam pembungkusan CFB, suhu berubah 19–26 ºC dan RH 55–85% pada hari 0 (mula) hingga akhir tempoh penyimpanan (hari 3). Penerimaan keseluruhan limau madu PM di dalam pembungkusan FG masih diterima dengan purata skor 6.8 walaupun selepas 2 hari penyimpanan. Bagaimanapun, skor bagi limau madu PM di dalam pembungkusan CFB ialah 5 pada hari 0. Limau madu PM di dalam pembungkusan CFB tidak diterima selepas hari 1.

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