*MARDI Res. J. 20(1) 1992: 67–72*

# Reproductive performance of Japanese quail (*Coturnix coturnix japonica*) in Malaysia

[Prestasi pembiakan puyuh Jepun (*Coturnix coturnix japonica*) di Malaysia]

C. P. Seet*

Key words: Japanese quail, laying performance, mating procedure, mating ratio, fertility, hatchability

**Abstrak**

Sekumpulan puyuh Jepun betina telah dipelihara untuk menilai prestasi pengeluaran telur. Umur puyuh ini mulai bertelur ialah 37 hari. Pengeluaran telur dari umur 7 hingga 82 minggu ialah 65.3% dan jumlah telur purata yang dihasilkan ialah 347.2 biji untuk seekor puyuh. Berat telur purata ialah 11.7 g dan jumlah jisim telur yang dihasilkan ialah 4.1 kg. Penukaran makanan kepada jisim telur ialah sebanyak 4.5. Dalam pengawanan burung puyuh secara berkumpulan, daya kesuburan dan penetasan telur yang dieramkan pada nisbah jantina 1:1 dan 1:2 masing-masing ialah 87.1, 62.7% dan 88.8, 63.2%. Nilai ini lebih baik berbanding dengan yang diperoleh daripada nisbah pengawanan pada 1:6 dengan daya untuk ciri-ciri tersebut masing-masing sebanyak 79.4 dan 50.6%. Walau bagaimanapun, semua nisbah pengawanan (1:1, 1:2, 1:4 dan 1:6) dalam pengawanan secara individu tidak menunjukkan kesan yang ketara terhadap kedua-dua ciri pembiakan tersebut. Kadar pembiakan untuk pengawanan secara individu pada nisbah jantina 1:4 dan 1:6 adalah lebih baik daripada cara pengawanan secara berkumpulan. Pada keseluruhannya, kadar penetasan telur daripada pengawanan secara individu adalah lebih baik ($p < 0.01$) berbanding dengan pengawanan secara berkumpulan. Analisis terhadap nisbah pengawanan tanpa mengambil kira cara pengawanan telah menunjukkan bahawa nisbah seekor jantan kepada dua ekor betina jelas dapat membaiki daya kesuburan. Terdapat juga aliran yang menunjukkan bahawa kumpulan nisbah ini lebih baik untuk ciri daya penetasan. Pengawanan secara individu juga dapat meninggikan pengeluaran anak puyuh.

**Abstract**

A group of female Japanese quail was maintained for the evaluation of their laying performance. The age of quail at the point of lay was 37 days. The egg production from 7 to 82 weeks of age was 65.3% and an average of 347.2 eggs/quail were produced. Average egg weight was 11.7 g and 4.1 kg egg mass was obtained. A feed conversion of 4.5 was achieved. When the quail were mass mated, the fertility and hatchability of total eggs set for the 1:1 and 1:2 ratio groups were 87.1, 62.7% and 88.8, 63.2% respectively. These results were better than those from 1:6 ratio group where the corresponding values were 79.4 and 50.6%. However, all mating ratios (1:1, 1:2, 1:4 and 1:6) did not have significant effects on both the reproductive traits when the quail were individually mated.

*Livestock Research Division, MARDI Headquarters, P. O. Box 12301, 50774 Kuala Lumpur, Malaysia
Author's full name: Seet Chin Puan

Between the two mating procedures, the fertility and hatchability of total eggs set from the 1:4 and 1:6 mating groups of the individual mating was significantly better than those when mass mated. Overall results, irrespective of mating ratios, indicated that the hatchability was significantly ($p < 0.01$) better for the eggs from the individual mating. Analysis of mating ratio, irrespective of mating procedures, indicated that a sex ratio of 1 male to 2 females definitely improved fertility significantly over the other ratios studied and the use of individual mating rather than mass mating could lead to improved production of quailings from the fertile eggs.

## Introduction

The Japanese quail *(Coturnix coturnix japonica)* is an excellent egg producer laying about 250 eggs annually (Woodard et al. 1965). Its egg requires only 17–18 days of incubation to hatch and it takes approximately 42 days to reach sexual maturity (Woodard et al. 1965). These facts allow it to produce 3–4 generations per year. Reproduction is normally through natural mating. Its fertility rates were reported to range from 42.1% (Woodard and Abplanalp 1967) to 95.3 % (Hughes et al. 1980), whereas the hatchability of total eggs set ranged from 67.8% (Sreenivasaiah and Ramappa 1985) to 83.3% (Hughes et al. 1980). These results were obtained with mating ratios ranging from 1:6 to 1:1. Higher ratios resulted in lower fertility (Woodard and Abplanalp 1967).

Although Japanese quail have been reared for egg production for years, information on their laying and reproductive performance is not well documented locally. In view of the growing importance of quail rearing, relevant information should be obtained for the benefit of rearers. This study was therefore undertaken to evaluate the laying performance as well as the effects of mating procedures and male to female ratios on fertility and hatchability of Japanese quail in Malaysia.

## Materials and methods

### *Laying performance evaluation*

Day-old Japanese quail used for the evaluation of laying performance were obtained from a local hatchery and reared as described by Seet and Azizah (1987). At 8 weeks of age, 128 healthy females were randomly chosen and these were divided into four replicates of 32 birds each. Each replicate was further subdivided into group of eight and each group was reared in a cage measuring 46 cm wide, 36 cm deep and 17 cm high. A floor space of approximately 0.02 $m^2$/quail was provided. Each replicate therefore occupied four identical cages arranged in columns in a 5-tier laying compartment. A layer diet *(Table 1)* and water were given ad libitum throughout the 76-week laying period.

### *Mass mating*

Day-old Japanese quail used were purchased from the same source. After the brooding and growing periods, 67 males and 152

Table 1. Composition of layer/breeder diet for the Japanese quail

| | Composition |
|---|---|
| **Ingredient** | |
| Corn | 49.6% |
| Fish meal | 14.0% |
| Soybean meal | 28.0% |
| Palm oil | 1.0% |
| Salt | 0.3% |
| Vitamin-mineral mix | 0.1% |
| Dicalcium phosphate | 1.0% |
| Limestone powder | 6.0% |
| **Calculated component** | |
| Crude protein | 24.0% |
| Metabolizable energy | 11.7 MJ/kg |
| Lysine | 1.1% |
| Methionine + cystine | 0.8% |
| Calcium | 3.5% |
| Total phosphorus | 0.8% |

females were divided into four mating groups and mass mated in the ratios as indicated below:

- 1:1 (30 males to 30 females)
- 1:2 (20 males to 40 females)
- 1:4 (10 males to 40 females)
- 1:6 (7 males to 42 females)

Each group of quail was placed in a box having a floor area of 1.70 $m^2$. Hence a floor area of approximately 0.03 $m^2$/quail was provided. The quail had free access to a breeder feed *(Table 1)* and fresh drinking water.

***Individual mating***

The experiment was the same as mass mating except that only one male (M) was allotted to each mating ratio group. The number of females (F) was allocated according to the respective male to female ratios, namely 1:1, 1:2, 1:4 and 1:6. The number of females for these mating groups were 1, 2, 4 and 6 quail respectively. The procedure was repeated four times. Therefore the total number of male and female quail used were 4 M:4 F, 4 M:8 F, 4 M:16 F and 4 M:24 F. Each mating group was allotted to four cages arranged in four columns in a 5-tier laying compartment as those used in laying performance evaluation. The quail had free access to a breeder feed *(Table 1)* and fresh drinking water.

***Data recording***

Laying variables such as number of eggs and egg weight were recorded daily, whereas feed intake was measured weekly for each replicate, from 7 to 82 weeks of production. The eggs collected from the mating ratio trials (age of birds 9–27 weeks) were set in a commercial chicken setter every 2 days for fertility and hatchability determinations. The eggs were incubated for 14 days and transferred to a hatcher for another 3 days for hatching. The unhatched eggs were broken and checked macroscopically for embryonic development.

Table 2. Laying performance of individual Japanese quail* during 76 laying weeks

| Trait | Value |
|---|---|
| Av. egg production (%) | 65.3 ± 1.5 |
| Mean no. egg | 347.2 ± 12.8 |
| Av. egg weight (g) | 11.7 ± 0.1 |
| Total feed intake (g) | 18 200.0 ± 25.7 |
| Total egg mass (g) | 4 060.0 ± 5.6 |
| Feed/egg mass | 4.5 ± 0.2 |

*7–82 weeks of age

## Results and discussion

***Laying performance***

The quail started laying at an average age of 37 days which agreed with the report of Woodard et al. (1965) but was slightly earlier than those quoted by Wilson et al. (1961) and Ino et al. (1983). During the 76-week (532 days) laying period, the mean number of eggs per quail was 347.2 *(Table 2)*. This was obtained from the average of the four replicates throughout the trial period. The average egg production was calculated to be 65.3% based on the ratio of mean number of eggs and number of days in production. The egg weight was 11.7 g. Based on the 4.1 kg of feed consumed, a feed conversion efficiency of 4.5 was obtained. The monthly production curve *(Figure 1)* indicates that egg production peaked at the fourth month of production (19–22 weeks after point of lay) at 85% and then dropped gradually as the production period prolonged. The laying rate was about 52% at the 19th month (79–82 weeks of lay) and continued to fall towards the end of the trial period. The laying pattern followed that reported by Woodard et al. (1965). Although the egg weight was constant at 11–12 g for each production month, the pattern of change in egg mass appeared to be similar to that of the egg production curve. This was because egg production fluctuated from month to month. Monthly feed intake indicated that higher laying rate correlated with higher feed intake. The intakes were higher towards the end of the laying period. For the first 4 months of lay, the number of eggs increased with the increase in feed

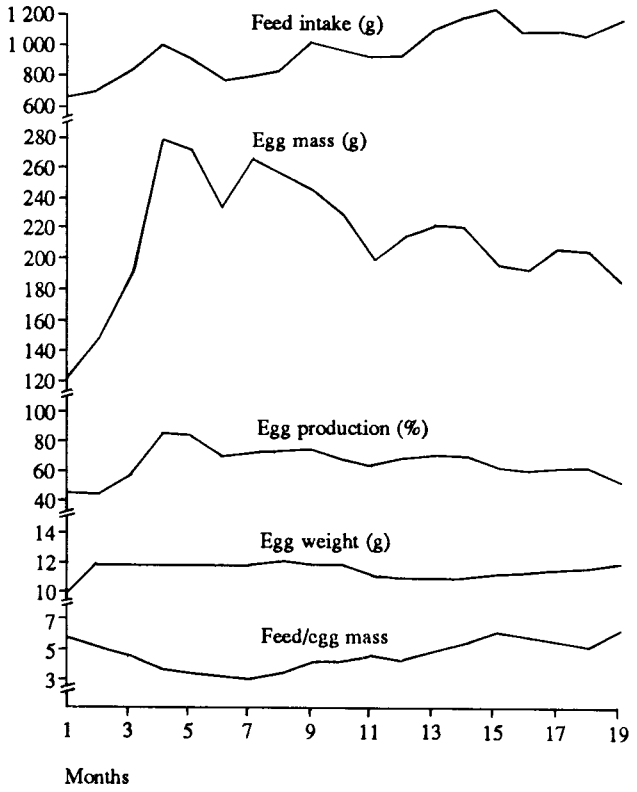


*Figure 1. Monthly performance of Japanese quail (7–82 weeks of age)*

intake. After the fourth month of lay, more feed was consumed but the laying rate decreased.

The Japanese quail was reported to produce 250 eggs annually (Woodard et al. 1965; Chiaravanont 1978). Some researchers reported that quail can lay as many as 300 eggs/bird in the first year of production (Wilson et al. 1961). In the People's Republic of China, the Philippines and Singapore, the annual egg productions were reported to be 216, 235 and 210 eggs respectively (Hertrampf 1987). In this study, the mean number of eggs produced during the 76 laying weeks was 347.2. The annual (52 laying weeks) production recorded was 245 eggs/quail. This was higher than those reported by Hertrampf (1987). The egg weight observed was slightly heavier than those quoted by Woodard et al. (1965). Feed conversion efficiency in this study was slightly poorer than those reported by Chiaravanont (1978) where 3 kg of feed was required to produce 1 kg of egg.

### *Fertility and hatchability*

**Mass mating** Results of various mating ratios on fertility and hatchability showed that the fertility from the ratio of 1 male to 6 females was 79.4% *(Table 3)*. This was significantly lower than those from the other three mating ratio groups. Among the latter groups, the fertility from the 1 male to 2 females ratio was observed to be numerically higher, although not statistically significant. This agreed with the report by Woodard and Abplanalp (1967) that higher fertility was obtained with a mating ratio of 1:2 or fewer females. The decline in fertility at higher mating ratios may be due to

Table 3. Effects of mating ratios and mating procedures on fertility and hatchability

| Mating ratio | No. eggs set | | Fertility (%) | | Hatchability (%) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Total eggs set | | Fertile eggs | |
| | MM | IM | MM | IM | MM | IM | MM | IM |
| 1:1 | 1 297 | 216 | 87.1a | 81.3 | 62.7a | 61.2 | 72.2 | 74.9 |
| 1:2 | 1 257 | 337 | 88.8a | 86.8 | 63.2a | 71.0 | 70.6 | 81.5 |
| 1:4 | 1 588 | 522 | 85.2a | 82.5 | 57.6ab | 66.6* | 67.5 | 80.7 |
| 1:6 | 1 548 | 594 | 79.4b | 82.3 | 50.6b | 65.0* | 63.6 | 77.7 |
| Mean | – | – | 85.1 | 83.2 | 58.5 | 66.0** | 68.5 | 78.7** |
| SE of mean | | | 1.4 | 2.1 | 3.8 | 2.7 | 3.1 | 2.7 |
| LSD (at 5%) | | | 4.0 | 6.0 | 7.7 | 7.6 | 8.6 | 7.7 |

MM = mass mating
IM = individual mating
a,b = Values in any column with different letters are significantly different ($p < 0.05$)
* = Significant difference ($p < 0.05$) between mass and individual matings
** = Highly significant difference ($p < 0.01$) between mass and individual matings

preferential mating behaviour in mass mated birds (Woodard et al. 1965). The hatchability from the total eggs set in 1:6 ratio group was significantly lower than those from 1:1 and 1:2 ratios. However, the differences in hatching rate between the 1:4 and 1:6 ratios were not statistically significant. The hatchability of the fertile eggs was not significantly affected by various mating ratios, although increasing the number of females per cage tended to cause a decline in hatchability. Reports on the Japanese quail (Woodard et al. 1965; Woodard and Abplanalp 1967) and Bobwhite breeder quail (Wilson and Holland 1974) also indicated that mating ratios had no significant effect on subsequent hatchability of fertile eggs in mass mating.

**Individual mating** Results showed no significant effects of mating ratio on fertility and hatchability of quail in individual mating *(Table 3)*. However, the fertility and hatchability were numerically better for the 1:2 ratio group. These results were in concurrence with those obtained by Hughes et al. (1980), that single male matings in the $D_1$ strain coturnix quail with up to three females did not have significant effect on reproductive traits. Supramaniam et al. (1989) also reported that the mating ratio of 1:3 did not significantly affect the hatchability of Japanese quail when compared with other lower mating ratio groups.

There was no significant difference between mass mating and individual mating procedures on fertility and hatchability from fertile eggs within each mating ratio group *(Table 3)*. Hatchability of total eggs set was, however, significantly better for the individual mating procedure in the 1:4 and 1:6 ratio groups. The overall mean of hatchability, irrespective of the ratio, was also significantly better for those from individual mating. The hatchability of fertile eggs also showed the same pattern although no difference was found when making comparison within each ratio group.

Based on the pooled data, regardless of the mating procedures *(Table 4)*, it was clearly demonstrated that sex ratio of 1 male to 2 females improved fertility ($p < 0.05$) as compared with the other ratios. The hatchability of the total eggs set from the same ratio was significantly better than those from 1:6 and numerically better than the rest of the ratio groups. Results of the hatchability of the fertile eggs also indicated that 1:2 ratio was better (not significant) than

Table 4. Effects of mating ratio on reproductive performance of Japanese quail irrespective of mating procedures

| Mating ratio | Total eggs set | Fertility (%) | Hatchability (%) | |
|---|---|---|---|---|
| | | | Total eggs set | Fertile eggs |
| 1:1 | 1 513 | 83.9a | 61.9ab | 73.7 |
| 1:2 | 1 594 | 87.7b | 67.5a | 76.6 |
| 1:4 | 2 110 | 83.7a | 62.5ab | 74.7 |
| 1:6 | 2 142 | 81.0a | 58.5b | 71.3 |
| SE of mean | | 1.3 | 2.1 | 2.2 |
| LSD (at 5%) | | 3.5 | 5.8 | 6.0 |

a,b = Values in any column with different letters are significantly different ($p < 0.05$)

the others. It, therefore, appears that more advantages for the reproductive traits could be gained if a mating ratio of 1:2 was used. Supramaniam et al. (1989), however, recommended that a ratio of 1:3 was more appropriate under commercial production because more feed could be saved from feeding the extra males. Since the 1:3 ratio was not included in the this study, a definite conclusion could not be drawn. With regard to mating procedure, individual mating was found to be better than mass matings because more quailings could be obtained.

## Acknowledgements

The author wishes to thank Ms Azizah Mohd Din and Mr Zainodin Hitam for the assistance rendered during the course of the experiment. Thanks are also due to Mr Ahmad Shokri Othman for the statistical analysis of the data.

## References

Chiaravanont, C. (1978). Quail farming thriving. *Poultry Int. 17(9):* 40–6

Hertrampf, J. (1987). Quail in Asia. *Poultry Int. 26(5):* 114–22

Hughes, B. L., Jones, J. E. and Resseguie, W. D. (1980). Effect of male to female ratios on reproduction of cage coturnix $D_1$ breeders. *Poult. Sci.* **59:** 1339–41

Ino, T., Kawamoto, Y. and Sato, K. (1983). Origin and various characters of the Japanese quail. *Proc. 5th World congress of animal production 1983 2:* 131–2

Seet, C. P. and Azizah M. D. (1987). Growth performance and carcass characteristics of Japanese quail in Malaysia. *MARDI. Res. Bull. 15(1):* 55–8

Sreenivasaiah, P. A. and Ramappa, B. S. (1985). Influence of mating ratio and pre-incubation storage on fertility and hatchability of Japanese quail egg (*Coturnix coturnix japonica*). *World Review of Animal Production 21(4):* 3, 5, 25–8

Supramaniam, P., Saonah bte Noor, Mohamad bin Saad and Wan Yub Ibrahim bin Ahmad (1989). Pengeluaran puyuh telur dan daging. Laporan tahunan, Pusat Penternakan Unggas, Bukit Tengah, Jabatan Perkhidmatan Haiwan p. 24–43

Wilson, H. R. and Holland, M. W. JR. (1974). Male to female ratios for Bob-white quail breeders. *Poult. Sci. 53:*1571–5

Wilson, W. O., Abbott, W. K. and Abplanalp, H. (1961). Evaluation of coturnix (Japanese quail) as pilot animal for poultry. *Poult. Sci. 40:* 651–7

Woodard, A. E. and Abplanalp, H. (1967). The effects of mating ratio and age on fertility and hatchability in Japanese quail. *Poult. Sci. 46:* 383–8

Woodard, A. E., Abplanalp, H. and Wilson, W. O. (1965). Japanese quail husbandry in the laboratory (*Coturnix coturnix japonica*) Davis, U.S.A,: Department of Poultry Husbandry, University of California

*Accepted for publication on 10 July 1991*

*MARDI Res. J. 20(1) 1992: 73–78*

# Effects of perforated polyethylene bags and waxing on the quality of guava (*Psidium guajava* L. cv. Taiwan) during storage

[Kesan beg polietilena yang bertebuk dan pelilinan pada mutu jambu batu (*Psidium guajava* L. kv. Taiwan) semasa penyimpanan]

H. Abdullah*, M. A. Rohaya* and H. Salbiah**

Key words: guava cv. Taiwan, perforated polyethylene bags, waxing, storage

**Abstrak**

Jambu batu kv. Taiwan telah diberikan perlakuan-perlakuan iaitu pembungkusan dengan beg polietilena (PE) yang bertebuk, pelilinan dan gabungan kedua-duanya. Buah tersebut disimpan selama 6 minggu pada suhu 5 °C. Penggunaan beg PE yang bertebuk didapati lebih berkesan bagi memelihara mutu buah berbanding dengan pelilinan dari segi pengurangan kadar susutan berat dan pemerangan kulit semasa penyimpanan. Bagaimanapun, pelilinan lebih berkesan untuk melambatkan jangkitan penyakit dan sama kesannya dengan beg PE yang bertebuk bagi merencatkan pemasakan. Pelilinan menyebabkan kecederaan pada kulit buah iaitu warnanya berubah menjadi lebih perang walaupun diberi perlakuan gabungan kedua-duanya. Selepas 6 minggu penyimpanan, aras-aras asid tertitrat keseluruhan dan pepejal larut keseluruhan bagi perlakuan yang berlainan adalah sama. Penggunaan beg PE yang bertebuk dan pelilinan juga boleh memelihara kandungan asid askorbik semasa penyimpanan pada aras yang sama seperti buah yang baru dipetik. pH buah berubah-ubah antara perlakuan yang diuji.

**Abstract**

Guava cv. Taiwan were subjected to several treatments namely packing in perforated polyethylene (PE) bags, waxing and combination of both. The fruit were stored for 6 weeks at 5 °C. Packing in perforated PE bags was found to be more effective than waxing in maintaining the fruit quality in terms of reduction in weight loss and browning of the skin. However, waxing was beneficial in retarding disease development, and equally effective as the perforated PE bags in delaying fruit ripening. Waxing tended to injure the guava skin since browning continued even if waxing was combined with packing in PE bags. After 6 weeks of storage, the percentage of total titratable acidity and total soluble solids among the treatments were at the same levels. The use of PE bags and waxing preserved the ascorbic acid contents at a level similar to that of the freshly harvested fruit. The pH varied among the treatments.

## Introduction

The main problems encountered during low temperature storage of guava are excessive weight loss, browning and disease infection, all of which reduce the storage life and saleability of the fruit. According to Broughton and Leong (1979), guava of GU3 and GU4 cultivars are best stored at 20 °C. However, this temperature is considered too high for guava as it has been established that

*Food Technology Research Centre, MARDI Serdang, P.O. Box 12301, 50774 Kuala Lumpur, Malaysia

**Techno-Economic and Social Studies Division, MARDI Headquarters, P.O. Box 12301, 50774 Kuala Lumpur, Malaysia

Authors' full names: Abdullah Hassan, Rohaya Md. Atan and Salbiah Hj. Husin

all tropical fruits can tolerate a much lower temperature (Pantastico et al. 1975). Wills et al. (1982) reported that the storage life of fresh guavas can be extended by about 2 weeks at 5 °C with good retention of fresh fruit quality compared with storage at 20 °C.The temperature of 5 °C was also found to be suitable for Taiwan guava for a storage period of up to 3 weeks without showing any symptom of chilling injury (Abdullah 1985). However, the occurrence of skin browning was observed by Augustin and Azizah (1988) in Taiwan guava after 2 weeks of storage at 5 °C without any evidence of rot development.

The storage life of guava can be extended by wrapping it in appropriate packaging materials. Abdullah (1985) reported that the freshness of Taiwan guava was extended by another 3 weeks at 5 °C in fruit wrapped in either perforated or non-perforated low density polyethylene (PE) bags. The effectiveness of other packaging materials such as polypropylene (PP) and high density polyethylene (HDPE) was studied by Jamilah et al. (1988).

The application of wax emulsion to guava fruit was reported to reduce weight loss and gave the fruit a surface gloss (Wills et al. 1982). Other studies showed that waxing is effective in prolonging the storage life of a number of fruits such as citrus (Brusewitz and Singh 1985; Motlagh and Quantick 1988), mango (Dhalla and Hanson 1988) and banana (Abdullah et al. 1990). The use of wax coating has also been reported to control the development of physiological disorders during storage, especially the black heart in pineapple (Rohrbach and Paull 1982). The effectiveness of waxing in comparison to packing in perforated PE bags on Malaysian guava cv. Taiwan is reported in this paper.

## Materials and methods

### *Fruit and sample preparation*

The guava fruit of Taiwan cultivar at commercial maturity stage (approximately 19 weeks from fruit-set) were obtained from a private orchard in Bidor, Perak in August 1990. After harvesting, the fruit were transported immediately to the MARDI laboratory at Serdang, Selangor. The paper bags used by the farmer to protect the fruit at preharvest were retained during transportation in order to minimize mechanical injury. Upon arrival at the laboratory, the paper bags were removed and the fruit were washed and left to dry in the air. Only good quality fruit with firm texture and free from mechanical injury and disease infections were used in the study.

### *Treatment and storage*

The fruit were divided into five lots comprising 10 fruit each. Four lots were treated as follows:

- control (nil),
- wrapped in perforated PE bag,
- waxed, and
- waxed and wrapped in perforated PE bag.

Another lot of fruit were used immediately for initial quality evaluation. The bags used were 45.7 cm (length) x 30.5 cm (width) x 0.04 mm (thickness) with 0.5% perforation of the total area. Waxing was applied by spraying the fruit surface evenly with a specially formulated Carnauba wax emulsion (*Brogdex 119–559–20 guava wax supplied by Stansolv Chemical Pte. Ltd., Singapore) in the ratio of 1:2 (wax:water) as recommended by the supplier.

Fruit of control and waxing treatments were placed in telescopic fibreboard cartons with partitions. Two fruit were placed in each cell of the carton to represent a replicate. For the wrapped treatments either waxed or unwaxed, two fruit were placed in each PE bag to represent a replicate. The opening of the bag was folded approximately 10 cm from the top and placed in telescopic fibreboard cartons. Each

**This is not an endorsement of the product*

treatment comprised five replicates. The fruit were stored at 5 °C.

***Determination of weight loss, colour score, browning score and disease intensity***

The initial weight of each fruit was taken during the commencement of the experiment. The changes in weight of individual fruit were examined weekly. The colour score of the skin, browning score and disease intensity were examined weekly from the second week onwards. The following scales were used:

Colour: 1 = green
2 = less than 25% yellow
3 = 25–50% yellow
4 = more than 50% yellow

Browning: 0 = clean
1 = less than 10% brown
2 = 10–25% brown
3 = 25–50% brown
4 = 50–75% brown
5 = 75–100% brown

Disease: 0 = disease free
1 = slight
2 = moderate
3 = severe

***Determination of chemical composition***

The total soluble solids (TSS), pH and total titratable acidity (TTA) of fruit before and after storage were analysed according to Lam (1987). Ascorbic acid content was determined by titration with 2, 6 dichlorophenolindophenol (Ranganna 1977).

## Results and discussion

### *Weight loss*

*Figure 1* shows the effect of waxing and packing in PE bags on weight loss of guava during storage at 5 °C. The fruit weight loss in all treatments increased as the storage period was extended. Significant reduction in weight loss was observed in the treated fruit as compared with the control. Waxing alone was effective in reducing weight loss but was less effective compared with packing in perforated PE bags. The lowest percentage of weight loss was observed in

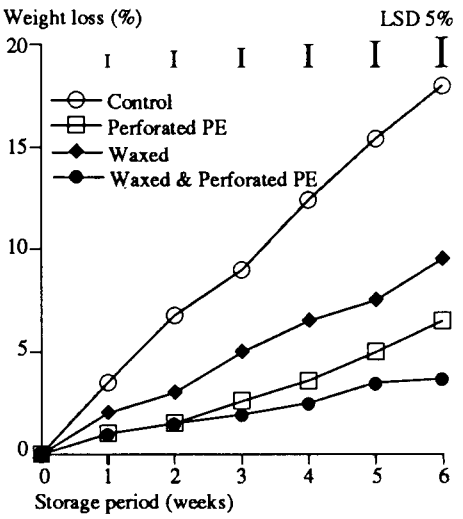


*Figure 1. Effect of waxing and wrapping in perforated polyethylene bags on weight loss of guava during storage at 5 °C*

waxed fruit packed in PE bags.

The effectiveness of waxing and packing in perforated PE bags in reducing the weight loss of guava is related to the ability of these materials to reduce moisture loss from the fruit. The wax coating on the fruit acts as a moisture barrier between the fruit and the surrounding atmosphere. In the case of packing in perforated PE bags, the formation of moisture-saturated air around the fruit surface plays a role in reducing excessive weight loss during storage.

### *Fruit appearance*

Colour development of guava skin between the second and the sixth week storage at 5 °C is shown in *Figure 2*. Both the waxed samples and those packed in perforated PE bags showed delayed colour change at almost the same rate. However, the colour of the waxed fruit packed in PE bag changed at almost the same rate as the control. The skin of the control fruit also turned brown faster than the treated ones, especially from the third week onwards *(Figure 3)*. The browning rates between the treatments were in the order of: control > waxing > combined treatment > packing in PE bags.

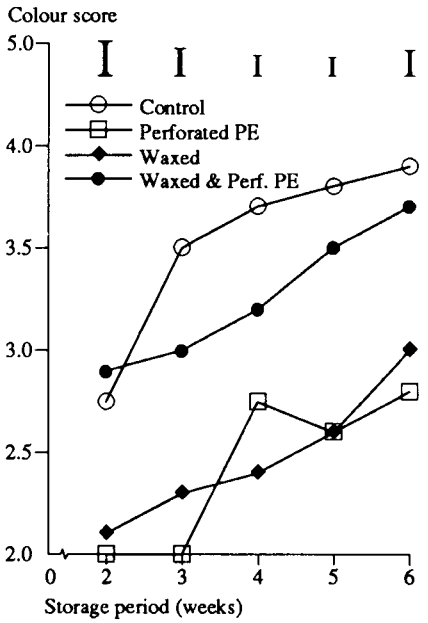


*Figure 2. Colour changes of guava skin during storage at 5 °C*

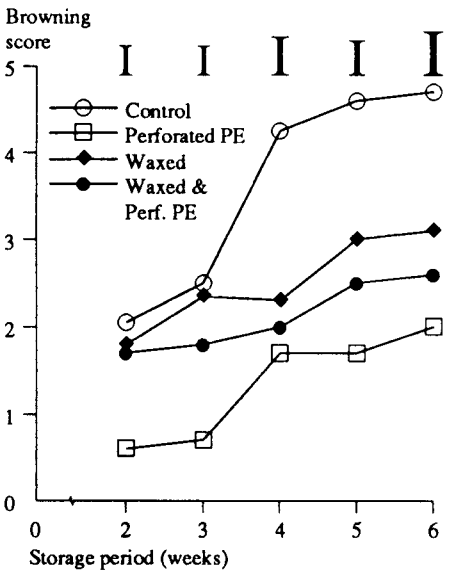


*Figure 3. Browning of guava skin during storage at 5 °C*

It was obvious that the fresh appearance of guava during storage was highly associated with the amount of moisture retained in the fruit. By applying wax or packing in perforated PE bags, colour development was slowed down, which also indicated that the ripening process was also delayed. Packing in perforated PE bags also minimized browning of the skin as the storage period was extended. Faster colour development and formation of the brown colour in the control fruit could be due to water stress, a condition similar to the observations made on rambutan (Lam et al. 1987). Water stress has been associated with the increase in respiratory activities and ethylene production in fruits which affect the storage life (Yang 1980).

Waxing also tends to delay ripening in guava. This is due to the dual effects of waxing in reducing moisture loss and respiratory activity. According to Tongdee et al. (1990), besides reducing moisture loss, waxing restricts gas movement through the rind of fresh durian resulting in higher internal $CO_2$, lower $O_2$ and lower $C_2H_4$ concentrations compared with non-waxed fruit. The browning of the waxed guava was probably due to the injury caused by the wax formulation itself. This was evident in the fruit given the combined treatments (waxed and packed in perforated PE bag) which still developed the brown colour at a relatively higher level than the fruit wrapped in perforated PE bag alone. Similar observation has also been made on starfruit by using the same wax formulation (Rohani, M. Y., MARDI, Serdang, pers. comm. 1990).

*Disease development*

Disease infection was observed from the fourth week of storage onwards *(Figure 4)*. On the fourth week, the disease scores were at low levels for the control, samples in PE bags and waxed samples in PE bags but almost negligible for the waxed fruit. As the storage period lengthened, disease intensity increased steadily where the scores were highest for the control fruit and the lowest in the waxed fruit. Fruit, either waxed or unwaxed, packed in perforated PE bags, had the same levels of disease occurrence throughout storage.

Augustin and Azizah (1988) reported that the presence of rots in guava cv. Taiwan was not evident during storage at 5 °C up to 25 days. Apparently, excessive moisture loss in the control fruit also resulted in the drying up and destruction of cell structure on the skin. This condition was ideal for infection to take place. The use of PE bags and waxing has reduced the level of infection considerably. However, waxing tended to be more effective than packing in perforated PE bags in disease control. This is probably due to the fact that waxing also sealed-off the fruit surface, especially the injured part from being easily infected, in addition to lowering the moisture loss.

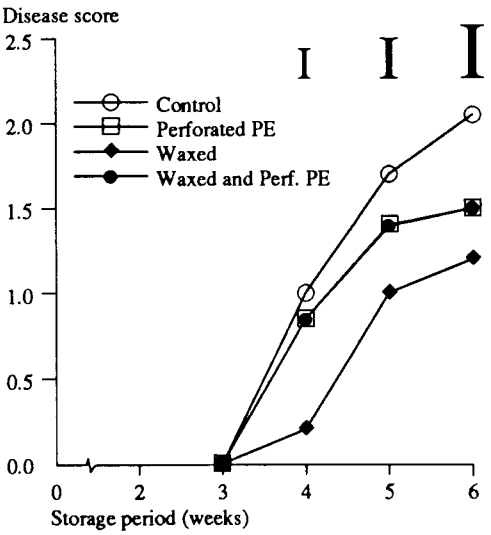


*Figure 4. Disease development on guava during storage at 5°C*

### *Chemical changes*

*Table 1* shows the amount of TTA, TSS, pH and ascorbic acid of freshly harvested guava and treated fruit after storage for 6 weeks at 5 °C. There was no significant difference in the TTA values of all fruit although the TTA values in the stored fruit tended to be higher than the fresh ones. These results are in agreement with Augustin and Azizah (1988) who reported no significant changes in TTA of guava during storage at the same temperature. The pH, however, showed a slight increase, especially in the waxed fruit and guava packed in PE bag up to 6 weeks of storage at 5 °C.

The TSS of all fruit after 6 weeks of storage was significantly higher than the freshly harvested fruit. This is in agreement with the results reported by Augustin and Azizah (1988). However, there were no significant differences in the levels of TSS among the treatments in the stored fruit which indicated that the TSS levels were not actually influenced by the type of treatment given. The ascorbic acid contents after 6 weeks of storage remained constant in the treated fruit but decreased significantly in the control as compared with the freshly harvested fruit. These results showed that both waxing and packing in perforated PE

Table 1. Chemical composition of guava after storage at 5 °C as compared with the freshly harvested fruit*

| Treatment | Total titratable acidity (%) | Total soluble solids (%) | pH | Ascorbic acid (mg/100 g flesh) |
|---|---|---|---|---|
| Freshly harvested | 0.54a | 7.4b | 3.70c | 65.8a |
| 6 weeks storage at 5 °C | | | | |
| Control | 0.57a | 9.3a | 3.98bc | 25.6b |
| Wrapped in perforated PE bag | 0.58a | 8.6a | 4.22a | 86.4a |
| Waxed | 0.67a | 8.6a | 4.04ab | 71.3a |
| Waxed & wrapped in perforated PE bag | 0.58a | 8.7a | 3.80c | 85.5a |

*Each value is the mean of five replicates. Mean values with the same letters in the same column are not significantly different from each other at 5% level by DMRT.

bags helped to preserve the ascorbic acid content in guava during storage at 5 °C.

**Acknowledgements**

The authors wish to express their appreciation to Mr Talip Yacob and Mr Zholkarnain Jaafar for their assistance which led to the completion of the study. Sincere thanks are also extended to Stansolv Chemical Pte. Ltd., Singapore for supplying the wax.

## References

Abdullah, H. (1985). Postharvest physiology, storage and handling of tropical fruits. Food Technology Division, MARDI Annual Report, p. 16–26

Abdullah, H., Lizada, M. C. C., Tan, S. C., Pantastico, Er. B. and Tongdee, S. C. (1990). Storage of banana. In *Banana: Fruit development, postharvest physiology, handling and marketing in ASEAN* (Abdullah, H. and Pantastico, Er. B., ed.) p. 44–64. Kuala Lumpur: ASEAN Food Handling Bureau

Augustin, M. A. and Azizah, O. (1988). Postharvest storage of guava *(Psidium guajava* L. var. Taiwan). *Pertanika 11(1):* 45–50

Broughton, W. J. and Leong, S. F. (1979). Maturation of Malaysian fruits III. Storage conditions and ripening of guava (*Psidium guajava* L. var. GU3 and GU4). *MARDI Res. Bull 7(2):* 12–26

Brusewitz, G. H. and Singh, R. P. (1985). Natural and applied wax coatings on oranges. *J. Food Processing and Preservation 9(1):* 1–9

Dhalla, R. and Hanson, S. W. (1988). Effect of permeable coating on the storage life of fruits. II. Prolong treatments of mangoes (*Mangifera indica* L. cv. Julie). *Int. J. Food Sci. and Technol. 23:* 107–12

Jamilah, B., Augustin, M. A. and Heng, L. S. (1988). Sensory evaluations of packaged guava. *Proc. sem. on advances in food research in Malaysia II* 3–4 Feb. 1988, Serdang, Selangor (Jinap, S. and Jamilah, B., ed.) p. 85–90 . Serdang: Universiti Pertanian Malaysia

Lam, P. F. (1987). Physico-chemical changes and eating quality of bagged and unbagged guava (*Psidium guajava* L. cv. Taiwan) during maturation. *MARDI Res. Bull. 15(1):* 27–30

Lam, P. F., Kosiyachinda, S., Lizada, M. C. C., Mendoza, D. B., Prabawati, S. and Lee, S. K. (1987). Postharvest physiology and storage of rambutan. In *Rambutan: Fruit development, postharvest physiology and marketing in ASEAN* (Lam, P. F. and Kosiyachinda, S., ed.) p. 39–50. Kuala Lumpur: ASEAN Food Handling Bureau

Motlagh, F. H. and Quantick, P. C. (1988). Effect of permeable coatings on the storage life of fruits. I. Prolong treatment of limes (*Citrus aurantifolia* cv. Persian). *Int. J. Food Sci. and Technol. 23:* 99–105

Pantastico, Er. B., Chattopadhyay, T. K. and Subramaniam, H. (1975). Storage and commercial storage operations. In *Postharvest physiology, handling and utilization of tropical and sub-tropical fruits and vegetables* (Pantastico, Er. B., ed.) p. 314–38. Westport, Connecticut: AVI Pub. Co., Inc.

Ranganna, S. (1977). *Manual of analysis of fruit and vegetable products* p. 94–5. New Delhi: Tata McGraw-Hill Publ. Co. Ltd.

Rohrbach, K. G. and Paull, R. E. (1982). Incidence and severity of chilling induced internal browning of waxed Smooth Cayenne pineapple. *J. Amer. Soc. Hort. Sci. 107 (3):* 453–7

Tongdee, S. C., Suwanagul, A., Neamprem, S. and Bunrvengsri, J. (1990). Effect of surface coatings on weight loss and internal atmosphere of durian *(Durio zibethinus* Murray) fruit. *ASEAN Food J. 5(3):* 103–7

Wills, R. B. H., Brown, B. I. and Scott, K. J. (1982). Control of ripe rots of guavas by heated benomyl and guazatine dips. *Aust. J. Exp. Agric. Anim. Husb. 22:* 437–40

Yang, S. F. (1980). Regulation of ethylene biosynthesis. *Hort. Sci. 15:* 238–43

*Accepted for publication on 15 January 1992*