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Evaluation of Different Packaging Films on Shelf Life and Quality of Bell Pepper (*Capsicum annuum* L.)

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ABSTRACT

Bell pepper (*Capsicum annuum* L.) is a highly perishable vegetable and needs appropriate handling and adequate care to maintain shelf-life and quality. In the present investigations, the post-harvest shelf life of bell pepper was evaluated using shrink film, cling film, low density polyethylene (LDPE) film and high density polyethylene (HDPE) film followed by storage at 8-10°C and 90-95% relative humidity. Data on weight loss, firmness, chlorophyll, ascorbic acid and sensory quality were recorded periodically. Shrink film proved to be the best packaging film in maintaining quality up to 20 days storage as indicated by minimum weight loss (1.28%); highest fruit firmness (1370 g force), highest retention of chlorophyll (0.062 mg%) and ascorbic acid (15.92 mg%). On the other hand, control fruit (unpacked) maintained marketable quality only up to 10 days. Shrink film packed bell pepper registered almost double the shelf-life compared to unpacked fruit.

Keywords: firmness, sensory quality, storage, weight loss
Abbreviations: HDPE, high density polyethylene; **LDPE**, low density polyethylene; **PLW**, physiological loss in weight; **RH**, relative humidity

INTRODUCTION

Bell pepper (*Capsicum annuum* L.) is one of the most important commercial vegetable crops of India. It is being grown on wider scale in net houses by the farmers due to its higher yield, better quality and good economic returns (Singh *et al*. 2002). However, it is a highly perishable vegetable with a short shelf life and high susceptibility to fungal diseases (Hardenburg *et al.* 1990; Shika and Dough 2001). Pepper fruits after harvesting commonly encountered many postharvest problems, such as strong physiological activities, quality degradation and rapid senescence (Smith *et al.* 2006; Bayoumi 2008). Most growers and produce handlers keep the perishables under ambient conditions where the quality of pepper deteriorates rapidly due to water loss leading to fruit softening, reduced glossiness and shelf life (Watada *et al*. 1987; Lownds *et al*. 1993; Maalekuu *et al*. 2002). Owing to perishable nature of the fruit and lack of awareness about handling practices, the farmers are forced to sell their produce at throw-away prices. The purpose of post-harvest handling system is to deliver appealing and nutritious food to the consumer in an economical manner. Handlers and consumers, therefore, attach a lot of importance to the retention of fruit colour, freshness and firmness as quality attributes during handling and storage (Sigge *et al*. 2001; Ozden and Bayindrili 2002) and these quality parameters are functions of storage environment such as temperature and relative humidity (Gorini *et al*. 1977; Jobling 2001).

The best way to maintain the quality of fresh fruits and vegetables is probably by conditioning them in an adequate temperature throughout the supply chain (Brecht *et al.* 2003). It is therefore, significant to avoid quick deterioration of capsicum in order to preserve its commercial quality. Packing of fruits in films creates modified atmospheric conditions around the produce inside the package allowing extended shelf life, lower physiological weight loss, reduce fruit decay and maintain retention of colour and texture of fruits (Nath *et al*. 2010). Thus, the present study was planned to investigate the effects of different packaging films on post-harvest shelf life and quality of bell pepper.

MATERIALS AND METHODS

Plant material

Fruit of bell pepper cv. 'Orobelle' grown under net house were harvested at the fully developed and bright green stage and sorted according to size. Those with defects or disease were discarded.

Packaging and storage

The commercially available packaging films of different thickness: low density polyethylene film (LDPE, 25 µm), high density polyethylene film (HDPE, 20 µm), shrink film (15 µm) and cling film (15 µm) were used. Fruit were packed in molded paper trays (22 × 13 cm) and tightly sealed in pouches made from the LDPE and HDPE films. Shrink film wrapped packs were sealed with a shrink wrapping machine (Model BS-450, Samrath Engineers, New Delhi, India) with the heating process occurring at 180°C and lasting for 10 sec. The cling film was wrapped around pack of capsicum with the help of cling wrapping machine. The control treatment was kept without packaging. There were 6 fruit in each tray. After packing, four small pin holes were made in all packs to prevent condensation of moisture inside packages. The packed and control fruit were stored at 8-10°C and 90-95% RH. The various observations were recorded at five day intervals for 20 days.

Quality evaluation

Physiological weight loss (PLW), after each storage interval, was determined by subtracting the final weight from the initial weight of the fruit. Fruit firmness was measured with a texture analyser (Model TA-HDi, Stable Micro System, UK). Fruit were placed on the platform of the instrument and compressed to a distance of 5 mm with a 75 mm diameter compression probe. Ascorbic acid

Received: 23 July, 2012. Accepted: 14 August, 2012.

Short Communication

content was determined by titration (AOAC 2005) and chlorophyll content were estimated as described by Ranganna (1979). Overall organoleptic rating of fruit was done by a panel of ten judges on the basis of external appearance of fruit, texture, and flavour and graded on a 9-point Hedonic scale (Amerine *et al*. 1965).

Statistical analysis

The experiment consists of five treatments (films) and four storage intervals and each treatment was replicated thrice. The experiment was arranged in a completely randomized design. SAS 9.3 was used for analysis of variance and p-values were worked out from data. The parameters which differed significantly at the $P < 0.05$ level were further subjected to mean comparison using LSD at 5% level of significance.

RESULTS AND DISCUSSION

Physiological loss in weight

A steady increase in the physiological loss in weight (PLW) of the fruits was observed with the advancement of storage period (**Table 1**). However, the fruit packed in shrink film registered the lowest PLW while the control fruit (unpacked) recorded the highest PLW during storage. The PLW of bell pepper in different packaging films ranged from 0.60-1.80, 0.90-2.10, 1.00-3.30, and 1.00-3.50% from 5 to 20 days of storage. On the other hand, in control fruits the PLW varied between 2.77-6.90%. The lower PLW in film-wrapped fruits may be attributed to the positive role of shrink polymeric films played in preventing dehydration by creating a saturated micro-atmosphere around the fruits (Gonzalez *et al*. 1999). The higher rate of PLW in control is probably due to higher moisture loss and increased respiration through uninterrupted atmospheric column and lower relative humidity in comparison to wrapped fruits (Wills *et al*. 1998). Sealing of cucumber (*Cucumis sativus* L.) in shrink wrap or other polymeric films has been reported to minimize weight loss (Elkashif *et al*. 1983; Homin and Woo 1999).

Table 1 Effect of packaging films on physiological loss in weight (%) of bell pepper.

Treatments	Storage days				
	5	10	15	20	Mean
Shrink film	0.60	1.20	1.50	1.80	1.28 ^{D}
Cling film	0.90	1.32	1.72	2.10	1.51 ^{C}
LDPE film	1.00	1.80	2.40	3.30	2.13 ^{B}
HDPE film	1.00	1.90	2.60	3.50	2.25 ^{B}
Control	2.77	3.70	4.85	6.90	4.56 ^{A}
Mean	1.25 ^{D}	1.98 ^{C}	2.61 ^{B}	3.52 ^{A}	

LSD at 5% Treatment = 0.12 Storage = 0.10 Treatment × Storage = 0.23

Table 2 Effect of packaging films on loss of firmness (g force) in bell pepper.

Treatments	Storage days					
	0	5	10	15	20	Mean
Shrink film	1450	1420	1390	1330	1260	1370 ^{A}
Cling film	1450	1408	1373	1310	1235	1355 ^{B}
LDPE film	1450	1382	1340	1270	1180	1324 ^{C}
HDPE film	1450	1390	1320	1284	1160	1321 ^{D}
Control	1450	1320	1204	1010	840	1165 ^{E}
Mean	1450 ^{A}	1384 ^{B}	1325 ^{C}	1241 ^{D}	1135 ^{E}	

LSD at 5% Treatment = 3.80 Storage = 3.80 Treatment × Storage = 8.50

Table 3 Effect of packaging films on chlorophyll content (mg%) in bell pepper.

Treatments	Storage days					
	0	5	10	15	20	Mean
Shrink film	0.080	0.060	0.058	0.056	0.055	0.062 ^{A}
Cling film	0.080	0.058	0.056	0.053	0.051	0.060 ^{B}
LDPE film	0.080	0.055	0.053	0.051	0.049	0.058 ^{C}
HDPE film	0.080	0.052	0.050	0.048	0.046	0.055 ^{D}
Control	0.080	0.053	0.041	0.037	0.036	0.049 ^{E}
Mean	0.080 ^{A}	0.056 ^{B}	0.052 ^{C}	0.049 ^{D}	0.047 ^{D}	

LSD at 5% Treatment = 0.002 Storage = 0.002 Treatment × Storage = 0.004

Table 4 Effect of packaging films on ascorbic acid content (mg %) of bell pepper.

Treatments	Storage days					
	0	5	10	15	20	Mean
Shrink film	20.5	18.6	16.0	13.5	11.0	15.9 ^{A}
Cling film	20.5	18.0	15.4	13.6	11.6	15.8 ^{AB}
LDPE film	20.5	18.0	15.0	13.0	10.5	15.4 ^{AB}
HDPE film	20.5	17.4	16.0	12.0	10.6	15.3 ^{B}
Control	20.5	16.2	14.0	11.2	9.0	14.2 ^{C}
Mean	20.5 ^{A}	17.6 ^{B}	15.3 ^{C}	12.7 ^{D}	10.5 ^{E}	

LSD at 5% Treatment = 0.53 Storage = 0.53 Treatment × Storage = ns

Firmness

The fruit firmness, in general, followed a declining trend commensurate with advancement in storage period (**Table 2**). The highest fruit firmness was observed in shrink film wrapped fruits, followed by cling film. Control fruit, on the other hand, had the lowest fruit firmness. The shrink film packed fruit maintained the highest firmness as compared to other packaging films throughout the stipulated storage period of 20 days and ranged between 1450-1260 *g* force. The control fruits experienced faster loss of firmness during storage and ranged between 1450-840 *g* force. The minimum loss in firmness and freshness of capsicum in shrink film may be due to maintenance of a modified atmosphere around fruit which reduces senescence and ageing and thus aids in retention of surface appearance (Nyanjage *et al.* 2005). Pongener *et al* (2011) reported higher firmness in peach fruits packed with shrink films.

Chlorophyll content

The chlorophyll content declined during storage irrespective of different packaging films (**Table 3**). However, the decline was more pronounced in control as compared to film packed bell pepper. Among different packaging films, the shrink film wrapped capsicum registered maximum chlorophyll content followed by cling film. On the other hand control fruit had the lowest chlorophyll content. The maintenance of higher chlorophyll content due to shrink packaging film might be due to reduction in respiratory activity and tissue deterioration (Kay 1991) which allowed the maintenance or retention of green color (Nyanjage *et al*. 2005).

Ascorbic acid

A steady decrease in the ascorbic acid of fruit occurred over time and irrespective of packaging films during storage (**Table 4**). However, the shrink film packaging maintained the highest mean ascorbic acid content followed by cling, LDPE, and HDPE film. The control fruits recorded the lowest ascorbic acid content. The fall in ascorbic acid during storage might be due to conversion of ascorbic acid into dehydroascorbic acid (Lin *et al.* 1988).

Sensory quality

Shrink wrap and cling packed bell pepper fruit maintained acceptable sensory quality score (7.0 on a 9 point scale) attributes up to 20 days. However, the control fruit maintained acceptable score (6.5) up to 10 days of storage and thereafter deteriorated at a faster pace (**Table 5**). The effect of shrink polymeric film in maintaining sensory quality of vegetables and fruits might be due to its role in maintaining colour, firmness and freshness due to creation of modified atmospheric conditions inside the package (Goyal and Russel 1991; Kudachikar *et al*. 2007; Pongener *et al*. 2011).

Table 5 Effect of packaging films on sensory quality of bell pepper.

Treatments	Storage days					
	0	5	10	15	20	Mean
Shrink film	8.00	7.80	7.50	7.20	7.00	7.50 [A]
Cling film	8.00	7.80	7.50	7.20	7.00	7.50 [A]
LDPE film	8.00	7.50	6.80	6.00	5.00	6.66 [B]
HDPE film	8.00	7.20	6.50	6.00	4.80	6.50 [B]
Control	8.00	7.00	6.50	5.00	3.00	5.90 [C]
Mean	8.00 [A]	7.46 [B]	6.96 [C]	6.28 [D]	5.36 [E]	

LSD at 5% Treatment = 0.30 Storage = 0.30 Treatment × Storage = 0.67

CONCLUSIONS

From the present studies, it can be concluded that green capsicum placed in paper moulded tray followed by packing with shrink film can be successfully stored at 8-10°C and 90-95% RH for 20 days with minimum weight loss, highest fruit firmness, highest retention of chlorophyll and ascorbic acid content. On the other hand, the control (unpacked) capsicum maintained marketable quality only up to 10 days. Shrink film packed bell pepper had almost double the shelf-life compared to unpacked fruit.

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