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Storage life and fruit quality of individually shrink-wrapped apples (*Malus domestica*) in zero energy cool chamber*

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Apple (*Malus domestica* L.) is considered as the most important temperate fruit crops of the world. In India, it is primarily grown in Himachal Pradesh, Jammu and Kashmir, Uttrakhand and to some extent in north-eastern states. 'Royal Delicious' cultivar dominates this region which matures by mid-August or early September and often results in the glut of fruits in the market (Chadha and Awasthi 2005). Many techniques are used to extend the storage life, but refrigeration and controlled atmosphere storage are mostly used. However, these facilities are very expensive and are mostly available in plains, and the producers have to bring the fruits to plains for storage, which results not only in high post-harvest losses but also lands in higher costs.

Considering the problems of marginal farmers, and importance of short-term storage in Indian conditions, zero energy cool chamber has been developed for short-term storage of fruits and vegetables (Roy and Pal 1991). Several farmers of India use this chamber for short-term storage of horticultural produce (Dadhich *et al.* 2008). However, it has not yet been effectively utilized for any commodity by transporting the produce from hills and then storing it in plains in this chamber. Similarly, shrink-wrapping is a new technique, which has been used in some fruits to reduce post harvest losses and to extend the shelf or storage life but it has not been effectively utilized in apple, although on the basis of log-term experience, Batagurki *et al.* (1995) have strongly recommended its use in India. Thus, considering the importance of zero energy cool chamber and usefulness of shrink-wrapping this study was conducted.

These studies were conducted at the Division of Post Harvest Technology of the Institute, New Delhi during 2006–07. Fully mature 'Royal Delicious' apples were harvested from a private orchard at Kullu (Himachal Pradesh), packed in corrugated fibre board boxes (5 ply open top type) and transported to Delhi in about 14 hr. After sorting and grading, 100 fruits were either shrink-wrapped in heat shrinkable films, such as cryovac (9 µ), polyolefin (13µ) and LDPE (25µ) or were not wrapped at all (control). The fruits were kept in plastic crates and then stored in zero energy cool chamber having 100 kg capacity and 70 kg load for 60 days. The average temperature and relative humidity of the zero energy cool chamber during the period varied from 18 to 22°C and 82 to 88% respectively. Observations on physiological loss in weight (%), decay loss (%), firmness (N), juice recovery (%) and quality parameters like total soluble solids (%), acidity (%), ascorbic acid content (mg/100 g pulp) etc. were recorded immediately before wrapping in films and at 15 days intervals after wrapping.

Fruit firmness was recorded by measuring firmness force with the help of Instron texture analyzer and represented as N (Newton). Total soluble solids (%) was recorded with hand refractometer. Acidity was determined by titrating known amount of fruit juice with 0.1 N NaOH solution. Ascorbic acid (mg/100 g pulp) was also determined by following standard procedures. For recording all these parameters, 5 fruits were randomly selected from a single lot, which was replicated 5 times. Sensory evaluation of stored apples was conducted by a panel of 5 trained experts and represented on hedonic scale (0–9).

The experiment was laid out in completely randomized design with 4 treatments having 5 replications/treatment. Data obtained from different parameters between the years were non-significant and these were pooled and subjected to analysis of variance (ANOVA) as per standard procedure.

All heat shrinkable films have significantly influenced the Physiological loss of weight (PLW) and decay loss over unwrapped (control) apples stored in zero energy cool chamber. Among films, cryovac (9 µ) was most effective in reducing the physiological loss in weight (6.7%) and decay loss (6.5%) over unwrapped apples (12.5 and 11.9%,

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Table 1 Effect of heat shrinkable films on physiological loss in weight and decay loss of apple stored in zero energy cool chamber

Film	Storage period (days)									
	Physiological loss in weight (%)					Decay loss (%)				
	15th	30th	45th	60th	Mean	15th	30th	45th	60th	Mean
Cryovac (9 m)	2.2	5.8	8.4	10.2	6.7	2.4	5.4	8.9	9.8	6.6
Polyolefin (13 m)	2.8	6.4	8.9	11.3	7.4	3.5	6.6	9.2	10.6	7.5
LDPE (25 m)	3.2	7.2	9.2	13.3	8.2	3.6	7.3	9.6	13.4	8.5
Unwrapped	5.3	9.2	15.2	20.4	12.5	5.5	9.8	14.2	18.2	11.9
Mean	3.8	7.2	10.4	13.8		3.8	7.3	10.5	11.9	
CD (P=0.05)	Film (F) = 0.3, Storage period (S) = 0.8, F × S = 1.2					Film (F) = 0.3, Storage period (S) = 0.7, F × S = 1.3				

respectively) at the end of 60th day storage in zero energy cool chamber. An increase in physiological loss in weight and decay loss was observed with the increase in storage period from 15th (3.8%) to 60th day of storage (Table 1). Interestingly, PLW was nearly 15% even on 45th day of storage in unwrapped apples, which increased to nearly 20% on 60th day of storage in zero energy cool chamber. Similarly, decay loss was quite high in unwrapped apples (14.2%) on 45th day of storage, which increased to 18.2% on 60th days of storage (Table 1). These observations suggest that heat shrinkable films were quite effective in reducing the physiological loss in weight and decay loss in apples in zero energy cool chamber. Reduction in physiological loss in weight or decay loss may primarily be due to creation of modified atmosphere around apples by the shrinkable films, and reduction in evaporation due to low temperature and high relative humidity in zero energy cool chamber. Zero energy cool chamber is known for reducing physiological loss in weight and decay loss in fruits and vegetables by lowering the temperature and increasing the relative humidity as compared to ambient conditions (Pal and Roy 1988, Roy and Pal 1991). Cryovac films were more effective in doing so, primarily because these films have ideal properties of gas and vapour permeability, which probably modified the atmosphere around the apples effectively than other films or control (Ladaniya 2003). Increase in physiological loss in weight or decay loss during storage has also been reported by Asrey *et al.* (2004) in strawberry.

Heat shrinkable films have significantly influenced fruit firmness (N) and juice recovery (%) of 'Delicious apples' stored in zero energy cool chamber. Interestingly unwrapped apples had much higher firmness force (27.6 N) over either type of heat shrinkable film used for wrapping of apples (Table 2). Among different heat shrinkable films, apples wrapped in cryovac films were comparatively firmer (24.1 N) than the other films and had least decline in firmness over storage period. Further, the firmness force decreased with the advancement of storage period from 15th (25.8 N) to 60th days (21.9 N) of storage (Table 2). Higher firmness force in unwrapped apples might due to higher loss of moisture from the fruits; as a result, their peel became hard, thereby requiring higher force for puncturing it by the probe of texture analyzer. Wrapped apples exhibited lesser physiological loss in weight as compared to unwrapped apples; hence, they had higher firmness force. Similarly, decrease in firmness force with the increase in storage period must be due to the fact that there is development of mealyness in the fruit pulp with the advancement in storage period, which took lesser force to puncture the fruit (Pal 1998). The juice recovery was the better in apples wrapped in heat shrinkable films over unwrapped fruits (52.2%) (Table 2). Among different heat shrinkable films, apples wrapped in

Table 2 Effect of heat shrinkable films on fruit firmness and juice recovery of apple stored in zero energy cool chamber

Film	Storage period (days)									
	Fruit firmness (N)					Juice recovery				
	15th	30th	45th	60th	Mean	15th	30th	45th	60th	Mean
Cryovac (9 m)	26.3	25.2	23.6	21.3	24.1	69.5	65.2	63.2	61.2	64.8
Polyolefin (13 m)	25.2	23.4	20.3	19.1	22.0	67.3	63.6	62.0	59.2	63.0
LDPE (25 m)	25.0	22.5	19.2	18.3	21.3	66.0	61.2	60.0	58.4	61.4
Unwrapped	26.7	27.2	27.8	28.8	27.6	65.0	56.2	45.3	42.2	52.2
Mean	25.8	24.6	22.7	21.9		67.0	61.6	57.6	55.3	
CD (P=0.05)	Film (F) 1.4, Storage period (S) 1.2, F × S 2. 4					Film (F) 2.2, Storage period (S) 3.7, F × S 4.1				

Initial values: Fruit firmness (N) = 26.4, juice content (%) = 71.2

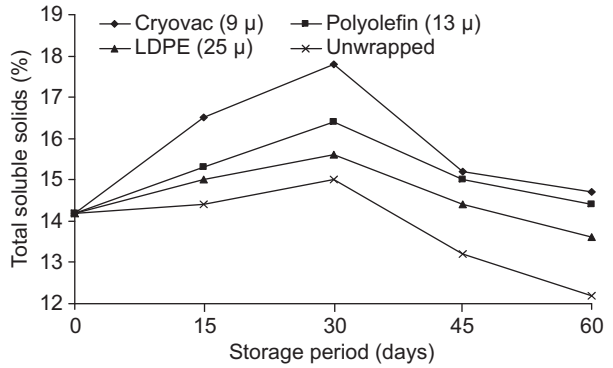

Fig 1 Effect of heat shrinkable films on total soluble solids of Delicious apples under zero energy cool chamber

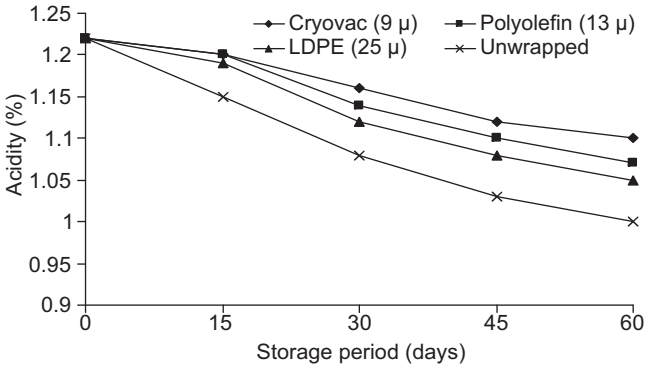

Fig 2 Effect of heat shrinkable films on acidity of Delicious apples under zero energy cool chamber

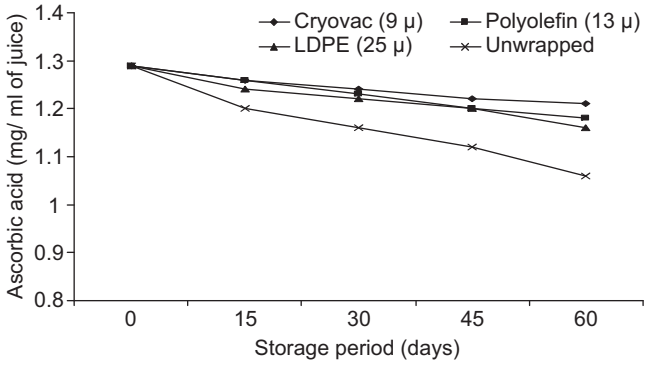

Fig 3 Effect of heat shrinkable films on ascorbic acid content in Delicious apples under zero energy cool chamber

cryovac films have highest juice recovery (64.8%) than those wrapped either in polyolefin (63.0%) or low-density polyethylene film (61.4%). The percentage of extractable juice decreased with the increase in storage period from 15th (67.0%) to 60th days of storage (55.3%) in zero energy cool chamber (Table 2). Reduction in juice recovery following increase in storage period was the least in apples wrapped in Cryovac films in comparison to other films or control. Such influence of heat shrinkable films on juice recovery may partly be due to differential rate of water loss from the fruits and ideal gas and vapour permeability properties of heat shrinkable films. Heat shrinkable films have been reported to positively influence the juice recovery in citrus, primarily due to reduction in physiological loss in weight over unwrapped fruits (Ladaniya 2003). Pandey *et al.* (2006) had also reported decline in juice recovery following increase in storage period of apples and Bhardwaj and Sen (2003) reported so in Nagpur santra stored in zero energy cool chamber.

Heat shrinkable films have significantly influenced the quality parameters like total soluble solids, and ascorbic acid content of apples stored in zero energy cool chamber. Apples wrapped in Cryovac films had highest total soluble solids (16.1%) and those in control had the least (13.7%) (Fig 1). Total soluble solids increased sharply in apples packed in Cryovac films from 15th to 30th day of storage and then declined linearly over storage period than those packed either in polyolefin film or those under control (Unwrapped) (Fig 1). However, in general TSS content increased with the increase in storage period from 15th (15.3%) to 30th day (16.2%) and then started decreasing on 45th day of storage (14.5%), and reached to 13.7% at the end of 60th day (Fig 1). In zero energy cool chamber, the influence on total soluble solids was significant because of low temperature and high humidity inside the chamber in comparison to room temperature. Juice acidity showed declining trend over storage period and heat shrinkable films also had significant effect on it (Fig 2). Further, apples packed in Cryovac films have significantly higher ascorbic acid content (1.23 mg/100 g pulp) over those kept under control (1.14 mg/100 g pulp) (Fig 3). Similarly, there was significant decline in ascorbic acid content with the increase in storage period from 15th day (1.24 mg/100 g pulp) to 60th day of storage in zero energy cool chamber (1.15 mg/100 g pulp). Such influence of heat shrinkable films or storage period on ascorbic acid content has also been reported by Ladaniya (2003).

On an average, apples packed in Cryovac films have highest sensory score (8.7) while least score (5.6) was recorded by the unwrapped apples, primarily because apples packed in Cryovac films have attractive colour, and texture and these were juicier and sweeter than those packed in other heat shrinkable films or unwrapped ones. Similarly, the sensory score decreased with the increase in storage period from 15th (7.9) to 60th day of storage (6.1), primarily because with the increase in storage there was decline in all attributes like colour, texture, TSS, sweetness etc., responsible for high score initially.

Thus, it can be concluded that Cryovac heat shrinkable films were the best for extending the storage life of apples in zero energy cool chamber up to 45 days without affecting their colour, texture or quality.

SUMMARY

Studies were conducted during 2006–07 to observe the effect of individually shrink-wrapped apples on storage life and quality under zero energy cool chamber. Fully mature 'Royal Delicious apples were either shrink-wrapped in 3 heat shrinkable' films, viz. cryovac (9 µ), polyolefin (13 µ) and low-density polyethylene (25µ) or were not wrapped at all (control) and then stored in zero energy cool chamber for 60 days. Cryovac (9 µ) films exhibited the least physiological loss in weight (6.7%) and decay loss (6.5), and higher juice recovery (64.8%) and total soluble solids (16.1%) over other films or control. Physiological loss in weight and decay increased with the increase in storage period and total soluble solids showed increasing trend up to 30th day of storage. Apples wrapped in cryovac films also had higher sensory acceptability (7.7) over the other films or control (5.5) indicating that Cryovac film was the best for shrink-wrapping of apples, and individually wrapped apples could be very well stored in zero energy cool chamber for 45 days without any adverse effect on quality parameters.

REFERENCES

Asrey R Jain R K and Singh R. 2004. Effect of pre-harvest chemical treatments on shelf life of Chandler strawberry (*Fragaria* × *ananassa*). *Indian Journal of Agricultural Sciences* **74**(9): 485–7.

Batagurki S B, Raghavan G S V, Smith J P and Orsat V. 1995. Plastic film packaging of apples and mangoes. *Phala Samskarana* **5**: 172–7.

Chadha K L and Awasthi R P. 2005. *The Apple*, pp 540–5. Malhotra Publishing House, New Delhi.

Dadhich S M, Dadhich H and Verma R C. 2008. Comparative study on storage of fruits and vegetables in evaporative cool chamber and in ambient. *International Journal of Food Engineering* **4** (1): 2.

Ladaniya MS. 2003. Shelf-life of seal-packed Mosambi sweet orange fruits in heat shrinkable and stretchable films. *Haryana Journal of Horticultural Science* **32**: 50–3.

Pal R K. 1998. Influence of ethrel and calcium carbide on respiration rate, ethylene evolution, electrolyte leakage and firmness of Dashehari mango (*M. indica*). *Indian Journal of Agricultural Sciences* **68** (4): 201–3.

Pal R K and Roy S K. 1988. Zero energy cool chamber for maintaining post-harvest quality of carrot (*Daucus carota* var. *sativa*). *Indian Journal of Agricultural Sciences* **58** (9): 665–7.

Roy S K and Pal R K. 1991. A low cost zero energy cool chamber for short term storage of mango. *Acta Horticulturae* **291**: 519–23.