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Effect of Harvesting Stage and Storage Conditions on Storage Life of Okra(*Abelmoschus esculentus* L. Moench)

D.G.S. Ratnapala, B.C.N. Peiris[1]

Regional Agricultural Research and Development Centre
Angunakolapelessa

ABSTRACT. Okra pods are very susceptible to postharvest losses due to their tenderness. This study was therefore carried out to develop a suitable method to prolong the storage life of okra. The experiment consisted of two harvesting stages (6-8 cm. length -immature pods and 10-12 cm. length-mature pods) and four different storage conditions (11±2°C in polyethylene bags, 20±1°C in polyethylene bags, 20±1°C with 93±2% RH in cardboard containers and 27±2°C with 83±5% RH untreated - control). Immature pods stored under different conditions had higher weight loss when compared with mature pods. Pods stored at 11±2°C in polyethylene bags, at 20±1°C in polyethylene bags and at 20±1°C with 93±2% RH in cardboard containers reduced the crude fibre content in comparison to the control. Storage in polyethylene at 11±2°C was the best condition for longer storage life. Under this condition, both immature and mature pods maintained an acceptable appearance for 5 and 7 days, respectively. In addition, this storage condition reduced weight loss and crude fibre content when compared with other storage conditions tested.

INTRODUCTION

Okra (*Abelmoschus esculentus* L) a popular vegetable of tropical origin, is well adapted to hot humid climates. It is a good source of vitamin A and B, and contains vitamin C. It is rich in protein and minerals (Katyal, 1977). About 60% of okra grown in the world is used for processing. It has a high demand both in local and foreign markets.

Okra pods are attractive in the market when presented in a bright green and turgid form, free of blemishes with a high snapping quality. However, as okra is not a hardy crop it deteriorates rapidly and has a very high rate

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[1] Department of Crop Science, Faculty of Agriculture, University of Peradeniya

of respiration at warm temperatures (Hunt *et. al.*, 1987). Deterioration of okra pods occurs mainly in the form of shrivelling, discoloration and toughening. A controlled atmosphere of 5% to 10% CO_2 and 11.1°C to 12.8°C extends the storage life of okra for about a week (Salunkhe *et. al.*, 1984). However, under ambient conditions pods exhibit considerable unmarketable qualities within 24 hours of storage, drastically affecting both local and export markets (Labios, 1984). Therefore, the identification of agronomic factors, as well as postharvest methods to improve the shelf life of okra could be of considerable advantage. The general objective of the present investigation was to identify postharvest losses in relation to harvesting conditions, and to develop a suitable method of storage to prolong the storage life of okra.

MATERIALS AND METHODS

A field experiment was conducted at the University farm Dodangolla situated in the Intermediate zone in Sri Lanka, in 1992 *Yala* (May-September). The elevation of the site is 410 m above sea level. The major soil group of the experimental site is reddish brown latasol.

A split plot design with 3 replicates was used in the experiment. The stage of maturity was used as main plots and storage conditions were used as subplots. Seeds of variety MI-18 (mean germination 98%) were sown at a spacing of 0.6 m x 0.5 m in a plot measuring 44.4 sq meters. Four seeds were sown at each planting hole and seedlings thinned to 2 per plant hill 2 weeks after sowing. All forms of treatment received fertilizers according to the 1990 recommendations of the Department of Agriculture (135 kg N, 90 kg P_2O_5 and 90 kg K_2O/ha) (Anonymous, 1990). Insecticides were applied at different stages as a routine measure to control insect damage.

The pods were harvested at two stages of maturity.

These were :- stage 1 - Immature pods (6-8 cm length)

stage 2 - Mature pods (10-12 cm length)

Harvesting was done between 0700-0900 HRS. Harvesting and handling operations were carried out carefully to avoid bruising the pods. After collecting pods from each plot, the harvest was spread on paper, under the shade, sorted and stored under the different conditions stated below. Each storage condition contained 15 pods and the conditions were replicated thrice.

The storage conditions used in this study were :-

T-1 - $11 \pm 2°C$ temperature; Pods sealed in 300 gauge white polyethylene bags.

T-2 - $20 \pm 1°C$ temperature; Pods sealed in 300 gauge white polyethylene bags.

The size of the polyethylene bags was determined on the basis of the volume required for the number of pods. The dimensions of polyethylene bags used in T-1 and T-2 forms of treatment were :

For stage 1 (immature pods) - 26 cm x 21 cm

For stage 2 (mature pods) - 26 cm x 31 cm

T-3 - $20 \pm 1°C$ temperature and a relative humidity of $93 \pm 2\%$. The pods were kept in ventilated cardboard containers. Each container was partitioned into two (Plate 1). Pods from a particular treatment were packed randomly on one side of the container. A set of 6 containers was placed one over the other (Plate 2). The top of the container was covered with a flatboard.

T-4 - Ambient temperature ($27 \pm 2°C$ with $83 \pm 5\%$ RH) without packaging (control).

The following measurements were made daily up to 5 days and thereafter, at 2 day intervals for a further 4 days.

Discoloration

Score	Description
4	None
3	Slight, up to 10% surface affected by discoloration.
2	Moderate, up to 25% of surface affected by discoloration.
1	Severe, more than 25% of surface affected by discoloration.

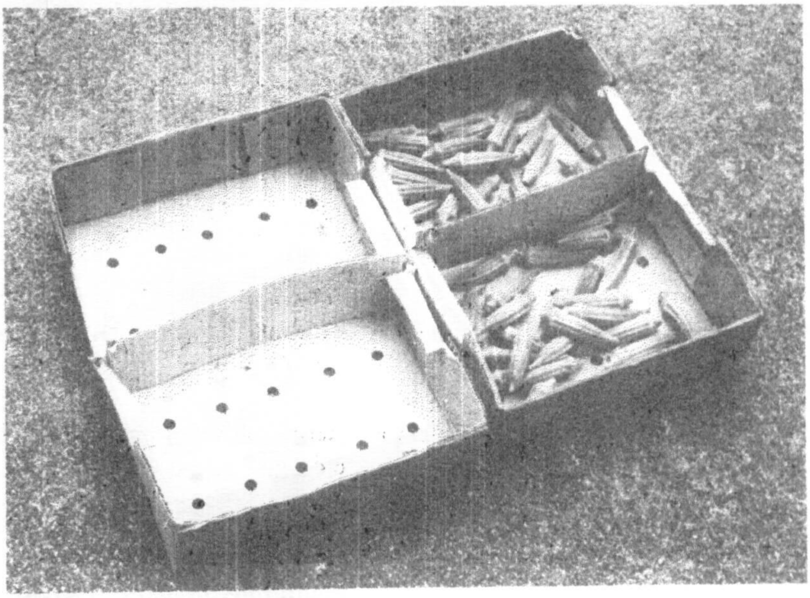


Plate 1. View of containers

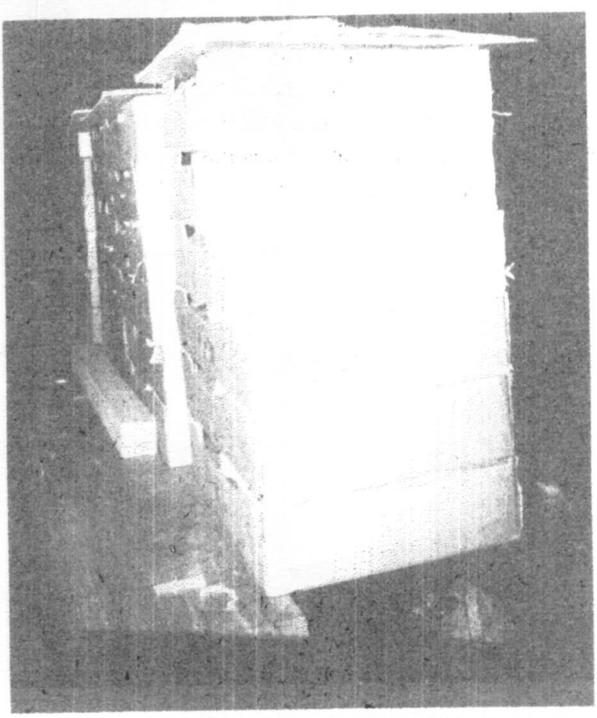


Plate 2. Arrangements of containers in storage.

Shrivelling

Score	Description
3	Turgid.
2	Moderately turgid.
1	Shrivelled.

Snapping quality

Score	Description
3	Snaps readily
2	Snaps moderately
1	Does not snap readily.

Visual quality rating

Score	Description
3	Good, a highly saleable produce.
2	Fair,
1	Poor, non edible, non saleable produce.

For visual qualities each pod was scored and the average for the smpl̶e was used as the index.

Weight loss

Each sample was weighted before and after storage. The percentage weight loss was calculated by using the following formula:

$$\textit{Weight loss } \% = \frac{(W_1 - W_2)}{W_1} 100$$

Where, W_1 - initial weigtht
W_2 - final weight

The crude fibre content of pods were determined as per method of Ranganna (1977).

RESULTS AND DISCUSSION

A. Visual quality parameters

There was a positive significant relationship between stage of maturity, storage conditions and visual qualities (discoloration, shrivelling, snapping quality and visual quality rating) of okra.

Discoloration

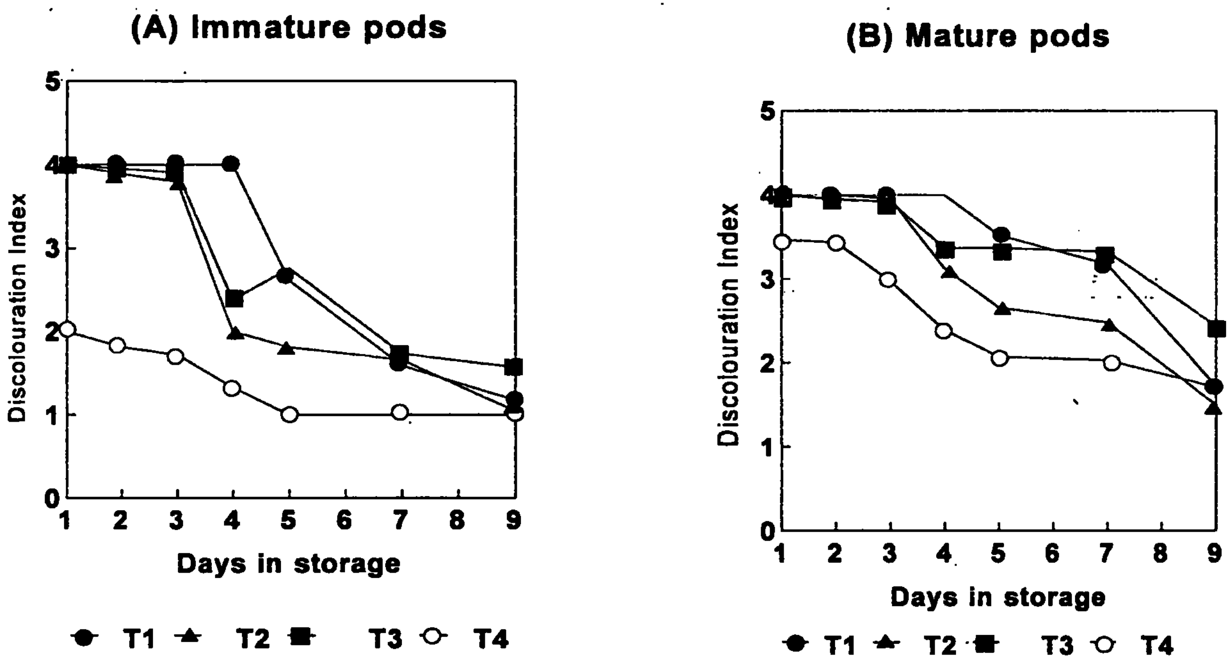
With increasing storage time discoloration increased in all forms of treatment (Figure 1). All pods stored in polyethylene at 11±2°C had no discoloration up to 4 days. Furthermore, immature pods (6-8 cm length) stored at 20±1°C in cardboard containers had lower discoloration than pods stored in polyethylene (T-2), (Figure 1). Pods stored under normal conditions had high discoloration. On the 7th day immature pods stored under all the storage conditions exhibited a high degree of discoloration, while the mature pods (10-12 cm length) stored at 11±2°C in polyethylene and at 20±1°C in containers did not exhibit high discoloration.

Shrivelling

All pods stored in polyethylene under different storage conditions remained turgid during the period of study. Immature pods stored in cardboard containers at 20±1°C lost their turgidity after 7 day of storage (Figure 2A). Mature pods had moderate turgidity at this time (Figure 2B). In the control treatment, immature pods were shrivelled even on the 2nd day of storage while the mature pods shrivelled after 3 days of storage. This could be due to high water loss (transpiration) in the ambient condition.

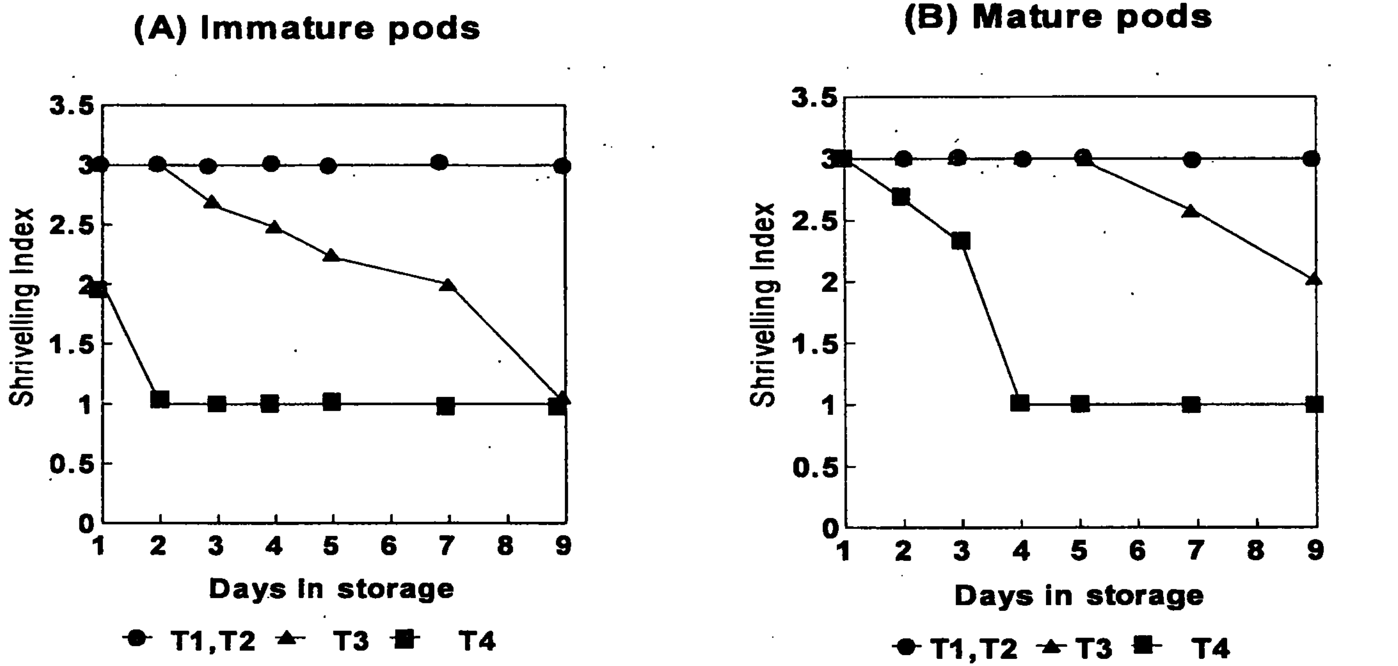
Snapping quality

Immature and mature pods stored in polyethylene at 11±2°C and 20±1°C snapped readily throughout the storage time (Figure 3A). Immature pods stored in containers at 20±1°C maintained a high snapping quality up to 5 days. On the 7th day these pods had a moderate snapping quality. In contrast, pods in this control treatment had poor snapping quality after 2 days of storage (Figure 3A). Mature pods stored in containers at 20±1°C



T-1 : 11±2°C in polyethylene bags, T-2 : 20±1°C in polyethylene bags, T-3 : 20±1°C and 93±2% RH in cardboard containers, T-4 : 27±2°C and 83±5% RH - untreated (control)

Figure 1. Discolouration of okra pods as affected by storage duration, pod maturity and storage conditions.



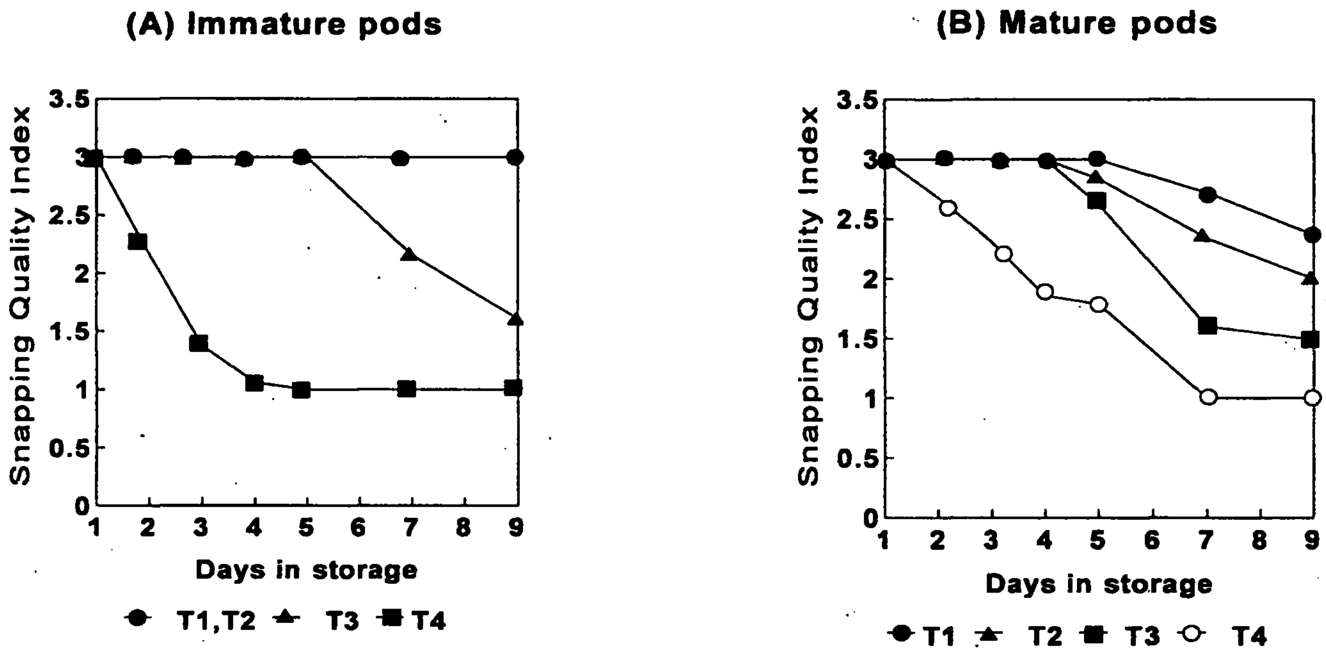
T1 : 11±2°C in polyethylene bags

T-2 : 20±1°C in polyethylene bags

T-3 : 20±1°C and 93±2% RH in cardboard containers

T-4 : 27±2°C and 83±5% RH - untreated (control)

Figure 2. Shrivelling of okra pods as affected by storage duration, pod maturity and storage conditions.



T-1 : 11±2°C in polyethylene bags
T-2 : 20±1°C in polyethylene bags
T-3 : 20±1°C and 93±2% RH in cardboard containers
T-4 : 27±2°C and 83±5% RH - untreated (control)

Figure 3. Snapping quality of okra pods as affected by storage duration, pod maturity and storage conditions.

drastically reduced their snapping quality after 5 days (Figure 3B). The mature pods in the control treatment had poor snapping quality after 3 days of storage.

Visual quality rating

Immature pods stored in polyethylene at 11±2°C and in containers at 20±1°C maintained good visual quality rating for 5 days of storage (Figure 4A). All pods in the control treatment (ambient condition) lost their superior visual quality rating early (Figure 4). Shrivelling and low snapping quality reduced their keeping quality. Mature pods stored in polyethylene at 11±2°C maintained their superior appearance up to 7 days, while those stored in containers at 20±1°C maintained good visual quality for 5 days (Figure 4B).

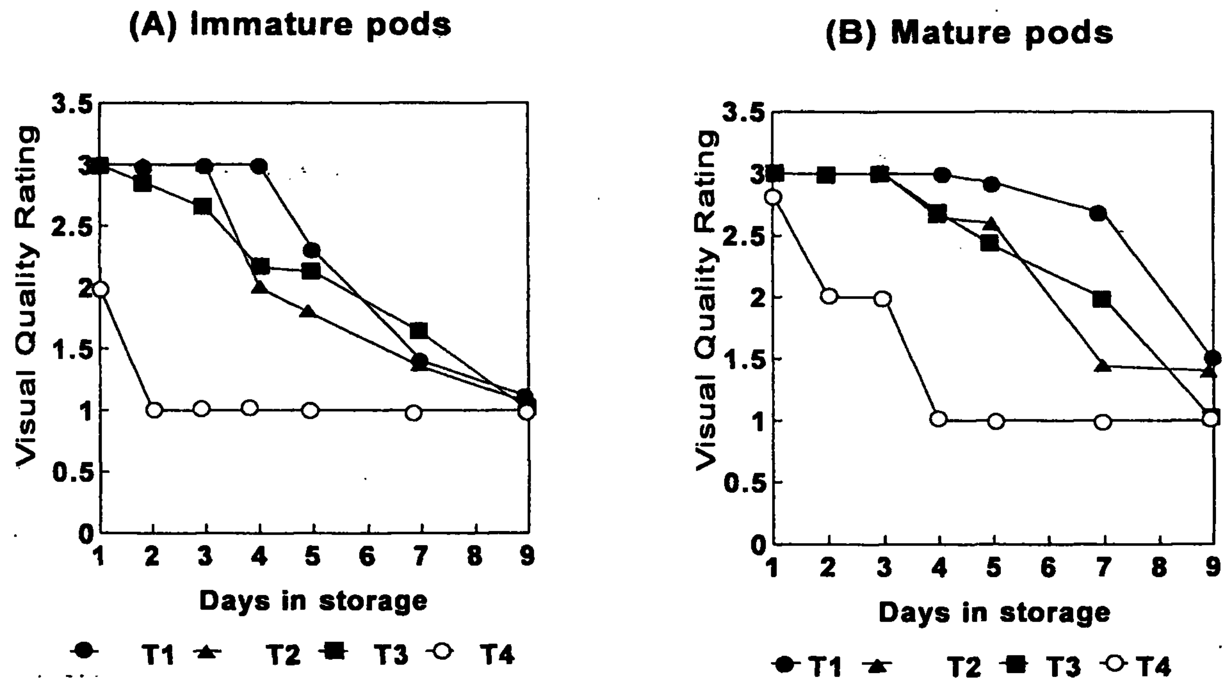
B. Weight loss

Stage of maturity and storage conditions showed a significant interaction with weight loss ($P=0.05$) on the 5^{th} and 7^{th} days of storage.

Weight loss in mature pods was lower than in immature pods. Mature and immature pods stored in the control treatment lost weight drastically when compared to other forms of treatment (Figure 5). The weight loss of pods in polyethylene at 11±2°C and 20±1°C was negligible (Figure 5). Hughes *et. al.*, (1981) also observed similar results with green capsicum and stated that the main effect of plastic film was a reduction in weight loss. Low weight loss in polyethylene packages could be due to lower rates of respiration (reduces the rate of substrate depletion) and transpiration. The weight loss of immature and mature pods stored in containers at 20±1oC was significantly higher than in pods stored in polyethylene at 11±2°C and 20±1°C. Additionally, it was significantly lower than in the control treatment.

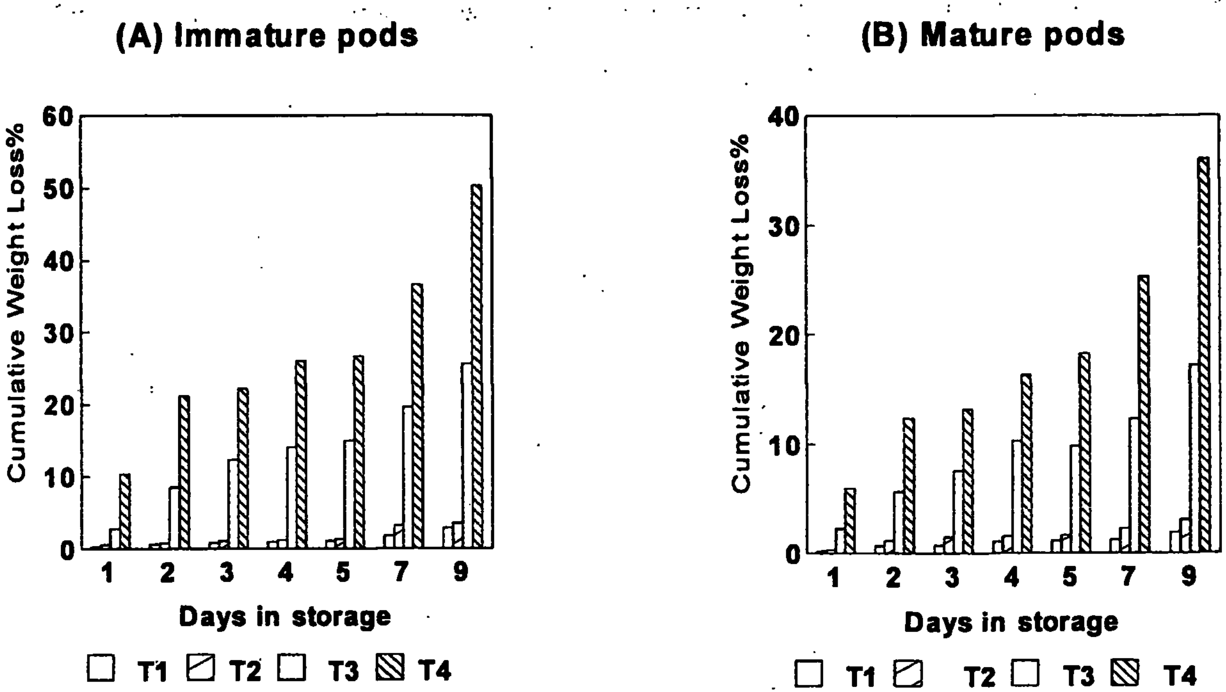
C. Storage period

The immature pods stored in polyethylene at 11±2°C and containers at 20±1°C had a longer storage period of 5 days when compared to other storage conditions. In contrast immature pods of the control treatment could



T-1 : 11±2°C in polyethylene bags
T-2 : 20±1°C in polyethylene bags
T-3 : 20±1°C and 93±2% RH in cardboard containers
T-4 : 27±2°C and 83±5% RH - untreated (control)

Figure 4. Visual quality rating of okra pods as affected by storage duration, pod maturity and storage conditions.



T-1 : 11±2°C in polyethylene bags
T-2 : 20±1°C in polyethylene bags
T-3 : 20±1°C and 93±2% RH in cardboard containers
T-4 : 27±2°C and 83±5% RH - untreated (control)

Figure 5. Weight loss of immature (A) and mature (B) okra pods, stored in different storage conditions.

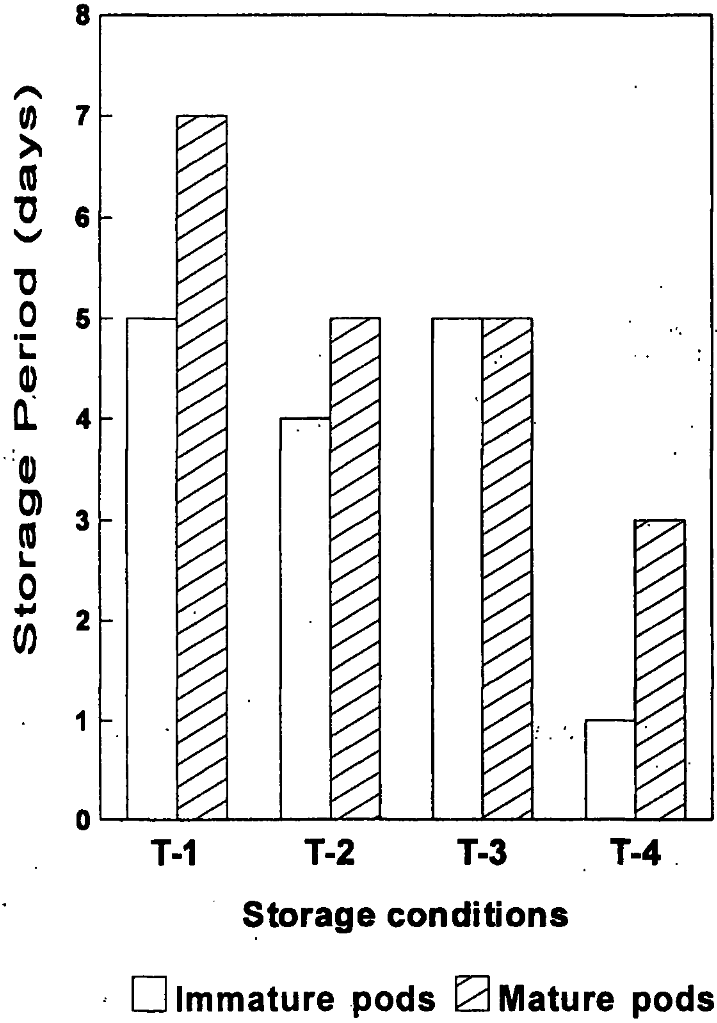
be stored only for one day (Figure 6). The mature pods stored in polyethylene at 11±2°C had the longest storage life (7 days), while pods stored at 20±°1C in polyethylene and containers could be stored for 5 days. The storage life of mature pods in the control treatment was only 3 days.

D. Crude fibre content

Crude fibre content increased with storage time in all treatments. Saltveit (1988) has also shown that the fibre content of asparagus spears increased with the storage period which was attributed to fibre development and lignification. The crude fibre content of immature pods changed marginally in all storage conditions (Table 1). However, immature pods stored at ambient conditions had the highest percentage (9%) when compared to the other storage conditions. There was no significant difference between the crude fibre content of pods stored in polyethylene at 11±2°C and 20±1°C. Mature pods stored in containers at 20±1°C had a significantly higher fibre content than pods stored in polyethylene. However, it was lower than the same in pods of the control treatment (Table 1).

CONCLUSIONS

The study revealed that weight loss of immature pods was higher when compared to mature pods under the different storage conditions. Pods stored in polyethylene at different temperatures and in cardboard containers at 20±1°C had a significant reduction in weight loss when compared with pods stored under ambient conditions. Furthermore, immature and mature pods stored in cardboard containers at 20±1°C with 93+2% RH maintained their quality for 5 days. Storage in polyethylene (300 gauge) at 11±2°C was the best condition for a longer storage life. Both immature and mature pods maintained an acceptable appearance under this condition for 5 and 7 days, respectively. Additionally, this storage condition reduced weight loss and crude fibre content when compared with other storage conditions tested.



T-1 : 11±2°C in polyethylene bags, T-2 : 20±1°C in polyethylene bags
T-3 : 20±1°C and 93±2% RH in cardboard containers
T-4 : 27±2°C and 83±5% RH - untreated (control)

Figure 6. Optimum storage period of okra pods in different storage conditions. (visual quality rating to score ≥ 2)

Table 1. Crude fibre content of okra pods in immature and mature pods, 7 days after storage.

Stage of maturity	Storage condition	Crude fibre content (%)	
Immature pods	T-1	8.47	a [z]
	T-2	8.62	a
	T-3	8.88	a
	T-4	9.05	a
	Initial	5.42	
Mature pods	T-1	9.86	a
	T-2	9.90	a
	T-3	11.32	b
	T-4	13.38	c
	Initial	6.85	
cv %		7.75	

The interaction between stage of maturity and storage condition was significantly different at the 5% probability level.

[z] Values in columns followed by the same letter of each maturity level are not significantly different at a 5% level.

T-1 : 11±2°C in polyethylene bags, T-2 : 20±1°C in polyethylene bags
T-3 : 20±1°C and 93+2% RH in cardboard containers
T-4 : 27±2°C and 83+5% RH untreated (control)

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