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Enhancing the postharvest shelf life and quality of papaya fruits using different packaging materials and storage conditions

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Abstract
In India, papaya is cultivated on an area of 68,000 ha with a total production of 2.15 million tonnes. Being a climacteric crop, papaya has relatively a shorter shelf-life and is characterized by increased respiration and ethylene evolution during ripening leading to fruit softening and susceptibility to postharvest diseases and mechanical losses. Postharvest loss in papaya is reported to be 40-100%. This study was conducted to assess the effects of packaging materials and storage environments on shelf life of papaya fruit (*Carica papaya* L.). A factorial combination of four packaging materials (LDPE, PP, stretch film and newspaper) and two storage environments using randomized complete block design with three replications were used. The physico chemical parameters like physiological loss in weight (7.26 %), TSS (11.4˚ brix), firmness (7.42 N), ascorbic acid (43.01 mg/100g) and total sugar (8.40%) were retained maximum in LDPE upto 16 days of storage as compared to control and other packaging materials under refrigerated condition.

Keywords: papaya, storage, packaging, shelf life

Introduction

India is largest producer of many fruits including papaya. The area and production of papaya has increased from 16050 hectare and 0.25 million tonne in 1965 to more than 67.7 thousand hectare and 1.58 million tonnes in 1998-99, respectively. The productivity of papaya is 23.4 tonnes per hectare.

Papaya has usually high amounts of bound water (37-43% as compared to <10% for other fruits). This bound water has high affinity to some structural components such as polysaccharides and proteins, and remains unfrozen even at -20°C. Quality changes associated with processed papaya products include development of off flavor and color modification after prolonged storage. Freezing and frozen storage (-18°C) produced an increase of peroxidase activity while polyphenol activity was only slightly affected. Papaya pulp has 13.5 °Brix, acidity 1.83% with 4.5 pH and total and reducing sugars of 10.6 and 10.4% respectively. The physiological and biochemical changes persistently occur after harvest till fruit become unfit for consumption with short shelf life. Nowadays, individual wrapping of fresh commodities have gained widespread interest to extend their shelf life. Individual wrapping have potential merits over traditional methods of packaging i.e., reduction in weight loss and deformation, maintenance of firmness, alleviation of chilling injury, reduction of decay from secondary infection, delay in colour development and senescence (Risse 2001) [7]. Cling film the plastic packaging film has revolutionized the food industry by protecting and preserving the food. Cling film is very thin polyethylene film that adheres to the fruit and serves as an extra covering.

Materials and Methods

Different packaging materials namely low density polyethylene (LDPE), polypropylene (PP), stretch film and newspaper were used to store the individual TNAU Papaya CO.8 fruits under two storage environments (refrigerated storage and ambient storage) with three replications were used in this study. The treatments were arranged in a randomized complete block design with three replications. The physico-chemical parameters viz., physiological loss in weight, firmness, total soluble solids, ascorbic acid, total sugars, which are the indicators of the storage quality were determined in this study.

Results and Discussion

1. Permeability of the Packaging Materials

The permeability of low density polyethylene (LDPE) and polypropylene (PP) of 3 different thicknesses was measured. The results indicate that the permeability of the packaging material decreases with increase in thickness of the material irrespective of the type of packaging material. The highest permeability of oxygen was observed in LDPE (50μ) which was 2354 ml/m^{2}day and the lowest was observed in LDPE (150μ) which was 1051 ml/m^{2}day. The highest permeability of carbon dioxide was observed in LDPE (50μ) which was 5954 ml/m^{2}day and the lowest was observed in LDPE (150μ) which was 2416 ml/m^{2}day (Table. 1).

Table 1: Permeability of the packaging materials

Packaging materials	Thickness (μ)	O_2 Permeability (ml/m^{2}day)	CO_2 Permeability (ml/m^{2}day)
LDPE-1	150	1051	3287
LDPE-2	100	1806	3880
LDPE-3	50	2354	5954
PP-1	150	1402	2416
PP-2	100	1987	3560
PP-3	50	2007	3653

2. Physiological loss in weight (%)

In ambient storage condition, maximum PLW was recorded in control (20.67 %) in 8 days of storage, whereas minimum PLW was recorded in LDPE (1.92 %) in 4 days of storage (Fig. 1). Similarly, under refrigerated storage condition, the interaction effect of packaging material and storage period recorded a maximum PLW in control (11.24 %) in 16 days of storage, whereas minimum PLW was recorded in LDPE (0.76 %) in 4 days of storage (Fig. 2). Similar results were also reported by Gonzalez *et al.*, (1990) [2] and Lazan *et al.*, (1990) [4].

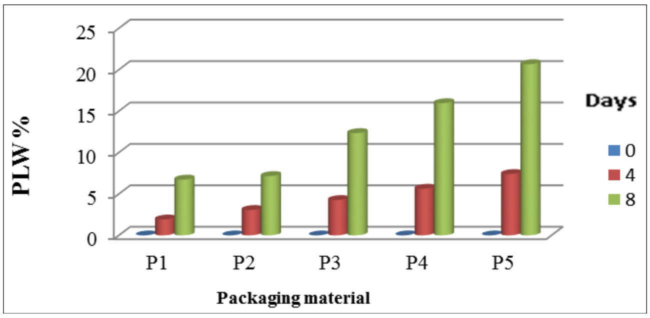

Fig 1: Effect of packaging material on PLW % of TNAU Papaya CO.8 fruits under ambient storage

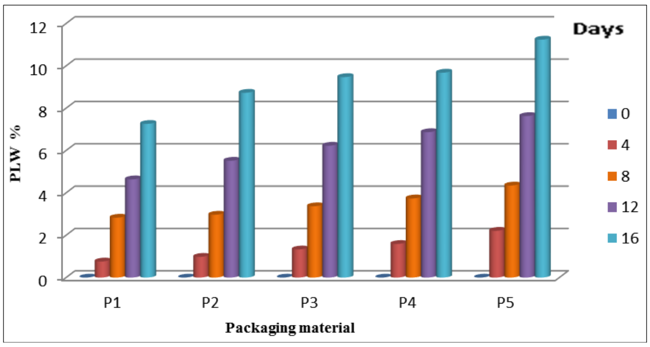

Fig 2: Effect of packaging material on PLW % of TNAU Papaya CO.8 fruits under refrigerated storage

3. Firmness (N)

The experiment resulted that under ambient storage condition, a maximum firmness was found in LDPE (12.73 N) in 0 days of storage and a minimum firmness of 0.24 N in control recorded in 8 days of storage (Fig. 3). In refrigerated storage condition, maximum firmness of 12.84 N was recorded in LDPE during 0 day of storage and minimum firmness of 3.19 N was recorded in 16 days of storage (Fig. 4). Generally, there was softening of fruits as the storage time progressed which could be due to texture modification through degradation of polysaccharides such as pectins, cellulose and hemicellulose that takes place during ripening (Irtwange, 2006) [3].

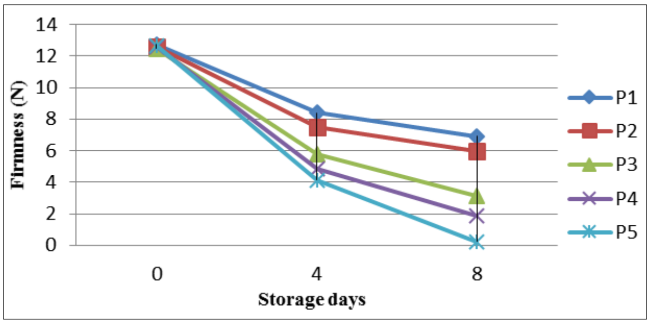

Fig 3: Effect of packaging material on firmness (N) of TNAU Papaya CO.8 fruits under ambient storage

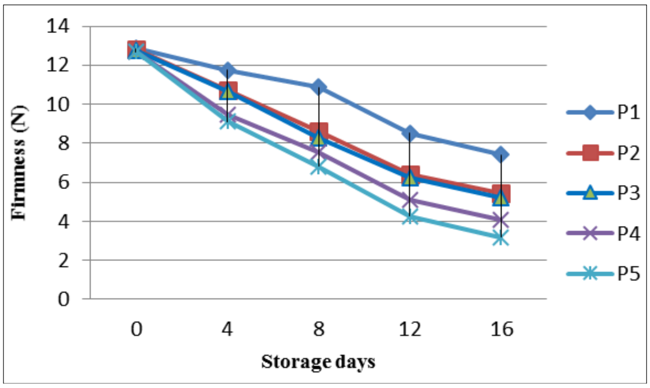

Fig. 4: Effect of packaging material on firmness (N) of TNAU Papaya CO.8 fruits under refrigerated storage

4. Total Soluble Solids (^{0} brix)

The total soluble solids (TSS) of papaya was recorded with respect to the period of storage, packaging material and also with respect to the interaction effect. Under ambient storage condition, a maximum TSS was recorded in control (12.80 ˚brix) in 4 days of storage and decreased to 11.40 ˚brix in 8 days of storage. Similar trend was also recorded for the refrigerated storage condition with a maximum TSS of 12.70 ˚brix was recorded in control during 12 days of storage and decreased to 10.80 ˚brix in 16 days of storage (Table 2). The TSS content of fruits packaged with LDPE and PP bags and stored in refrigerated condition increased slowly and reached their maximum on 16 days of storage. Hence, packaged fruits do not rapidly deplete their soluble solids as those of the control fruits as observed in this study. The decrease in TSS in prolonged storage was associated in the oxidative breakdown of sugars as a result of respiration and over-ripening. These results were supported by the earlier research findings of Rao and Rao in mango (2009) [6] and Sood *et al.* (2012) [8] in strawberry.

Table 2: Effect of packaging material and storage condition on TSS (˚ brix) of TNAU Papaya CO.8

Treatments	Ambient condition (S_1)				Refrigerated condition (S_2)					
	Storage period (days)				Storage period (days)					
	0	4	8	Mean	0	4	8	12	16	Mean
P_1	10.20	10.90	11.30	10.80	10.40	10.60	10.80	11.20	11.40	10.88
P_2	10.10	11.10	11.60	10.93	10.50	10.70	10.90	11.30	11.500	10.98
P_3	10.30	11.50	11.80	11.20	10.30	10.70	11.10	11.60	11.70	11.08
P_4	10.20	12.40	11.70	11.43	10.40	10.90	11.40	11.90	11.20	11.16
P_5	10.40	12.80	11.40	11.53	10.50	11.10	12.10	12.70	10.80	11.44
Mean	10.24	11.74	11.56	11.18	10.42	10.80	11.26	11.74	11.32	11.11

Source	Ambient condition			Refrigerated condition		
	Days (D)	Treatment (T)	Interaction (T×D)	Days (D)	Treatment (T)	Interaction (T×D)
S. Ed	0.130	0.168	0.291	0.096	0.096	0.216
CD (p=0.05)	0.266*	0.343*	0.595*	0.194*	0.194*	0.434*

*Significant level at 0.05%, NS- Non significant

P_1- LDPE - Low density polyethylene P_2- PP – Poly propylene P_3- Stretch film wrapping P_4- Newspaper wrapping P_5- Control	S_1 - Ambient storage S_2 – Refrigerated storage

5. Ascorbic Acid (mg/100g)

As a general trend, ascorbic acid content of papaya fruits increased during ripening under both storage conditions and showed a decline there after. This trend was in agreement in the previous reports by Wills and Widjanarko (1995) [10]. The authors reported that cell wall degradation during ripening provides substrates for ascorbic acid synthesis, explaining the ascorbic acid increase of papaya in advance in ripening (Bron and Jacomino, 2006) [1]. High retention of ascorbic acid content was noted in samples stored in low temperature. The interaction effect on ascorbic acid content was best at ambient storage (44.80 mg/100g) in 4 days of storage and LDPE (45.90 mg/100g) in 12 days of refrigerated storage (Table 3).

Table 3: Effect of packaging material and storage condition on ascorbic acid (mg/100g) of TNAU Papaya CO.8

Treatments	Ambient condition (S_1)				Refrigerated condition (S_2)					
	Storage period (days)				Storage period (days)					
	0	4	8	Mean	0	4	8	12	16	Mean
P_1	36.18	40.10	39.30	38.53	36.06	36.40	40.70	41.90	43.01	39.61
P_2	36.14	40.80	38.60	38.51	36.40	36.60	41.60	42.80	44.80	40.44
P_3	36.08	43.50	39.90	39.83	36.12	37.70	41.80	42.90	44.50	40.60
P_4	36.95	43.90	39.20	40.02	36.70	38.20	42.50	43.70	44.20	41.06
P_5	36.85	44.80	41.70	41.12	35.96	39.90	44.40	45.90	40.80	41.39
Mean	36.44	42.62	39.74	39.60	36.25	37.76	42.20	43.44	43.46	40.62

Source	Ambient condition			Refrigerated condition		
	Days (D)	Treatment (T)	Interaction (T×D)	Days (D)	Treatment (T)	Interaction (T×D)
S. Ed	0.377	0.487	0.843	0.399	0.399	0.894
CD (p=0.05)	0.770*	0.995*	NS	0.803*	0.803*	1.796*

*Significant level at 0.05%, NS- Non significant

P_1- LDPE - Low density polyethylene P_2- PP – Poly propylene P_3- Stretch film wrapping P_4- Newspaper wrapping P_5- Control	S_1 - Ambient storage S_2 – Refrigerated storage

Total sugar (%)

Total sugars of the stored papaya fruits recorded a significant variation over the storage period, packaging materials and also with respect to interaction effect. In ambient storage, maximum total sugar content was observed in control (9.90 %) in 4 days of storage and minimum on LDPE (7.36 %) 0 days of storage (Table 4). In the refrigerated storage, maximum total sugar content was recorded in control (9.88 %) in 16 days of storage and minimum in stretch film (7.30 %) in 0 day of storage. At both storage conditions, during the initial days of storage, the increase in total sugars might be attributed to the on-going ripening process of fruits. Later on a decline in total sugars was recorded, which might be due to the cellular respiration process and also the release of sugar by the hydrolysis of polysaccharides (Wills *et al.,* 1989, Ramakrishnan *et al.* 2010) [9, 1].

Table 4: Effect of packaging material and storage condition on total sugar (%) of TNAU Papaya CO.8

Treatments	Ambient condition (S_1)				Refrigerated condition (S_2)					
	Storage period (days)				Storage period (days)					
	0	4	8	Mean	0	4	8	12	16	Mean
P_1	7.36	7.70	8.30	7.79	7.40	7.60	7.80	8.20	8.40	7.88
P_2	7.49	7.80	8.60	7.96	7.50	7.70	7.90	8.30	8.50	7.98
P_3	7.43	8.50	8.70	8.21	7.30	7.70	8.10	8.50	8.60	8.04
P_4	7.47	8.80	8.30	8.19	7.40	7.90	8.30	8.70	8.40	8.14
P_5	7.38	9.90	8.40	8.56	7.50	8.10	9.30	9.88	7.80	8.52
Mean	7.42	8.54	8.46	8.14	7.42	7.80	8.28	8.72	8.34	8.11

Source	Ambient condition			Refrigerated condition		
	Days (D)	Treatment (T)	Interaction(T×D)	Days (D)	Treatment (T)	Interaction (T×D)
S. Ed	0.053	0.069	0.119	0.068	0.068	0.153
CD (p=0.05)	0.109*	0.141*	0.244*	0.137*	0.137*	0.308*

*Significant level at 0.05%, NS- Non significant

P_1- LDPE - Low density polyethylene
P_2- PP – Poly propylene
P_3- Stretch film wrapping
P_4- Newspaper wrapping
P_5- Control

S_1 - Ambient storage
S_2 – Refrigerated storage

Conclusion

The experimental findings revealed that, among the packaging materials and storage environments, TNAU Papaya CO.8 fruits packaged in LDPE and stored in refrigerated condition (14 ˚C) significantly influenced the physiological paramaters namely, physiological loss in weight (7.26 %), maximum firmness (7.42 N) and quality parameters namely, TSS content (11.40 ˚brix), ascorbic acid content (43.01 mg/100g), total sugar content (8.40 %) up to 16 days of storage.

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