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Post-harvest Storage of Guava (*Psidium guajava*, L, var. Taiwan)

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ABSTRAK

Buah jambu batu (jenis Taiwan) telah disimpan pada suhu bilik (26°C), 20°C dan 5°C, dan ciri-ciri buah semasa penyimpanan telah dinilai. Jangka masa penstoran buah jambu batu pada suhu bilik adalah lebih kurang 1 minggu dan jangka masa penstoran dilanjutkan beberapa hari pada 20°C. Pada 26°C dan 20°C, jangka masa penstoran dihadkan oleh kewujudan kulat. Pada 5°C, pemerangan ('bronzing') kulit buah jambu batu berlaku lebih kurang selepas 2 minggu penstoran. Kulat tidak merupakan suatu masalah semasa penstoran pada 5°C. Purata pH, jumlah pepejal terlarut dan keasidan tertitrat buah jambu batu pada masa dituai, masing-masing 3.5, 5.4° Brix dan 62.8 ml 0.1N NaOH/100g. Paras gula terlarut individu adalah: fruktosa 1.60g/100g, glukosa 1.06g/100g dan sukrosa 0.78g/100g pada permulaan kajian. Peningkatan pepejal terlarut yang bererti didapati semasa penyimpanan pada semua suhu penstoran. Perubahan keasidan tertitrat didapati tidak bererti semasa penstoran selama 10 hari pada suhu bilik, dan 20°C dan semasa penstoran selama 4 minggu pada 5°C. Terdapat peningkatan yang bererti bagi paras fruktosa, glukosa dan jumlah pepejal terlarut tetapi tidak terdapat perbezaan yang bererti bagi paras sukrosa semasa penstoran pada suhu bilik. Terdapat peningkatan yang bererti pada paras fruktosa dan paras jumlah pepejal terlarut semasa penstoran pada 20°C dan 5°C. Nisbah fruktosa/glukosa meningkat dengan bererti semasa penstoran pada semua suhu penstoran.

ABSTRACT

Guava fruit (var. Taiwan) were stored at room temperature (26°C), 20°C and 5°C and the characteristics of the fruits during storage were evaluated. Guava fruit has a post-harvest life of about 1 week during room temperature storage and post-harvest life can be extended by a few days during storage at 20°C. At 26° C and 20° C, post-harvest life is limited by the occurrence of rots. At 5°C, bronzing of the guava skin occurs at about 2 weeks of storage. Rots were not evident during storage at 5°C. The average pH, total soluble solids and titratable acidity of guava at harvest was 3.5, 5.4° Brix and 62.8 ml 0.1NaOH/100g respectively. The levels of individual soluble sugars were: fructose 1.60 g/100g, glucose 1.06g/100g and sucrose 0.78g/100g at the commencement of the study. There were significant increases in total soluble solids during storage at all temperatures. Titratable acidity did not change significantly during storage for 10 days at room temperature and 20°C and during storage for 4 weeks at 5° C. There were significant increases in fructose, glucose and total soluble sugars but no significant differences in sucrose levels during storage at room temperature. Significant increase in fructose levels and total soluble sugar levels were also obtained during storage at 20°C and 5°C. The fructose/glucose ratios significantly increased during storage at all temperatures.

INTRODUCTION

Guava (*Psidium guajava*, L) is the most widely known and important commercial crop of the *Myrtaceae* family. It is native to tropical America

and is widely distributed throughout the tropics (Kennard and Winters, 1960).

The characteristics of different varieties of guava vary considerably. Fruit shape ranges from round to pear shape. Skin colour of mature ripe fruit can be various shades of green or yellow. The flesh colour can range from white to yellow to pink and red. Texture and taste of different guava as well as the seed content also vary (Brown and Paxton, 1983). The guava is rich in vitamin C and levels of 200 mg/100g are generally found (Thomas and Corden, 1970).

The guava is a soft thin-skinned fruit. It is very susceptible to mechanical damage, insect attack and fungal rots and has a short post-harvest life (Brown and Paxton, 1983). Cool storage of the fruit can prolong the post-harvest life of the guava (Broughton and Leong, 1979; Singh and Mathur, 1954, Wills *et al.*, 1983). Different varieties respond differently to cool storage and shelf-life extension obtained upon cool storage varies. Work on the 'Safeda' guava showed that optimum storage conditions for cool storage were 8 – 10°C and 85–90% relative humidity (Singh and Mathur, 1954). Broughton and Leong (1979) suggested that the optimum temperature of storage for green, mature but unripe guava (var. GU 3 and GU 4) was 20°C. Wills *et al.* (1983) found that the optimum cool storage temperature of guava (var. '1050' and 'GA 11–56') was 5°C. In their work, guava was packed on a fiber-board tray fitted with a polyethylene cover.

This paper reports the changes in guava (var. Taiwan) during post-harvest storage at different temperatures.

MATERIALS AND METHODS

Fruits

Guava fruits (var. Taiwan) were obtained from a farm in Slim River, Perak. The fruits of commercial maturity (about 15 weeks after fruit set) were used in the study. The fruits used for the assessment of post-harvest storage life was obtained at a different season from those used for study of the compositional changes and weight loss of the fruits during storage.

Sampling and Storage of Fruit

Fruits of commercial maturity were brought to the laboratory on the day of harvest. The fruits were washed and left to dry in the air. Only acceptable fruit of firm texture which were free from mechanical injury were used in the study. The fruits were randomly sampled, placed in plastic trays and put in rooms set at room temperature (26 ± 2°C), 20°C and 5°C on the next day.

At intervals during the storage period, six fruits were randomly sampled and taken out for analysis of compositional changes. Twenty fruits at each storage temperature were randomly sampled and set aside for assessment of weight loss.

For evaluation of storage life, the fruits were distributed into replicates of 10 fruits, placed in plastic trays, with five replicates for each temperature. At various storage intervals, the fruits were individually scored for incidence of rots (where 1 = no rots, 2 = slight rots, 3 = medium rots and 4 = severe rots). The degree of surface bronzing (discolouration of the skin) of fruits stored at 5°C was also assessed (where 1 = no bronzing, 2 = slight bronzing, 3 = medium bronzing and 4 = severe bronzing).

Analysis of Compositional Changes in the Fruits

A representative portion of each fruit was homogenized. Samples of each homogenate were used for analysis of pH, titratable acidity, total soluble solids and soluble sugars.

For the measurement of pH, 25g of the homogenized pulp was mixed with 100 ml distilled water. The slurry was filtered and the pH of the filtrate was measured.

The AOAC (1980) method was used for the determination of titratable acidity. 25 g of the homogenized sample was put into a 100 ml volumetric flask and the volume was made up to the mark with distilled water. A 10 ml portion of this solution was used for titration with 0.1N NaOH using phenolphthalein as indicator. The total soluble solids content of the expressed juice from the pulp was measured using an Erma hand refractometer.

The method for determination of soluble sugars was based on that of Wills *et al.* (1980). 5 g of the homogenized pulp was extracted with hot 85% methanol for 20 min. The mixture was filtered and the residue was re-extracted twice with 25 ml volumes of hot 85% methanol. The extracts were combined and methanol was re-

moved by rotary evaporation. Portions of the extract were filtered through C-18 Sep-pak cartridges and analysed by HPLC using conditions described before (Augustin and Khor, 1986). The column used was NH_2 polar bonded phase. The mobile phase was acetonitrile: water (85:15). Quantification of sugars was obtained by comparing peak areas of samples to peak areas of sugar standards of fructose, glucose and sucrose. Recovery studies showed that there was between 94–97% recovery of sugars using the extraction procedure described and HPLC analysis.

RESULTS AND DISCUSSION

Storage Life of Guava

The storage life of guava stored at room temperature was about 1 week. Storage at 20°C extended the post-harvest life by a few days compared to room temperature. At room temperature and at 20°C storage, the post-harvest life of guava was limited by the occurrence of rots and softening of fruits (Table 1). The incidence of rots during storage at room temperature was significantly greater ($p < 0.05$) than during storage at 20°C. It was noted that the skin colour of guava changed from light green to greenish yellow on storage at 20°C. Rots were not a problem when guava was stored at 5°C but the major factor limiting the acceptability was the bronzing of the guava skin (Table 2). Bronzing was observed at about 2 weeks of storage at 5°C. After 5 weeks' storage at 5°C, there was severe bronzing of the guava but there was no obvious sign of pulp injury. It may be noted that the mean rots and bronzing scores for guava from two different harvests are different but nevertheless similar trends were observed.

TABLE 1
Rots score of guava during storage[a]

Trial	Days of storage	Storage Temperature		
		5°	20°	Room Temperature
		Rots Score		
I	1	1.0a	1.0a	1.0a
	4	1.0a	1.0a	1.2b
	7	1.0a	1.2a	2.2b
	10	1.0a	1.7b	3.1c
	14	1.0a	2.4b	3.6c
	17	1.0a	3.1b	4.0c
II	1	1.0a	1.0a	1.0a
	4	1.0a	1.0a	1.0a
	8	1.0a	1.1a	1.4b
	11	1.0a	1.2a	1.9b
	15	1.0a	1.9b	2.9c
	18	1.0a	2.1b	3.3c
	22	1.0a	2.5b	3.9c
	25	1.0a	2.9b	4.0c

[a]Mean Scores for 5 replicates of 10 fruit each. Numbers in each row followed by the same alphabet are not significantly different ($p < 0.05$). Trials I and II refer to studies on fruits of commercial maturity of a different harvest.

TABLE 2
Bronzing scores of guava during storage at 5°C.[a]

Week of storage	Bronzing Score	
	Trial I	Trial II
0	1.0a	1.0a
0.5	1.0a	1.0a
1	1.0a	1.0a
1.5	1.4b	1.1a
2	2.5c	1.6b
2.5	3.0d	–
3	3.2d	3.1c
3.5	3.6e	3.3d
4	3.8f	3.6e
4.5	3.9f	3.7f
5	4.0f	3.9f

[a]Mean Scores for 5 replicates of 10 fruits each. Numbers in each column followed by the same alphabet are not significantly different ($p < 0.05$).
Trials I and II refer to studies on fruits of commercial maturity of a different harvest.

The short post-havest life of guava (var. Taiwan) obtained in this study is in line with the observations of other workers on different varieties of guava. Wills *et al.* (1983) reported that guava (var. '1050' and 'GA 11–56') had a storage life of about a week at 20°C. Broughton and Young (1979) found that green, mature but unripe guava (var. GU3 and GU4) took 8–9 days to ripen at 20°C and remained in good condition for another 5 days. Wills *et al.* (1983) found that

storing guava fruits at 0°C reduces rotting considerably but that darkening of the flesh of the guava during storage at 0°C and 5°C became evident after 3 weeks and 4 weeks respectively. Broughton and Leong (1979) found that when guava (var. GU3 and GU4) was stored at 4°C and transferred to 20°C, the fruits developed brown blemishes and had a flat taste. Brown and Paxton (1983) reported that common guava showed pulp injury symptoms on cool storage. Differences in the responses of the various varieties of guava stored under similar temperature conditions may be expected. Commodities grown in different areas as well as varieties of the same crop can differ in their susceptibility to chilling injury and development of chilling injury symptoms.

Weight Loss

The weight loss from the fruit is dependent on both the temperature and duration of storage (Table 3). The rate of water loss from the fruit was higher at higher temperatures. This was observed for fruits stored at room temperature, where there is a 35.6% weight loss after storage for 17 days whereas fruits stored at 20°C experienced a weight loss of 18.4%. Weight loss for fruits stored at 5°C was 11.4% after 17 days of storage. Excessive loss of moisture from fruits is undesirable as it lowers the overall acceptability of the fruit. The effects of dehydration are noticeable visually. In the case of guava, fruits acquired a dehydrated appearance and the skin of the fruits became tougher. Work on the guava of the Kampuchean variety (Azizah Osman *et al.*, 1987) also showed that the guava was susceptible to dehydration during storage and weight losses of 20%, 14%, 9% and 8% were recorded after 8 days of storage at 26°C, 20°C, 12.5°C and 5°C respectively.

Compositional Changes in Fruits during Storage

The changes in total soluble solids, titratable acidity and soluble sugars are given in Table 4.

The average initial pH, total soluble solids

TABLE 3
Moisture loss from guava (var. Taiwan) during storage[a]

Days after harvest	Storage temperature		
	Room Temperature (26 ± 2°C)	20°C	5°C
	Moisture Loss (%)		
3	4.7 ± 0.8	2.2 ± 0.4	1.7 ± 0.4
6	9.9 ± 1.2	4.5 ± 0.6	3 9 ± 0.8
8	13.8 ± 1.5	7.0 ± 1.0	5.7 ± 1.2
10	18.7 ± 1.2	9.5 ± 1.4	7.0 ± 1.4
13	26.3 ± 2.7	13.4 ± 1.9	9.0 ± 1.8
17	35.6 ± 3.3	18.4 ± 2.9	11.4 ± 3.2
21	–	–	14.6 ± 2.9
24	–	–	16.6 ± 3.4
27	–	–	18.6 ± 3.8
29	–	–	20.1 ± 4.2
32	–	–	21.8 ± 4.3

[a]Results are the average weight loss from 20 fruits ± S.D.

Fruits used in this study was obtained at a different season from those used for the evaluation of rots and bronzing scores.

Analysis of moisture loss for fruits stored at room temperature and 20°C were terminated on day 17 of storage as most of the fruits were bad on day 21.

TABLE 4
Physico-chemical characteristics of guava (var. Taiwan) during storage[a]

Temperature	Days after harvest	Total soluble solids °Brix	Titratable acidity ml 0.1N NaOH/100g	Fructose g/100 g	Glucose g/100 g	Sucrose g/100 g	Total soluble sugar g/100g	Fructose / Glucose
Room Temperature (26 ± 2°c)	1	5.4a	62.8a	1.60a	1.06abcd	0.78abc	3.44a	1.54abc
	3	6.8bc	67.2a	1.68ab	1.18bcde	0.60b	3.46a	1.46a
	6	7.3cd	72.4abc	1.83abcd	1.16bcde	0.53a	3.52ab	1.51ab
	10	8.0cde	76.8abcd	2.25e	1.33ef	0.86abcde	4.44cd	1.69cde
	13	9.5f	86.8d	2.73f	1.51f	0.83abcd	5.07d	1.83ef
20°C	1	5.4a	62.8a	1.60a	1.06abcd	0.78abc	3.44a	1.54abc
	3	5.6ab	68.3a	1.76abc	1.08abcd	0.68ab	3.52ab	1.64bcd
	7	6.7bc	66.4a	1.73ab	1.02ab	0.77 abc	3.52ab	1.70cde
	10	6.9bc	68.8ab	2.09cde	1.18bcde	0.98bcdef	4.28bcd	1.79def
	14	7.3cd	85.2cd	2.11de	1.04abc	0.80abc	3.84abc	2.05g
	17	8.8ef	84.8bcd	2.16de	0.91a	1.24ef	4.11abc	2.36h
5°C	1	5.4a	62.8a	1.60a	1.06abcd	0.78abc	3.44a	1.54abc
	7	6.5abc	79.2abcd	1.89abcd	1.30def	1.26f	4.45cd	1.47ab
	13	7.0bcd	72.4abc	1.96bcde	1.26cde	1.15cdef	4.37cd	1.56abc
	21	7.7cde	70.4ab	2.12de	1.18bcde	1.18cdef	4.46cd	1.83ef
	27	8.4def	76.3abcd	1.97bcde	1.05abc	1.20def	4.22abc	1.91fg

[a]Mean of 5 – 6 fruits. Values in the same column followed by the same alphabet are not significantly different ($p < 0.05$).
Fruits used for these analysis were obtained at a different season from those used for evaluation of rots and bronzing scores.

and titratable acidity of guava used in this study were 3.5, 5.4° Brix and 62.8 ml 0.1N NaOH/100g respectively. The fructose, glucose, sucrose and total soluble sugar levels of the freshly harvested guava were 1.60 g/100 g, 1.06 g/100 g, 0.78 g/100 g and 3.44 g/100 g fruit respectively. The % distribution of soluble sugars were 46.5% fructose, 30.8% glucose and 22.7% sucrose. Chan and Kwok (1975) reported that fructose is the predominant sugar in guava constituting 58.9% of the sugar followed by glucose at 35.7% and sucrose at 5.3%. Wills *et al.* (1983) found that the guava used in their study had fructose, glucose and sucrose levels of 1.60 g/100 g, 0.5 g/100 g and 0.5 g/100 g respectively i.e. the % distribution of soluble sugars were 61.5% fructose, 19.2% glucose and 19.2% sucrose. Differences in sugar content and % distribution of sugars in different varieties may be expected. Even within the same variety, differences in total soluble solids, titratable acidity and sugars may occur in different seasons. Work done on guava (var. Kampuchea) showed that the distribution of the relative amounts of soluble sugars were different at different stages of maturity (Salmah Yusof and Suhaila Mohamed, 1987).

With respect to the changes in composition during storage it was noted that there were significant increases in total soluble solids of the fruit during storage. The rate of increase in total soluble solids was dependent on temperature, with greater rates of increase at higher temperatures of storage (Table 4). Increases in total soluble solids after harvest were also found in other varieties of guava (var. Kampuchea) (Azizah Osman *et al.*, 1987) and guava (var. GU3) (Tung and Nair, 1980). However, Wills *et al.* (1983) found that the levels of soluble solids of fruits did not change significantly during storage of fruits in fiber-board trays with a polyethylene wrap at 2–8°C.

There were no significant differences in the titratable acidity of the fruits during storage for 4 weeks at 5°C and during the first 10 days of storage at room temperature and 20°C. Significant

increases in titratable acidity were observed after 10 days of storage at room temperature and 20°C (Table 4). Wills *et al.* (1983) found that titratable acidity of guava (var. '1050' and 'GA 11–56' did not change significantly during storage at 2–8°C.

The levels of individual sugars and total soluble sugars in the guava (var. Taiwan) change during storage (Table 4). There were significant increases in fructose, glucose and total soluble sugars of fruits stored at room temperature but there was no significant changes in the level of sucrose. Significant increases in fructose and total soluble sugar levels were also found during storage at 20°C and 5°C. Levels of glucose remained relatively constant at 20°C and 5°C storage whereas sucrose levels were between 0.78 and 1.26g sucrose/100g during the storage period. It was noted that the glucose/ fructose ratios increased significantly during storage. In their work on guava (var. GU 3), Tung and Nair (1980) found that the concentration of sugars as well as sucrose increased with the onset of the climacteric and decreased when the fruit entered the post-climacteric storage. Studies on the storage of guava (var. '1050' and 'GA 11–56') showed that the levels of all soluble sugar in guava (placed in fibre-board trays with a polyethylene wrap) declined during storage at 2–8°C and that the relative proportions of each sugar remained the same (Wills *et al.*, 1983).

CONCLUSION

Guava (var. Taiwan) stored at 26°C has a post-harvest life of about 1 week. Storage at 20°C extended the post-harvest life by a few days. Storage at 5°C resulted in bronzing of the fruits but there was no obvious injury to the pulp. However, bronzing may reduce consumer acceptance when the fruit is marketed for fresh consumption.

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