Applied Biological Research 14 (2): 125-130, 2012

IMPROVING STRAWBERRY FRUIT STORABILITY BY APPLICATION OF POST HARVEST CHEMICAL TREATMENTS

Monika Sood, Raj Kumari Kaul and P. Sood*

Division of Post Harvest Technology, SK University of Agricultural Sciences and Technology of Jammu, Udheywalla, Jammu - 180 002 Jammu & Kashmir (India);
******Chowdhary Sawarn Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur, HP - 176 062 (India)*
*e-mail: *monikasoodpht@gmail.com*

(Received 3 December, 2011; accepted 25 May, 2012)

ABSTRACT

The present study was aimed to evaluate the effect of post-harvest treatments on the quality and prolongation of post-harvest life of strawberry fruits cv. 'Chandler'. Strawberry fruits were dipped either in calcium chloride (0.5 or 1.0%) for 1 min. or 0.02% ascorbic acid for 1 min. or fumigated with glacial acetic acid for 5 min. The air-dried treated and untreated fruits were packed in plastic punnets with ordinary cover, LDPE cover and PVC cover and stored at 4°C. The results revealed that physiological weight and decay loss were minimum in fruits treated with 1% $CaCl_2$ and packed in LDPE covered punnets. Total soluble solids increased up to 14th day and thereafter decreased; whereas, acidity decreased in all the treatments with least decrease in fruits packed in punnets with LDPE cover and treated with 1% $CaCl_2$. The treatment also showed lower acid and higher TSS. Thus 1% $CaCl_2$ in combination with punnets having LDPE cover was adjudged as the best treatment for maintaining the quality and improving the shelf life of strawberry.

Keywords: Acetic acid, ascorbic acid, calcium chloride, packaging, post-harvest treatments, shelf-life, storability, strawberry

INTRODUCTION

Strawberry is grown in India on hill and plains of northern states mostly. Strawberry is a non-climacteric fruit with a very short post-harvest shelf-life. Loss of fruit quality is mostly due to its relatively high metabolic activity and sensitivity to fungal decay, mainly grey mold. Strawberries are also susceptible to water loss, bruising and mechanical injury due to their soft texture and lack of a protective rind. To reduce spoilage, metabolic deterioration and to extend the shelf life, strawberry fruit should be kept at low temperature after harvest (Hern'andez *et al*., 2006).

The post-harvest life of strawberries can be extended by several techniques combined with refrigeration. Several chemicals are used as coating to prevent the damage from fruit rot during storage. The purpose is to extend the shelf life of produce and to provide a barrier against hazards. It may retard moisture migration and loss of volatile compounds, reduce the respiration rate and delay changes in textural properties (Del-valle *et al*., 2005). Dunn and Able (2005) reported that the application of calcium in strawberry delays ripening and development of grey mold and produces quality fruits. Avissar *et al.* (1989) reported that decay of strawberry fruit can be controlled by fumigation with acetic acid. The fumigation has been found effective in protecting strawberry fruit against spoilage for atleast 2 weeks at 5°C (Moyls *et al.*, 1996). The quality can be further improved by altering the gas atmosphere surrounding the fresh strawberry (Holcroft and Kader, 1999). Modified atmosphere packaging (MAP) is often utilized to maintain elevated CO_2 and reduced O_2 concentrations inside consumer produce containers (Exama *et al*., 1993). However, using MAP technology exclusively is not fully sufficient for fresh strawberry and it needs pre-treatment. Therefore, the objective of present study was to determine suitable post harvest treatment and packaging material to prolong the shelf life of strawberry fruits.

MATERIALS AND METHODS

The fruits of strawberry cv. 'Chandler', harvested at commercial maturity, were brought to the laboratory and divided into five lots comprizing of 170 fruits each. The 1st, 2nd and 3rd lot fruits were dipped in solutions of 0.5% calcium chloride ($CaCl_2$), 1.0% $CaCl_2$ and 0.02% ascorbic acid, respectively, for 1 min. and packed thereafter. The 4th lot of fruits was fumigated with the vapours of glacial acetic acid in a 0.60 m^3 fumigation chamber, made up of corrugated fiber board. The acid was evaporated from a 55 mm diameter glass petri-dish with the help of spirit lamp. Fruits were fumigated in fumigation chamber with 65 ml acetic acid (5.4 mg L^{-1}) for 20 min. Three plastic mesh baskets of 0.5 kg capacity were used for each fumigation-run. After fumigation, the chamber was opened, air flushed for 20 min. by an exhaust fan and strawberries subsequently removed, cooled at 2°C and packed. The 5th lot fruits kept untreated served as control. The treated and untreated fruits were covered with either transparent punnets (cap 200 g) or LDPE sheets (200 gauge thickness) or PVC sheets (15 μm thickness) and then fixed with elastic band. All the punnets were then stored at 4°C.

The fruits were analyzed on 2nd, 4th, 14th and 21st day after storage and estimated for specific gravity, physiological loss in weight (PLW), decay loss, total soluble solids (TSS), titratable acidity, ascorbic acid content and overall acceptability. The specific gravity of fruits was measured by water displacement method. The cumulative PLW of fruits was determined as per the formula of Srivastava and Tandon (1968) on the basis of initial weight of fruit and loss in weight observed during storage. Decay loss was assessed by counting the number of fruits that get spoiled and/or displaying fungal mycelia or sporulation. TSS was determined with Atago hand refractometer (0-52°B) by putting a drop of juice on the prism and corrections for the value were made to standard temperature (20°C). The titratable acidity was determined by the method of AOAC (2000). Five ml of filtered juice was titrated against N/10 NaOH solution using phenolphthalein as an indicator and results were expressed as % total titratable acidity. The ascorbic acid content was determined by using 2,6 dichlorophenol indophenol titration method as described in AOAC (2000). For overall acceptability, a nine point hedonic scale was used (Wills *et al*., 1980) and evaluation was carried by a panel of 12 judges. The data obtained was subjected to analysis of variance (Panse and Sukhatme, 1989) and mean values compared at 5% level of significance.

RESULTS AND DISCUSSION

The specific gravity of fruits showed decrease with the advancement of storage period and the values decreased from 0.67 to 0.42% (Table 1). The highest specific gravity (0.86) was recorded in fruits treated with $CaCl_2$ and packed in punnets with LDPE cover whereas fruits with lowest specific gravity were found in fruits packed in ordinary punnets without any chemical treatment (0.29). Decrease in specific gravity by various post-harvest treatments has been reported by Singh (1980) in case of guava fruits. The decrease in specific gravity could be attributed to the loss of weight and decrease in the volume of fruits (Bhat, 2002). The chemical treatments probably reduce weight and respiration losses, thereby help in maintaining higher values of specific gravity during storage.

The physiological weight loss increased significantly from 1.45 to 10.09% with the prolongation of storage period (Table 1). Normally, the weight loss occurs during fruit storage due to its respiratory process, the transference of humidity and some processes of oxidation (Ayranci and Tunc, 2003). Comparing all treatments, $CaCl_2$ treatment with LDPE cover significantly showed lowest values (4.52%)

Table 1: Effect of packaging and post-harvest chemical treatment on the specific gravity and physiological weight loss of strawberry fruits cv. Chandler during storage (days) at 4±1°C

Treatments	Specific gravity					Physiological weight loss (%)				
	2	4	14	21	Mean	2	4	14	21	Mean
$CaCl_2$ (0.5%) + punnet cover	0.74	0.65	0.54	0.43	0.59	1.41	2.58	6.73	8.86	4.90
$CaCl_2$ (0.5%) + LDPE cover	0.89	0.76	0.61	0.56	0.70	1.36	2.55	6.64	8.78	4.83
$CaCl_2$ (0.5%) + PVC cover	0.79	0.68	0.59	0.52	0.64	1.38	2.54	6.69	8.84	4.86
$CaCl_2$ (1.0%) + punnet cover	0.87	0.73	0.68	0.57	0.71	1.21	2.39	6.63	8.78	4.75
$CaCl_2$ (1.0%) + LDPE cover	0.99	0.87	0.84	0.75	0.86	1.09	2.11	6.38	8.50	4.52
$CaCl_2$ (1.0%) + PVC cover	0.94	0.82	0.74	0.66	0.79	1.16	2.20	6.44	8.62	4.61
Ascorbic Acid + punnet cover	0.59	0.49	0.39	0.31	0.46	1.46	2.63	6.78	9.93	5.20
Ascorbic Acid + LDPE cover	0.72	0.57	0.54	0.45	0.57	1.38	2.54	6.68	9.83	5.11
Ascorbic Acid + PVC cover	0.68	0.59	0.48	0.38	0.53	1.42	2.57	6.73	9.87	5.15
Acetic Acid + punnet cover	0.56	0.43	0.34	0.26	0.40	1.43	2.66	7.81	10.94	5.71
Acetic Acid + LDPE cover	0.54	0.45	0.44	0.39	0.45	1.45	2.69	7.84	9.98	5.49
Acetic Acid + PVC cover	0.51	0.42	0.40	0.34	0.42	1.42	2.64	7.78	10.91	5.69
Punnet (control) + Punnet cover	0.37	0.32	0.27	0.21	0.29	1.83	2.17	9.35	13.53	6.72
Punnet (control) + LDPE cover	0.46	0.38	0.34	0.22	0.35	1.91	2.23	9.39	10.55	6.02
Punnet (control) + PVC cover	0.45	0.37	0.31	0.21	0.33	1.88	2.14	9.29	13.48	6.70
Mean	0.67	0.60	0.50	0.42	-	1.45	2.44	7.41	10.09	-
$CD_{0.05}$: Treatment (T)					0.02					0.23
Storage period (S)					0.01					0.11
T x S					0.05					0.46

for physiological weight loss. However, highest PLW was observed in Punnet (control) with Punnet cover having values 6.72%. Calcium maintains integrity of cell wall and also acts as an anti-senescence agent, which might be responsible for less physiological loss in weight (Glenn *et al.*, 1988). The ascorbic acid treatment also helped to reduce weight loss when compared to control.

The losses due to decay were observed after 4 days of storage in all the treatments (Table 2). The highest fruit decay (7.13%) was recorded in Punnets with ordinary punnet cover and lowest in 1% $CaCl_2$ with LDPE cover (1.89%). Lower decay loss in chemically treated fruits has earlier been reported by Sholberg and Gaunce (1995) in strawberry fruits. The lower losses in calcium treated fruits may be attributed to the higher fruit firmness which might have delayed the infection of pathogens and other microorganisms for a longer period.

The total soluble solids (TSS) in strawberries increased during the first 14 days and then decreased with prolonged storage period (Table 2). This reduction might be due to the respiratory process. All chemical treatments significantly reduced the TSS losses as compared to control. Moreover, 1% $CaCl_2$ treatment with LDPE cover was the most effective treatment in maintaining TSS during storage. Similar results have been reported by Amal *et al.* (2010).

The titratable acidity significantly decreased as a function of storage time for all studied treatments (Table 2). However, all treatments used retained more acidity compared to untreated fruits during storage. The decrease in acidity during storage has also been reported by Garcia *et al.*, (1998) in strawberry. The decrease in acidity may be attributed to metabolization of organic acids and in the later stages of storage due to metabolisation of amino acids. The highest acidity (1.18%) was reported in fruits packed in ordinary punnets without any pretreatment whereas lowest acidity content of 0.40% was recorded in fruits treated with 1% $CaCl_2$ packed in punnets with LDPE cover.

The ascorbic acid content in strawberries decreased during prolongation of storage period (Table 3). This reduction may be due to high respiration rate of strawberry fruits Garcia *et al.* (1996). However, minimum reduction in this attribute was noticed in the fruits treated with 1% $CaCl_2$. The favourable effects

Table 2: Effect of packaging and post-harvest chemical treatment on decay, total soluble solids and titratable acidity of strawberry fruits cv. Chandler under different storage time (days) at 4±1°C

Treatments	Decay* (%)			Total soluble solids (%)					Titratable acidity (%)				
	14	21	Mean	2	4	14	21	Mean	2	4	14	21	Mean
$CaCl_2$ (0.5%) + punnet cover	2.57	2.72	2.65	6.12	6.42	6.67	6.24	6.36	0.85	0.79	0.62	0.51	0.69
$CaCl_2$ (0.5%) + LDPE cover	2.35	2.54	2.45	6.08	6.51	6.68	6.34	6.40	0.76	0.66	0.46	0.42	0.57
$CaCl_2$ (0.5%) + PVC cover	2.43	2.62	2.53	6.16	6.43	6.64	6.31	6.39	0.74	0.65	0.51	0.43	0.58
$CaCl_2$ (1.0%) + punnet cover	1.76	2.97	2.37	6.31	6.68	6.84	6.51	6.58	0.68	0.62	0.41	0.35	0.52
$CaCl_2$ (1.0%) + LDPE cover	1.29	2.48	1.89	6.81	7.16	7.40	6.99	7.09	0.57	0.47	0.32	0.25	0.40
$CaCl_2$ (1.0%) + PVC cover	1.51	2.69	2.10	6.46	6.76	6.87	6.58	6.67	0.65	0.58	0.37	0.35	0.49
Ascorbic Acid + punnet cover	3.89	4.12	4.01	5.96	6.35	6.49	6.13	6.23	0.94	0.85	0.63	0.45	0.72
Ascorbic Acid + LDPE cover	3.64	3.82	3.73	6.01	6.49	6.62	6.32	6.36	0.81	0.76	0.64	0.38	0.65
Ascorbic Acid + PVC cover	3.72	3.89	3.81	6.01	6.45	6.57	6.28	6.33	0.87	0.71	0.59	0.48	0.67
Acetic Acid + punnet cover	4.02	6.21	5.12	5.96	6.31	6.41	6.15	6.21	1.09	0.96	0.81	0.66	0.88
Acetic Acid + LDPE cover	4.82	6.01	5.42	6.06	6.39	6.55	6.23	6.31	1.01	0.91	0.68	0.56	0.79
Acetic Acid + PVC cover	4.86	6.07	5.47	6.03	6.38	6.54	6.20	6.29	0.95	0.82	0.72	0.71	0.80
Punnet (control) + Punnet cover	5.98	8.27	7.13	5.84	6.29	6.39	6.11	6.16	1.37	1.29	1.15	0.93	1.18
Punnet (control) + LDPE cover	5.09	8.31	6.70	5.94	6.36	6.48	6.19	6.24	1.16	1.05	0.91	0.67	0.95
Punnet (control) + PVC cover	5.19	8.38	6.79	5.90	6.33	6.45	6.17	6.21	1.27	1.16	1.06	0.85	1.08
Mean	3.54	4.74	-	6.11	6.49	6.64	6.32	-	0.92	0.82	0.66	0.53	-
$CD_{0.05}$ Treatment (T)			0.41					0.03					0.03
Storage period (S)			0.15					0.01					0.01
T x S			0.58					0.05					0.05

* Note: No decay (%) was observed on 2nd and 4th day of storage

Table 3: Effect of packaging and post-harvest chemical treatment on ascorbic acid and overall acceptability of strawberry fruits cv. Chandler kept at different storage time (days) at 4±1°C

Treatments	Ascorbic acid (%)					Overall acceptability (9 point score)				
	2	4	14	21	Mean	2	4	14	21	Mean
$CaCl_2$ (0.5%) + punnet cover	34.93	31.25	28.18	25.12	29.87	8.35	8.14	8.04	7.92	8.11
$CaCl_2$ (0.5%) + LDPE cover	43.49	39.98	35.29	31.21	37.49	8.57	8.32	8.23	8.04	8.29
$CaCl_2$ (0.5%) + PVC cover	41.37	38.87	33.93	28.21	35.59	8.41	8.19	8.09	7.97	8.16
$CaCl_2$ (1.0%) + punnet cover	46.32	43.71	40.54	36.45	41.75	8.59	8.38	8.21	8.05	8.30
$CaCl_2$ (1.0%) + LDPE cover	57.43	54.62	51.42	47.57	52.76	8.74	8.56	8.39	8.23	8.48
$CaCl_2$ (1.0%) + PVC cover	49.12	46.41	43.68	39.16	44.59	8.65	8.43	8.27	8.12	8.37
Ascorbic Acid + punnet cover	32.93	29.36	25.71	21.67	27.42	7.74	7.51	7.35	7.17	7.44
Ascorbic Acid + LDPE cover	38.21	34.56	31.37	27.34	32.87	7.87	7.69	7.52	7.34	7.60
Ascorbic Acid + PVC cover	37.84	33.19	29.84	24.93	31.45	7.79	7.57	7.43	7.23	7.50
Acetic Acid + punnet cover	21.53	19.73	16.45	15.97	18.42	7.15	6.97	6.84	6.61	6.89
Acetic Acid + LDPE cover	33.67	30.64	28.39	25.59	29.57	7.31	7.12	6.98	6.75	7.04
Acetic Acid + PVC cover	27.84	22.93	19.27	17.29	21.83	7.23	7.04	6.91	6.69	6.97
Punnet (control) + Punnet cover	19.91	17.81	15.19	13.47	16.59	6.72	6.63	6.42	6.21	6.49
Punnet (control) + LDPE cover	29.73	26.67	24.82	20.57	25.45	6.88	6.82	6.59	6.37	6.66
Punnet (control) + PVC cover	23.61	21.72	18.87	16.51	20.18	6.84	6.69	6.47	6.29	6.57
Mean	35.86	32.76	29.53	26.07	-	7.79	7.60	7.45	7.27	-
$CD_{0.05}$ Treatment (T)					0.06					0.02
Storage period (S)					0.03					0.01
T x S					0.13					0.05

of $CaCl_2$ treatment in reduction of vitamin C loss of strawberries during storage may be due to that $CaCl_2$ prevents losses of antioxidant such as ascorbic acid in horticultural commodities (Luna-Guzman and Barrett, 2000). Packaging has also significant influence on ascorbic acid content of strawberry fruits. Better retention of ascorbic acid in fruits packed in plastic punnets and LDPE may be due to the modification of the atmosphere and concomitant decrease in enzymatic oxidation of ascorbic acid (Agrahari *et al*., 2001).

The sensory evaluation of fruits during storage showed that overall acceptability of fruits decreased with increasing storage period. Highest organoleptic score (8.48) was recorded in $CaCl_2$ (1%) treatment packed in punnets with LDPE cover. Similar results were obtained by Garcia *et al*. (1998). The decrease in organoleptic rating in all the treatments during storage might be because of onset of senescence of tissues, which lead to decrease in firmness and rotting. $CaCl_2$ treated fruits packed in LDPE covered punnets were firm, glossy and with good colour. It might be due to reason that LDPE cover retained moisture and therefore weight loss was reduced. Good colour may be due to reduced degradation of pelargonidine 3-glucoside which is responsible for red colour (Garcia *et al.,* 1998).

Conclusion: The study revealed that chemical and packaging treatments has favourable effect on post harvest life of strawberry fruits. It maintains well the various physical as well as chemical characteristics at desired level of consumer acceptance during storage period. Among various treatments, fruits treated with $CaCl_2$ (1%) and packed in LDPE covered punnets maintained all quality characteristics of strawberry fruits. This treatment gave better result on extension of storage period and considerably reduced PLW, decay loss upto 21 days and kept fruits with good colour.

REFERENCES

Agrahari, P.R., Thakur, K.S., Sharma, R.M., Tripathi, V.K. and Singh, R.R. 2001. Effect of various packaging treatments and storage atmosphere on storage quality of chandler strawberry (*Fragaria x ananassa* Duch.). *Scientia Horticulturae,* **7**: 63-74.

Amal, S.H., Atress, M.M., El-Mogy, H.E., Aboul-Anean and Alsanius, B.W. 2010. Improving strawberry fruit storability by edible coating as a carrier of thymol or calcium chloride. *Journal of Horticultural Science and Ornamental Plants,* **2**: 88-97.

AOAC. 2000. *Association of Official Analytical Chemists* (17th edn). AOAC. Washington, USA.

Avissar J., Marinansky, R. and Pesis, E.1989. Post-harvest decay control of grapes by acetaldehyde vapors. *Acta Horticulturae,* **258**: 655-660.

Ayranci, E.S. and Tunc, S. 2003. A method for the measurement of the oxygen permeability and the development of edible films to reduce the rate of oxidative reactions in fresh foods. *Food Chemistry*, **80**: 423-431.

Bhat, S. 2002. *Effect of Foliar Application of Plant Growth Regulators on Changes in Post-harvest Quality of Guava (Psidium guajava L.) cv. Sardar*. M.Sc Thesis. SKUAST-J, Jammu, J&K, India.

Del-Valle, V.P., Hernandez-Munoz, G.A. and Galotto, M.J. 2005. Development of a cactus-mucilage edible coating (*Opuntia ficus indica*) and its application to extend strawberry (*Fragaria ananassa*) shelf-life. *Food Chemistry*, **91**: 751-756.

Dunn, J. L. and Able, A.J. 2005. Pre-harvest calcium effects on sensory quality and calcium mobility in strawberry fruit. *Acta Horticulturae,* **708**: 211-213.

Exama, A., Arul, J., Lencki, R.W., Lee, L.Z. and Toupin, C. 1993. Suitability of plastic films for modified atmosphere packaging of fruits and vegetables. *Journal of Food Science*, **58**:1365-1370.

Garcia, M.A., Martino M.N. and Zaritzky, N.E. 1998. Plasticized starch based coating to improve strawberry (*Fragaria x ananassa* Duch.) quality and stability. *Journal of Agricultural and Food Chemistry,* **46**: 3758.

Garcia, J.M., Herrera, S. and Morilla, A. 1996. Effects of postharvest dips in calcium chloride on strawberry. *Journal of Agricultural and Food Chemistry*, **44**: 30-33.

Glen, G.M., Reddy, A.S. and Poovaiah, B.W. 1988. Effect of calcium on wall structure, protein phosphorylation and protein profile in senescing apples. *Plant Cell Physiology,* **29**: 565-572.

Hern´andez, P.M., Almenar, E., Ocio, M.J.and Gavara, R. 2006. Effect of calcium dips and chitosan coatings on postharvest life of strawberries (*Fragaria x ananassa*). *Postharvest Biology and Technology*, **39**: 247-253.

Holcroft, D.M. and Kader, A.A. 1999. Controlled atmosphere induced changes in pH and organic acid metabolism may affect colour of stored strawberry fruit. *Postharvest Biology and Technology*, **17**: 19-32.

Luna-Guzman, S.J. and Barrett, D.M. 2000. Comparison of calcium chloride and calcium lactate effectiveness in maintaining shelf stability and quality of fresh-cut cantaloupe. *Postharvest Biology and Technology*, **19**: 61-72.

Moyls, A.L., Sholberg, P.L.and Gaunce, A.P.1996. Modified atmosphere packaging of grapes and strawberry fumigated with acetic acid. *HortScience*, **31**: 414-416.

Panse, V.C. and Sukhatme, P.V. 1989. *Statistical Methods for Agricultural Workers*, ICAR, New Delhi, India.

Sholberg, P.L. and. Gaunce, A.P. 1995. Fumigation of fruits with acetic acid to prevent post harvest decay. *Hort Science*, **36**: 1271-1275.

Singh, K. 1980. *Effect of Various Chemicals as Pre- and post-harvest Application on Shelf Life of Guava at Various Temperatures.* Ph.D. thesis, CCS Haryana Agricultural University, Hissar, India.

Srivastava, M.P. and Tandon, R.N. 1968. Influence of temperature on Botryodiplodia rots of citrus and sapota. *Indian Phytopathology*, **21**: 195-207.

Wills, R.B.H., Bembridge, P.A. and Scott, K.J. 1980. Use of flesh firmness and other objective tests to determine consumer acceptability of delicious apples. *Australian Journal of Experimental Agriculture and Animal Husbandry,* **20**: 252-256.