Effect of shrink wrap packaging for maintaining quality of cucumber during storage

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Abstract Immature green cucumber cv. ‘Padmini’ fruits were individually shrink wrapped with Cryovac D955 (60 gauge) film and stored at 12 ± 1 °C, 90–95% RH as well as ambient conditions (29–33 °C, 65–70% RH). At 12 ± 1 °C and 90–95% RH, individual shrink wrapped cucumber recorded minimum Physiological loss in weight (0.66%) as compared with unwrapped fruits (11.11%) at the end of refrigerated storage (15 days). The softening (loss of firmness) was maximum (1304.6–876.6 g force) in unwrapped cucumbers whereas in shrink wrapping, minimum loss in firmness (1304.6–1065.3 g force) was observed after 12 days storage at 12 ± 1 °C and 90–95% RH but greater loss of weight and firmness makes the control cucumbers unmarketable after 9 days of storage. There were no rotting at all both in shrink wrapped and unwrapped cucumbers upto 15 days of storage at 12 ± 1 °C and 90–95% RH. After 15 days storage of shrink wrapped cucumbers at 12 ± 1 °C and 90–95% RH, there was loss of green colour and development of yellowness and decay. The sensory attributes score was highest in shrink wrapped cucumbers as compared to unwrapped cucumbers at end of both storage conditions. Thus it can be concluded that individual shrink wrapped cucumber can be stored well upto 15 days at 12 ± 1 °C and 90–95% RH and for 5 days at

ambient conditions (29–33 °C, 65–70% RH) with maximum retention of green colour, no spoilage, minimum weight and firmness loss and very good sensory quality attributes whereas, unwrapped fruits can be stored well upto 9 days at 12 ± 1 °C and 90–95% RH and for 2 days at ambient conditions with maximum retention of physico-chemical quality attributes.

Keywords Cucumber · Shelf life · Shrink wrapping · Storage · Quality

Cucumber (*Cucumis sativus* L.) is an important vegetable in the world but due to highly perishable nature, it is not suited for long term storage even at low temperature. The main deteriorative changes in cucumber during storage and distribution are mostly due to yellowing, loss of moisture leading to shriveling and physiological injury caused by low temperature (Adamicki 1985). Therefore the firmness, colour and size are important quality characters which affect the market price of cucumber. Additional quality indices are freedom from handling defects and decay. Cucumbers are susceptible to chilling injury at 10 °C or low temperature and yellowing at 15 °C or higher, therefore cucumbers must be stored at temperatures between 10 °C and 15 °C. Yellowing during the postharvest period is also observed if the fruits were harvested at an advanced stage of development or exposure to ethylene during storage. Further, they are very susceptible to shriveling and hence the humidity during storage, transport and marketing should be kept at 90–95%. Waxing is generally used to reduce moisture loss from cucumber but it increases the incidence of decay (Seagall et al. 1974). Researchers have studied the effect of shrink wrapping on storage life and quality of many fruits and vegetables (Ben-Yehoshua 1985; Heaton et al. 1990; Sonkar and Ladaniya 1999; Sudhakar Rao and

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Gopalakrishna Rao 2002; Singh and Sudhakar Rao 2005). Individual shrink wrapping (ISW), a form of modified atmosphere packaging is used to enhance the storage life and to maintain the harvest freshness of fruits and vegetables. The principal advantage of shrink wrapping are: reduced weight loss, minimized fruit deformation, reduced chilling injury and reduced decay by preventing secondary infection. Sudhakar Rao et al. (2000) studied the effect of MAP and shrink wrapping on shelf life of cucumber and reported that shrink wrapping with Polyethylene (PE) film can extend the shelf life of cucumber upto 24 days at 10 °C. Hence in the present studies were attempted to see the feasibility of shrink wrapping of cucumber for extension of storage life and maintaining quality at ambient as well as low temperature storage conditions.

Materials and methods

Immature green cucumber cv. 'Padmini' (Seminis Seeds Pvt Ltd) was harvested in 2nd week of June from the field of progressive farmer of district Ludhiana (Punjab). Misshapen, damaged, decayed and defective were sorted out and healthy uniform size green cucumbers were selected for the present studies. Ten cucumbers were randomly selected from the lot of experimental and their physical attributes were studied before shrink wrapping. The fruits were shrink wrapped with Cryovac D955 (60 gauge) film procured from Cryovac Division, W.R. Grace and Co., Duncan, SC. The Cryovac D955 film is a biaxially oriented high density polyethylene (O₂ and H₂O transmission rates; 8900 cm²/m²/24 h and 1.48 g/100 in./h respectively). Shrink wrapping was achieved by sealing individual cucumber in loose pouches of shrink wrap film and then passing through shrink wrapping machine (Model BS-450 shrink packing machine, Samrath Engineers, India) at 165 °C for 5–7 s. The storage of wrapped and unwrapped fruits were carried out in walk in cold room maintained at 12±1 °C and 90–95% RH whereas another lot was kept under ambient conditions (29–33 °C, 65–70% RH) of the laboratory.

The experimental data on physiological loss in weight (PLW), colour, firmness, sensory quality and decay were recorded at 1 and 2 days interval of storage at ambient and cold storage conditions, respectively. The PLW of the fruits was calculated as cumulative percent loss in weight based on the initial fruit weight and loss in weight recorded at the time of periodical sampling. The firmness of the fruit was measured with the help of Texture Analyzer (Model TA-HDi make, stable Microsystems, UK) having probe speed of 5 mm/s using compression platen (75 mm diameter) and expressed in gram force. Measurements were made at three

locations (top, middle and bottom) of each fruit with peel. For colour determination of each sample, the reflectance spectra were measured at 2 different points on the fruit surface and then the mean reflectance spectrum was obtained. These measurements were taken with colour difference meter (model: Mini Scan XE Plus, Hunter Lab, USA) and expressed as L, a, b Hunter colour values (Hunter 1975). Sensory evaluation of cucumbers consisted of preference rating for three sensory characters viz. appearance, flavour and texture by a 10 member trained panel using 9 point Hedonic scale (9 = excellent pleasant, 1 = very poor) for each of four sensory characters as per method described by Amerine et al. (1965). Decay percentage was measured in terms of extent of cucumber spoilage due to shrivelling and softening of fruit ends due to water loss, development of chilling injury symptoms and rotting due to appearance of disease was recorded and the cumulative fruit decay percent was worked out. The experiment was laid out in completely randomized design and each treatment was replicated thrice. The significance among treatment mean values was determined by least significant difference (LSD) at $p < 0.05$ level.

Results and discussion

Physiological loss in weight (PLW) Changes in the weight loss of individually shrink wrapped cucumber during ambient (29–33 °C, 65–70% RH) and cold storage (12±1 °C, 90–95% RH) conditions are shown in Fig. 1a and b. The weight loss was significantly less in all shrink wrapped fruits as compared to unwrapped fruits during both storage conditions. The higher weight loss (10.48%) in the control fruits after 4 days of storage at ambient conditions can be attributed to faster rate of respiration which makes the fruits unmarketable whereas shrink wrapped fruits registered the lowest mean PLW (1.08%) even after 6 days of storage at ambient conditions. After 12±1 °C and 90–95% RH, individual shrink wrapped cucumbers recorded minimum PLW (0.66%) as compared to that of 11.11% in case of unwrapped cucumbers at the end of 15 days storage but weight loss of upto 6% was observed from unwrapped fruits in the first 9 days of storage, afterwards the skin of cucumber gets shrivelled and fruits become unsaleable. The reduction in weight loss in shrink wrap cucumbers may be due to alleviation of water stress creation around each piece of cucumber which reduces respiration rate as the film is differently permeable to O₂ and CO₂ transmission and. Similar trend in weight loss of cucumber were reported by Sudhakar Rao et al. 2000 and Risse et al. 1985. Sealing cucumbers in plastic films was also reported to significantly reduce the weight loss during storage at different temperatures (Elkashif et al. 1983; Homin and Woo 1999).

Fig. 1 **a** Changes in physiological loss in weight (%) of shrink wrapped vs. unwrapped (control) cucumbers during cold storage (12 ± 1 °C, 90–95% RH). **b** Changes in physiological loss in weight (%) of shrink wrapped vs. unwrapped (control) cucumbers stored at ambient conditions (29–33 °C, 65–70% RH)

Firmness The firmness of cucumbers was measured with peel and presented in Fig. 2a and b. The study revealed that shrink wrapped cucumbers maintained their firmness and freshness during ambient and cold storage conditions as compared to unwrapped cucumber. Similar maintenance of firmness was also reported in many fruits and vegetables (Risse 1989), Cucumber (Elkashif et al. 1983; Sudhakar Rao et al. 2000), Papaya (Singh and Sudhakar Rao 2005), Mandarin (Sonkar and Ladaniya 1999), Pomegranate (Nanda et al. 2001). The loss in firmness was maximum (1304.6–876.6 g force) in unwrapped cucumbers and minimum (1304.6–1065.3 g force) in shrink wrapped cucumbers after 12 days storage at 12 ± 1 °C and 90–95% RH whereas at ambient conditions the loss in firmness was maximum (1304.6–766.4 g force) in control fruits after 4 days of storage as compared to shrink wrapping (1304.6–963.8 g force) even after 6 days of storage. The minimum loss in firmness and freshness of shrink wrapped cucumbers may be due to maintaining a modified atmosphere (MA) around each piece of cucumber combined with high relative humidity which reduces senescence and aging plus serve as an aid in the retention of fresh surface appearance, thus increasing shelf life of cucumber even at ambient storage conditions.

Decay Individual wrapping did not allow spread of decay, as rotting was restricted to individual fruit inside the film. It was observed that incidence of decay was the same or slightly less for the wrapped cucumbers compared to unwrapped at 12 ± 1 °C and 90–95% RH. However at ambient conditions the incidence of decay was higher in wrapped cucumbers after 5 days of storage. Similar observations for incidence of decay were reported by Risse (1989). The deterioration in quality especially in non-wrapped cucumber is not a result of pathological decay but a consequence of normal postharvest senescence. Hence wrapped cucumber exhibited a trace amount of fungal growth after 18 days of storage at 12 ± 1 °C, 90–95% RH and after 5 days of storage at 29–33 °C, 65–70% RH.

Colour Gardner colour measurements on unwrapped and shrink wrapped cucumbers were monitored under ambient and cold storage conditions for 6 and 18 days respectively (Table 1). Gardner L (lightness) values of shrink wrapped and unwrapped cucumber decreases with increase in storage period under both storage conditions. There was consistent decrease in the greenness value (–a) and increase in the yellowness value (+b) at both storage

Fig. 2 **a** Changes in firmness (g force) of shrink wrapped vs. unwrapped (control) cucumbers during cold storage (12 ± 1 °C, 90–95% RH). **b** Changes in firmness (g force) of shrink wrapped vs. unwrapped (control) cucumbers stored at ambient conditions (29–33 °C, 65–70% RH)

Table 1 Colour values and sensory score of shrink wrapped vs. unwrapped (control) cucumbers stored at ambient and cold conditions

Storage period, days	Shrink wrapped	Control	CD ($p \leq 0.05$) ($n=3$)	Storage period, days	Shrink wrapped	Control	CD ($p \leq 0.05$) ($n=3$)
Cold Storage conditions (12±1 °C, 90–95% RH)				Ambient conditions (29–33 °C, 65–70% RH)			
Hunter colour L							
0	58.3	58.3	0.0	0	58.3	58.3	0.0
3	54.2	57.3	1.6	2	52.8	51.2	0.5
6	50.5	51.4	0.9	4	52.7	48.5	0.9
9	47.7	45.3	1.5	6	49.1	–	–
12	46.6	45.2	1.2				
15	44.4	–	–				
18	44.2	–	–				
Hunter colour a							
0	–7.4	–7.4	0.0	0	–7.4	–7.4	0.0
3	–6.2	–7.6	0.7	2	–6.7	–6.5	0.3
6	–5.7	–7.0	0.7	4	–6.3	–5.9	0.2
9	–5.5	–6.5	0.6	6	–5.3	–	–
12	–5.2	–6.3	0.5				
15	–5.1	–	–				
18	–4.7	–	–				
Hunter colour b							
0	12.4	12.4	0.0	0	12.4	12.4	0.0
3	12.8	14.6	0.9	2	13.2	14.9	1.2
6	13.0	16.9	1.1	4	14.3	15.8	1.1
9	14.6	19.6	1.2	6	14.8	–	–
12	15.6	22.8	1.8				
15	16.2	–	–				
18	18.5	–	–				
Overall sensory quality score							
0	8.1	8.1	0.0	0	8.1	8.1	
3	8.0	7.6	0.2	2	7.7	7.0	
6	7.7	7.3	0.3	4	7.2	6.4	
9	7.5	7.1	0.2	6	6.7	–	
12	7.2	6.7	0.3				
15	7.0	–	–				
18	6.7	–	–				

conditions irrespective of whether they are wrapped or unwrapped. There was comparatively more increase in the yellowness in the unwrapped cucumbers as compared to shrink wrapped at 12 ± 1 °C and 90–95% RH as depicted from the value of “b”. The increase in the value of “b” in unwrapped cucumber (control) may be due to rapid chlorophyll degradation during storage. After 9 days of cold storage, unwrapped cucumbers have good colour values ($a = -6.48$, $b = +19.62$) but had lost weight substantially which makes them unmarketable whereas in shrink wrapped cucumbers after 15 days of cold storage, there was slight changes in the colour ($a = -5.05$, $b = +16.24$) and firmness but have poor sensory qualities especially flavour

which also makes them unsaleable. The development of off-flavour in cucumber may be due to anaerobic conditions in the atmosphere with in shrink-wrap package.

Sensory quality Values showing the effect of shrink wrapping on sensory qualities (appearance, texture and flavour) of cucumber during different storage environments are shown in Table 1. Fruits were moderately acceptable with total sensory score nearly 7.00 (1–9 Hedonic scale). Shrink wrapped cucumbers stored at 12 ± 1 °C, 90–95% RH obtained the height total sensory score (appearance, texture and flavour) of 7.02 after 15 days of storage period, thereafter the flavour deteriorated and score was less due

to slight off-flavour as perceived by the panelists. Decreased respiration and accumulation of higher CO₂ concentration inside the shrink wrapped cucumber might have led to anaerobic conditions and off-flavour. Our results are in conformity with those reported by Sudhakar Rao et al. (2000).

Conclusion

Shrink wrapping of cucumber followed by storage at 12±1 °C, 90–95% RH was found to be beneficial because it helped to extend the shelf life without deterioration in quality of fruit. Shrink wrap packaging reduced the weight loss, retained the freshness, colour and firmness of cucumber without any decay. The storage life of shrink wrapped cucumber can be extended upto 15 days at 12±1 °C, 90–95% RH and 5 days at ambient conditions (29–33 °C, 65–70% RH).

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