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Physico-Chemical Properties of Strawberry under Supermarket Storage Condition with Passive Modified Atmospheric Packaging

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Abstract Strawberry (*Fragaria* × *ananassa* Duch.) fruits cv Sweet Charlie were harvested at the 75% maturity stage. Fresh fruits were packed in plastic punnets and wrapped with different packaging materials viz., low-density polyethylene (LDPE) 25, 50 and 75 micron, polypropylene (PP) 25 micron, cellophane paper and cling film. The LDPE 50 micron packaging material proved as the most effective one to control the weight loss (6.51%) and all of the LDPE films along with the PP and cling films appeared best to minimize decay loss. MAP conditions help prevent the decaying of strawberry fruits up to a day. The total soluble solids and titrable acidity were found to be decreased with the prolongation of storage periods, but no significant variation was recorded for different packaging materials. A better level of ascorbic acid in strawberry fruits packed with LDPE 50 and 75 micron packaging films was retained.

Keywords Cellophane paper, Polypropylene, Quality, Shelf life, Sweet Charlie.

Introduction

Strawberry (*Fragaria* × *ananassa* Duch.) is one of the most popular fruit in India. It is an attractive, delicious, refreshing and nutritious soft fruit and mostly preferred for its delicate flavor. It is popular among the red fruits and a rich source of anthocyanin possessing high antioxidant activity [1]. It shows non-climacteric ripening behavior but owing to its characteristic high respiration rate (50—100 ml CO_2 per kg of fruits per hour at 20°C) ; so it is a highly perishable fruit [2]. About 20—50% fruit loss occurs as post-harvest decay in strawberry depending upon harvesting month, fruit maturity, transportation distance and method of packaging [3]. The trend of supermarket is being a best representation of retain marketing. A number of high value fruits are being displayed with proper packaging in supermarkets to attract the middle upper-class and the upper-class strata of the society. Owing to its rich nutritional value as well as delicacy, strawberry keeps the buyers attention in various supermarkets during the production season. Modified atmospheric packaging (MAP) using different films can be illustrated as one of the best and low cost technology to have a better shelf life with proper quality for a soft fruit like strawberry. Modified atmosphere (MA) means an atmospheric composition around the fruit that is different from that of normal air i.e., 78.08% N_2, 20.95% O_2 and 0.03% CO_2 [4]. Such change in the gaseous atmosphere can be attributed to the factors like respiration and other biochemical processes of the produce and permeation of gases through the packaging film. It slows down the growth of aerobic microbes and the speed of oxidation reactions. Therefore, present investigation was carried out to evaluate the changes in physico-chemical properties of strawberry under su-

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Table 1. Effect of packaging materials on loss in weight (%) of strawberry cv Sweet Charlie under supermarket storage. NS = Treatment differences non-significant.

	Storage period (days)				
Treatments	1	2	3	4	5
LDPE 25 micron	1.002	2.16	3.49	5.76	8.29
LDPE 50 micron	0.67	1.56	3.09	4.96	6.51
LDPE 75 micron	0.82	1.82	3.22	5.22	7.39
PP 25 micron	0.93	2.07	3.35	5.58	7.87
Cling film	1.15	2.38	3.62	6.18	8.96
Cellophane paper	1.23	2.55	3.73	6.36	9.42
Control	1.49	2.75	5.04	7.84	10.98
CD (p = 0.05)	NS	NS	0.11	0.23	0.68

permarket storage condition with passive modified atmospheric packaging.

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Materials and Methods

This study was conducted in the Post-Harvest Laboratory of Department of Horticulture, CCS Haryana Agricultural University, Hisar during March 2015. Medium sized fruits of strawberry cv Sweet Charlie were harvested at approximately 75% color development stage in early morning hours. About 150 g fruits were packed in plastic punnets with due care to minimize the chances of injury. Individual punnets were wrapped with different packaging materials viz., low density polyethylene (LDPE) 25 micron, 50 micron and 75 micron, polypropylene (PP) 25 micron, cling, Film, cellophane Paper and then sealed. Fruits kept in punnets without any packaging material wrapping was taken as control in the experiment.

All the packages were stored under the supermarket condition (temp 20 ± 2°C and RH 80—90%) and various physic-chemical observations related to the quality of the stored fruits were recorded daily with three replications. The loss in weight during storage was calculated by subtracting the final weight from the initial weight of the fruits and expressed in per cent. The decay loss was calculated by subtracting the number of decayed fruit from the total number of fruits and expressed in per cent. The total soluble solids of preserved fruits and pulp were determined at room temperature by using hand refractometer having a range of 0 to 32° Brix by putting a drop of juice obtained by pressing the pulp on the prism and taking the readings. Acidity and ascorbic acid were determined as per the method suggested by AOAC [5].

Table 2. Effect of packaging materials on decay loss (%) of strawberry cv Sweet Charlie under supermarket storage. Original figures in parentheses were subjected to square root transformation (√ X + 1) before the statistical analysis.

	Storage period (days)							
Treatments	2		3		4		5	
LDPE 25 micron	1.00	(0.00)	1.77	(3.33)	2.97	(10.00)	4.91	(23.33)
LDPE 50 micron	1.00	(0.00)	1.73	(3.03)	2.27	(7.41)	3.93	(14.81)
LDPE 75 micron	1.00	(0.00)	1.82	(3.70)	2.85	(9.09)	4.29	(18.18)
PP 25 micron	1.00	(0.00)	1.89	(4.17)	3.26	(12.50)	4.51	(20.83)
Cling film	1.00	(0.00)	1.77	(3.33)	3.74	(13.33)	4.91	(23.33)
Cellophane paper	1.00	(0.00)	2.37	(5.56)	3.82	(13.89)	4.80	(22.22)
Control		(2.56)	2.67	(7.69)	4.25	(17.95)	5.60	(30.77)
CD (p = 0.05)	NS		0.38		0.62		0.32	

Table 3. Effect of packaging materials on total soluble solids (°Brix) of strawberry cv Sweet Charlie under supermarket storage. NS = Treatment differences non-significant.

Treatments	Storage period (days) 0	1	2	3	4	5	Mean
LDPE 25 micron	6.40	6.60	6.35	6.30	6.19	6.05	6.32
LDPE 50 micron	6.42	6.59	6.46	6.37	6.23	6.15	6.37
LDPE 75 micron	6.37	6.50	6.41	6.33	6.21	6.13	6.33
PP 25 micron	6.42	6.61	6.44	6.31	6.20	5.87	6.31
Cling film	6.36	6.53	6.40	6.28	6.17	5.88	6.27
Cellophane paper	6.35	6.47	6.34	6.22	6.10	5.79	6.21
Control	6.38	6.41	6.30	6.19	6.07	5.72	6.18
Mean	6.39	6.53	6.39	6.29	6.17	5.94	
CD (p = 0.05)		Treatments (T) = NS,		Storage period (S) = 0.13			
			T × S = NS				

The data were analyzed according to the procedure for analysis of completely randomized design (CRD) [6]. The overall significance of difference among the treatments was tested, using critical differences (CD) at 5% level of significance. The results were statistically analyzed with the help of a windows based computer package OPSTAT [7].

Results and Discussion

Loss in weight (%)

Table 1 reveals that there was no significant loss in weight of fruits on the 1st and 2nd day of storage. Significantly less loss in weight was recorded in LDPE 50 micron on the 3rd (3.09%), 4th (4.96%) and 5th (6.51%) day of storage as compared to all other packaging treatments (i.e., LDPE 25 micron, 75 micron, PP 25 micron, cling film, cellophane paper and the control one). On the other hand, fruits retained unwrapped conditions exhibited the highest physiological loss in weight as compared to fruits packed in films and that might be due to the exposure of fruit surface to the open atmosphere resulting in higher rate of transpiration and respiration thereby leading to higher physiological loss in weight. Similar results were reported in the study for packaging materials and storage condition in guava [8] and pear [9].

Decay loss (%)

The data pertaining to decay loss of the strawberry fruits stored under supermarket condition was illustrated in the Table 2. On the 1st day no decay was recorded. On the 2nd day, decay was there, but the variation was not significant for different packaging materials. On the 3rd day of storage a minimum decay was recorded in fruits packed in LDPE 50 (1.73%), 25

Table 4. Effect of packaging materials on titrable acidity (%) of strawberry cv Sweet Charlie under supermarket storage. NS = Treatment differences non-significant.

Treatments	Storage period (days) 0	1	2	3	4	5	Mean
LDPE 25 micron	0.90	0.90	0.86	0.83	0.77	0.74	0.83
LDPE 50 micron	0.96	0.93	0.89	0.86	0.83	0.80	0.88
LDPE 75 micron	0.96	0.90	0.90	0.86	0.83	0.77	0.87
PP 25 micron	0.87	0.87	0.83	0.83	0.80	0.77	0.83
Cling film	0.86	0.86	0.83	0.80	0.77	0.70	0.81
Cellophane paper	0.90	0.86	0.83	0.77	0.70	0.67	0.79
Control	0.93	0.83	0.80	0.77	0.64	0.58	0.76
Mean	0.91	0.88	0.85	0.82	0.76	0.72	0.82
CD (p = 0.05)		Treatments (T) = NS,		Storage period (S) = 0.03			
			T × S = NS				

Table 5. Effect of packaging materials on ascorbic acid (mg/100 g) of strawberry cv Sweet Charlie under supermarket storage. NS = Treatment differences non-significant.

Treatments	Storage period (days)						
	0	1	2	3	4	5	Mean
LDPE 25 micron	37.14	33.95	29.49	24.34	22.91	19.23	27.84
LDPE 50 micron	38.57	35.18	32.69	28.95	25.62	24.36	30.90
LDPE 75 micron	37.86	34.57	31.41	28.29	26.83	23.08	30.34
PP 25 micron	38.57	35.18	32.05	27.63	25.64	22.44	30.25
Cling film	36.43	33.95	30.13	25.00	23.53	20.51	28.26
Cellophane paper	40.00	34.57	28.20	22.37	20.27	19.87	27.55
Control	38.57	30.25	25.64	20.39	18.47	16.10	24.90
Mean	38.33	33.95	30.02	25.44	23.39	21.06	
CD (p = 0.05)	Treatments (T) = 2.41, Storage period (S) = 2.14; T × S = NS						

(1.77%), 75 micron (1.82%), PP 25 micron (1.77%) and cling film (1.89%) than those of packed in cellophane paper (2.37%) and unwrapped punnets (2.67%). On the 4th day of storage a lower level of decay was recorded in fruits packed with LDPE 50 micron (2.27%) and LDPE 75 micron (2.85%). The maximum decay loss was in the unwrapped punnets (4.25). On the 5th day of storage the minimum decay loss was observed in fruits packed in LDPE 50 micron packaging films (3.93%). Positive effects of film packaging are the maintenance of high relative humidity and reduction in water loss of produce at optimum temperature and these conditions are responsible for lowering the spoilage of fruits. However, in the present study the lowest decay loss (%) was reported in strawberry fruits packed with the packaging films in all the storage conditions. MAP prevented the occurrence of decayed loss in the packed strawberry fruits up to a single day. Different packaging films behaved differentially to regulate the fruit decay on different days under different storage conditions. Earlier such findings have been reported in strawberry [10]. This might be due to the property of packaging films to retain a higher level of CO_2 inside the packages. Higher atmospheric CO_2 level may show fungi static effect.

Total soluble solids (°Brix)

The TSS of strawberry fruits packed in different packaging materials exhibited significant variation with respect to the period of storage only, but no-significant variation was recorded with respect to the type of packaging films used. Under the supermarket storage condition (Table 3), the TSS was maximum on the 1st day (6.53 °Brix) of storage and but decreased gradually till 5th day (5.94 °Brix) of storage. TSS of strawberry fruits increased up to a short period of storage and then a steady decrease was observed. The initial rise in TSS might be attributed to the completion of ripening process of the unripe fruits. The decrease in TSS in the later phase of storage might be due to the on-going physiological catabolic processes in the fruits. In strawberry, similar results were reported earlier [11].

Titratable acidity (%)

The titratable acidity of strawberry fruits packed in different packaging films went on decreasing with the advancement of storage period. Under supermarket storage condition (Table 4), no significant variation in titratable acidity of fruits packed with different packaging films was found, however, over the storage period, significant variation in titratable acidity was observed. Titratable acidity was reported maximum on the 0th day (0.91%), which was statistically at par with 1st day and minimum on the 5th (0.72%) day of storage. No-significant variation was observed for different packaging films or for the interaction between the packaging film and the storage condition. Such reduction in acidity might be due to the utilization of different free acids present in the vacuole of cells during various metabolic processes like respiration and anthocyanin biosynthesis. Similar trend was reported in strawberry [12, 13]. In the present study, the variation in titratable acidity of strawberry fruits as a function of various packaging materials, which was not significant, is in close agreement with the early findings of in strawberry [11].

Ascorbic acid (mg/100g)

The data recorded during the period of study revealed that the ascorbic acid content of strawberry fruits packed in different packaging films varied significantly over the period of storage. Under the supermarket storage condition (Table 5), after 5 days of storage period, maximum ascorbic acid was recorded in fruits packed with LDPE 50 micron (30.90 mg/100g), which was statistically at par the fruits packed with LDPE 75 micron (30.34 mg/100 g) and PP 25 micron (30.25 mg/100 g). Minimum ascorbic acid content was found in fruits which were kept unwrapped. On the 0th day maximum (38.33 mg/100g) and on the 5th day minimum (21.06 mg/100 g) ascorbic acid was recorded. The interaction among the packaging materials and storage periods was statistically not-significant. Such results might be attributed to better modification of the atmosphere inside the packages by these materials with respect to the O_2 concentration and concomitant decrease in enzymatic oxidation of ascorbic acid [14]. Over the prolongation of the starage period, the ascorbic acid content was on a decreasing trend. This might be due to the oxidation and irreversible conversion of ascorbic acid to dehydroascorbic acid in the presence of enzyme ascorbinase. Similar results were also obtained earlier [12].

Conclusion

The strawberry is a highly perishable fruit cannot be stored for a longer period but different treatments maintained the qualitative characteristics of stored fruits at supermarket condition. From the day, first onwards the loss in weight of fruits was observed and among the packaging materials but LDPE 50 micron packaging material proved as the most effective one to control the weight loss. MAP conditions prevented decaying of strawberry fruits up to single day under the supermarket condition. The total soluble solids, titratable acidity and ascorbic acid decreased in the stored fruit at supermarket and spoiled completely after 5th day of storage.

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