Indian J. Hort. 67(Special Issue), November 2010: 488-491

Short communication

Effect of waxing on shelf life and quality of apple

Kanika Issar, S.K. Sharma* and M.C. Nautiyal
Department of Horticulture, G. B. Pant University of Agriculture and Technology, Hill Campus, Ranichauri, Tehri Garhwal, Uttarakhand 249199

Apple is the most important fruit of Himalayan region. It is a perishable fruit and postharvest losses in the terms of quality and quantity occur at various stages of fruit handling right from harvesting, till the fruits reach the consumer and are consumed. These losses occur due to lack of proper infrastructural facilities like sorting and grading lines, packing of the harvested produce using modern techniques, non- availability of cold stores and lack of cool chain during transport and storage. Postharvest losses can be minimized by harvesting the fruits at an optimum maturity, pre- cooling of fruits prior to storage, sorting, grading and proper packing of the fruits, checking the rate of transpiration, respiration, microbial infection, ripening, pre and post harvest treatments, usage of refrigerated transport and proper marketing procedures (Madan and Ullasa, 5; Sharma, 10). For the last few years, the application of various chemicals and waxing material at the pre- and post-harvest stages is becoming popular among growers to enhance the shelf life of fruits. The objective for shelf-life extension in apple can be achieved to some extent by using wax emulsion coatings and storage in perforated polythene, fungicides and chemicals. All these treatments when

accomplished in Zero Energy Cool Chamber (ZECC) are supposed to extend the storability of fruits. During glut in the market, the farmers do not get remunerative prices of their produce. If they are able to store the fruits for some period, safely at their orchards itself and delay the transportation to the destined markets for about a month or so, they can fetch better prices of their produce. Keeping all these points in view, the present study was undertaken to study the effects of various post harvest treatments such as application of waxes, for extending the shelf life of apple fruits.

The present investigation was conducted at Hill Campus, Ranichauri, Uttarakhand during October, 2005 to January, 2006. Apple fruits of cv. Royal Delicious, harvested at optimum maturity, from private orchards in Harsil area of district Uttarkashi, (Uttarakhand) were procured and brought to the laboratory of Department of Horticulture, Hill Campus, Ranichauri, in the month of October 2005. Fruits after thorough sorting and grading were washed and hydro- cooled at 0-2^0 C for about 2 hrs, followed by drying under shade. The dried fruits were then used for conducting further experiments.

Fruits were divided into two lots. One lot was kept undisturbed for recording physiological loss in weight (PLW) and the other lot was used for recording rest of the parameters. The fruits were dipped in solutions of "Nipro Fruit Wax", Nipro Technologies Ltd. Panchkula, Haryana, India for about 2 min., dried in shade and treatments named as T_1= 10% wax + ambient storage; T_2= No wax + ZECC storage; T_3= 5% wax + ZECC storage; T_4= 10% wax + ZECC storage; T_5= 15% wax + ZECC storage. Nearly 2 kg fruits were used for the determination of PLW. All fruits were kept under the storage conditions of Zero Energy Cool Chamber (163 cm (l) x 120 cm (b) x 68 cm (h)) internal dimensions (Sharma and Nautiyal, 11) and temperature 3.10 to 19.80^{0}C, RH 92 $\pm$ 2% and evaluated periodically, for any changes in quality at different storage intervals viz., initial, 20, 40, 60, 80 and 100 days. The changes were also compared with 10 % wax treated fruits stored at ambient temperatures (10.20 to 32.00^{0}C, 57- 93% RH).

Standard methods were used for recording observations on various physical, chemical and sensory parameters. Total soluble solids were recorded at room temperature using Erma hand refractrometer and were corrected using Standard Reference Tables and expressed in terms of ^{0}Brix at 20 ^{0}C. Acidity was determined by titrimetric method (Ranganna, 8, Sharma and Nautiyal, 12). Total and reducing sugars were estimated using Lane and Eynon's (3) volumetric method as detailed by Ranganna (8). Starch content of apple fruits was estimated by Anthrone Reagent method as detailed by Sadasivam and Manickam (9). Pressure/ fruit firmness was determined with the help of Effigy penetrometer (Model FT 327). The number of fruits showing signs of decay or rotting were counted separately in each treatment at each storage interval. The cumulative number of rotten fruits was calculated at the end of storage period and expressed as %.

*Corresponding author's E mail: sksharmajee@gmail.com

Physiological loss in weight (PLW) was worked out as cumulative loss in weight of fruits under various treatments based on the initial fruit weight (before storage). The data pertaining to the sensory evaluation of fruits were analysed according to Factorial Randomized Design (RBD) as described by Mahony (7), while, that on physico- chemical characteristics by Factorial Completely Randomised Design (Cochron and Cox, 1).

The mean physiological loss in weight increased from nil to 15.72 % during 100 days of storage of apple fruits (Table 1), which might be attributed to, rapid loss of moisture through evapo- transpiration and respiration. The higher mean values of physiological loss in weight in the control fruits was due to the continued processes of respiration and transpiration for longer period at higher temperatures. While, the fruits treated with 10 and 15 % wax concentrations recorded less PLW. It might be due to the fact that wax coating acted as a barrier for loss of moisture from the fruit surface and storage at low temperature reduced transpirational losses.

The decrease in flesh firmness from 8.68 to 5.12 lb/ inch^2 during 100 days of storage of apples (Table 1) was probably due to the breakdown of insoluble protopectins, a major component of cell wall, into water soluble pectic compounds, during storage, which ultimately affected the cell wall consistency or softening of fruit skin. The waxing might delay the cellular disintegration by maintaining protein and nucleic acid synthesis, thus delaying senescence (Faust and Shear, 2). A consistent increase in the total soluble solids from 13.64 ^{0} to 16.84 ^{0}Brix during 100 days of storage of apple was due to the increase in the concentration of sugars. The higher mean values of TSS of apple fruits stored at ambient temperatures were probably due to higher rate of biochemical changes occurring at ambient conditions than that in the fruits stored under ZECC. The increase in TSS may also be due to the higher PLW of the fruits stored at ambient conditions, as a result of which there might have been an increase in the concentration of sugars.

Waxing of apple fruits reduced spoilage during storage. The reduced spoilage in waxed fruits was probably due to the covering of bruised points with wax and restricting the entry of microorganisms into the fruit. The maximum rotting (14.28 %) was recorded in the fruits with no wax treatment under ZECC conditions (Fig. 1). This might be due to the uncovered bruised surface and high relative humidity in ZECC which is conducive for the growth of microorganisms, while, minimum (0 %) rotting in 10 % wax treatment under ZECC storage was probably due to prevention of entry of microorganisms into the fruits by wax layer. Increase in shelf life due to waxing treatment has also been reported earlier in many fruits (Jhogliker and Reddy, 3; Mahajan *et al*., 6).

Acidity of the fruits followed a declining trend throughout the storage period and suffered about 59.26 % loss during 100 days storage, irrespective of treatments. The decrease in acidity during storage might be due to utilization of organic acids in respiration. The faster rate of decline in acidity in control fruits was probably due to the faster metabolic reactions occurring in the fruits at ambient temperature. The higher mean acidity of apple fruits treated with 10 % wax was due to slower metabolic changes occurring in fruits coated with wax (Table 2). Starch content followed a decreasing trend from 0.047 to 0.009 % during 100 days storage of apple fruits, which, might be due to the bioconversion of starch into sugars during storage. Further, the lower mean values of starch in control fruits were probably due to higher metabolic activities and higher rate of changes occurring at ambient conditions, which were slowed down by wax treatments and storage in ZECC, thus giving higher mean values of starch in treatments T_2 to T_5.

Increase in mean total sugars of apple fruits from 9.92 to 16.40 % was observed with the advancement in storage period (Table 2). The higher amount of total sugars was recorded in the control fruits due to higher rates of biochemical changes occurring in this treatment at ambient temperature and increase in the concentration of sugars. The higher mean sugar content in control fruits might be due to a more rapid increase in the constituents during the earlier part of storage and also due to the higher transpirational losses. Low concentration of sugars in T_3, T_4 and T_5 might be due to the slowing down of respiration and transpirational changes in fruits when treated with wax.

During the 100 days storage of apple fruits, there was an initial increase in the mean sensory scores of all the attributes including skin colour, taste, flavour and texture, except juiciness, upto 60 days followed by some decline towards the end of storage interval, i.e. 100 days (Fig. 1) which might be attributed to the conversion of starch into sugars, loss of acidity and development of aroma volatiles during fruit ripening. However, some decline in the mean sensory scores towards the end of storage interval might be due to the reduction in juiciness, crispiness, sugar- acid blend and loss of aroma volatiles towards the later half of the storage period. Maximum mean sensory scores were obtained in fruits treated with 10 to 15 % wax concentrations which was probably due to the lesser quality changes occurring in these treatments, thereby indicating their suitability for the storage of apple fruits in ZECC. The overall acceptability of apple fruits on the basis of skin colour, flavour, texture, taste and juiciness was found to be

Table 1. Effect of waxing on PLW, firmness and TSS of apple during storage.

Storage	PLW (%)						Fruit firmness (lb/inch^2)						TSS (^{o}Brix)					
Intervals (days)	T1	T2	T3	T4	T5	Mean	T1	T2	T3	T4	T5	Mean	T1	T2	T3	T4	T5	Mean
Initial	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	8.07	7.90	9.63	8.02	9.8	8.68	14.24	14.84	12.72	13.24	13.15	13.64
20	1.46 (6.94)	1.42 (6.84)	1.22 (6.34)	0.52 (4.13)	0.20 (2.56)	0.96 (5.36)	6.93	7.59	9.20	8.18	8.65	8.11	15.48	15.19	14.48	14.68	14.73	14.91
40	6.34 (14.58)	4.82 (12.68)	3.90 (11.39)	2.08 (8.29)	1.90 (7.92)	3.80 (10.97)	6.98	6.62	8.63	7.70	7.34	7.45	17.08	14.62	14.44	13.84	15.24	15.04
60	9.75 (18.20)	7.48 (15.87)	4.92 (12.82)	3.64 (11.00)	2.56 (9.20)	5.67 (13.41)	6.66	5.97	8.18	7.35	6.41	6.91	17.74	16.12	16.12	16.21	15.93	16.43
80	16.50 (23.97)	12.56 (20.76)	8.84 (17.30)	4.16 (11.77)	3.92 (11.42)	9.19 (17.04)	5.98	5.16	6.37	7.11	5.49	6.02	17.47	16.56	15.93	16.23	15.74	16.39
100	21.46 (27.60)	19.72 (26.36)	14.48 (22.37)	13.02 (21.15)	9.94 (18.38)	15.72 (23.17)	4.85	4.40	6.00	5.44	4.93	5.12	18.50	16.71	16.45	16.72	15.79	16.84
Mean	9.25 (15.21)	7.66 (13.75)	5.56 (11.70)	3.90 (9.39)	3.08 (8.24)		6.58	6.28	8.00	7.30	7.10		16.75	15.67	15.02	15.15	15.10	
			CD at 5%						CD at 5%						CD at 5%			
Treatment (T)			0.013						0.72						0.51			
Storage interval (I)			0.014						0.78						0.55			
T x I			0.031						NS						NS			

T_1 = 10% wax + ambient storage; T_2 = No wax + ZECC storage; T_3 = 5% wax + ZECC storage; T_4 = 10% wax + ZECC storage; T_5 = 15% wax + ZECC storage; Figures in parentheses are arc sine transformed values.

Table 2. Effect of waxing on titratable acidity, starch and total sugars of apple during storage.

Storage	Titratable acidity (%)						Starch (lb/inch^2)						Total sugars (%)					
Intervals (days)	T1	T2	T3	T4	T5	Mean	T1	T2	T3	T4	T5	Mean	T1	T2	T3	T4	T5	Mean
Initial	0.46	0.45	0.55	0.60	0.63	0.54	0.047	0.047	0.047	0.047	0.047	0.047	12.67	9.90	9.21	8.40	9.42	9.92
20	0.45	0.53	0.52	0.58	0.56	0.53	0.009	0.028	0.036	0.021	0.029	0.025	11.30	10.83	9.91	10.51	10.52	10.61
40	0.15	0.29	0.33	0.52	0.50	0.36	0.007	0.026	0.027	0.017	0.023	0.020	13.15	14.31	9.93	9.60	9.60	11.32
60	0.18	0.23	0.28	0.42	0.24	0.27	0.006	0.018	0.021	0.013	0.019	0.015	15.63	15.71	14.64	14.85	13.13	14.79
80	0.19	0.24	0.27	0.36	0.31	0.27	0.004	0.016	0.019	0.011	0.014	0.013	15.53	16.43	16.40	16.12	16.03	16.10
100	0.14	0.20	0.22	0.30	0.25	0.22	0.003	0.010	0.009	0.011	0.011	0.009	16.88	16.73	16.17	16.10	16.12	16.40
Mean	0.26	0.32	0.36	0.46	0.41		0.013	0.024	0.027	0.020	0.024		14.19	13.99	12.71	12.60	12.47	
			CD at 5%						CD at 5%						CD at 5%			
Treatment (T)			0.066						0.004						0.74			
Storage interval (I)			0.072						0.005						0.81			
T x I			NS						0.011						1.82			

T_1= 10% wax + ambient storage; T_2= No wax + ZECC storage; T_3 = 5% wax + ZECC storage; T_4 = 10% wax + ZECC storage; T_5 = 15% wax + ZECC storage.

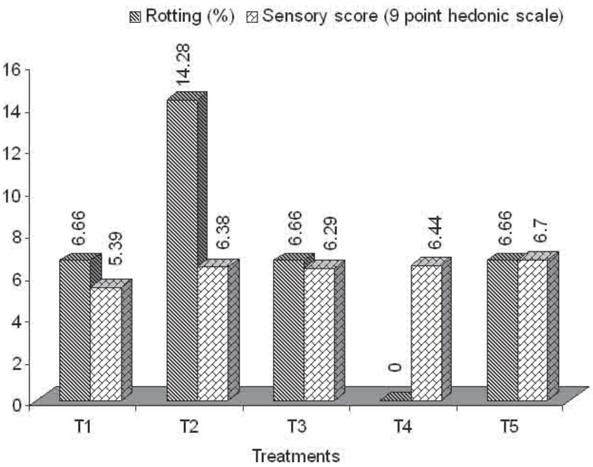

Fig. 1. Effect of waxing on rotting and sensory quality of apple after 100 days storage.

maximum in T_5 (6.70) followed by T_4 (6.44). Overall, wax coating treatments in different wax concentrations were helpful in retaining sensory quality of apple fruits, during storage, thereby increasing the acceptability of the fruits.

Conclusively, it can be said that apple fruits treated with 10 % wax for a storage period of 100 days in zero energy cool chamber was found to be highly successful than other wax concentrations of Nipro fruit wax for better retention of nutritional and sensory quality. Technology of waxing and storage in zero energy cool chamber can be successfully adopted by small farmers for short term on-farm storage of their fruits till they get remunerative prices in the market.

REFERENCES

1. Cochran, W.G. and Cox, G.W. 1967. *Experimental Designs*. John Wiley & Sons Inc., New York.
2. Faust, M. and Shear, C.B. 1972. The effect of calcium on respiration of apple. *J. Amer. Soc. Hortl. Sci.* **97**:437-39.
3. Jholgiker, P. and Reddy B.S. 2007. Effect of different surface coating material on postharvest physiology of *Annona squamosa* L. fruits under ambient and zero energy cool chamber storage. *Indian J. Hort.* **64**: 41-44.
4. Lane, J.H. and Eynon, L. 1923. Determination of reducing sugars by Fehling solution with methylene blue as an indicator. *J. Sci. Chem.* **42**: 32-37.
5. Madan, H.S. and Ullasa, B.A. 1993. Post-harvest losses in fruits. **In:** *Advances in Horticulture.* Vol. 4. Chadha, K.L. and Pareek, O.P. (Eds). Malhotra Pub. House, New Delhi, pp. 1795-1810.
6. Mahajan, B.V.C., Dhillon W.S. and Dhatt, A.S. 2006. Studies on waxing of pear: effect of cold storage and shelf-life environment on the storage behavior and quality of pear cv. Patharnakh. *Indian J. Hort.* **63**:166-70.
7. Mahony, M.O. 1985. Sensory evaluation of food. **In**: *Statistical Methods and Procedures*. Marcel Dekker, Inc. New York.
8. Ranganna, S. 1997. *Handbook of Analysis and Quality Control of Fruit and Vegetable Products*. 2nd edn, Tata McGraw Hill Pub. Co. Ltd., New Delhi.
9. Sadasivam, S. and Manickam, A. 2004. Estimation of starch by anthrone reagent. **In**: *Biochemical Methods* (2nd edn.), New Age Intl. Pub. New Delhi. pp. 11-12.
10. Sharma, S.K. 2010. *Postharvest Management and Processing of Fruits and Vegetables – Instant Notes*. New India Pub. Agency, New Delhi, 390 p.
11. Sharma, S.K. and Nautiyal, M.C. 2007. *Zero Energy Cool Chamber: A Low Cost Technology for Storage of Fruits and Vegetables*. Technical Bulletin No. FHA/15/Hort./07, University of Horticulture and Forestry, Ranichauri, Uttarakhand, 8 p.
12. Sharma, S.K. and Nautiyal, M.C. 2009. *Postharvest Technology of Horticultural Crops –A Practical Manual*. New India Pub. Agency, New Delhi, 229 p.

Received: September, 2008; Revised: June, 2010
Accepted: July, 2010