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Atta-Aly M.A., Lasheene Z.E.S., Ezzat M.A.

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REDUCING QUALITY LOSS OF STRAWBERRIES DURING LOCAL MARKETING AND EXPORTATION BY USING DIFFERENT COOL CHAINS

M. Atta Aly,
Z. El-S. Lasheene
Department of Horticulture,
Faculty of Agriculture,
Ain-Shams University, Egypt

M. A. Ezzat
Post-Harvest Research Section,
Agricultural Research Center, Egypt

Abstract

Strawberry (*Fragaria x ananassa*) fruits cvs. Sequoia, Chandler Pajaro, Selva and Parker were harvested at ¾ colored stage. Fruits were then divide into 3 groups for post-harvest treatments with different cool chains. Fruits of the first group were kept at room temperature for 4 days as control treatment. Second and third groups, however, were exposed to pre-cooling treatment by holding at 0°C / 18h (room cooling) followed by 15°C / 6h (transporting) and then to 5°C / 24h (transit or wholesale market re-cooling). After pre-cooling, fruits of the second group (pre-cooled fruits) were kept (marketed) at room temperature (as in unequipped consumer market), while fruits of the third group (cooled fruits) were held at 0°C (as in equipped consumer market) each for 8 days. Quality losses of strawberries were determined by measuring the percentage of fruit weight loss, firmness loss and the percentage of decayed fruits as physical properties and by measuring TSS, titratable acidity (TA) and L-ascorbic acid content (LAA) as chemical properties. Fruit panel taste, among cultivars and cool chains, was also determined at harvest and at the end of the storage period, respectively.

Pre-cooling treatment significantly reduced strawberries quality loss in comparison with those of control ones since pre-cooled fruits required double storage time to reach the same quality loss level of control fruits. Further and remarkable reduction in berries quality loss was observed when fruits were kept at 0°C after pre-cooling. Among all tested cultivars, both Selva and Parker showed the highest physical but intermediate chemical properties. Sequoia cultivar, however, was the lowest physical but the highest chemical and taste qualities followed by Chandler and then Pajaro. This work, therefore, recommended both Selva and Parker for local marketing with or without pre-cooling and for exportation with cooling, due to its high chemical and taste qualities. Sequoia cultivar can also be recommended for local marketing if pre-cooled, and for short distance exportation if cooled. Data presented in this work also indicate the necessity of pre-cooling and /or cooling, as required post-harvest treatment, for successful local marketing and/or exportation of such delicate and very perishable fruit. Different cool chains can be successfully used to achieve such purpose and to reduce the remarkable post-harvest quality and quantity losses in strawberries.

1. INTRODUCTION

Strawberries are highly perishable fruits due to their extreme tenderness, vulnerability to mechanical damage, high level of respiration and their susceptibility to fungal spoilage (Maxie *et al.*, 1959; Dennis, 1978). Fresh strawberries, therefore, have a very limited post-harvest life and cannot be stored except briefly (Dennis and Mountford, 1975). The temperature of harvested strawberries in the field can rose up to 30° C and higher when directly exposed to the sun. When fruits are allowed to remain at such temperature for 4 hours, marketability drops by at least 40% (*Mitchell et al.*, 1964). After a few days in storage, the fruit looses some if its bright color, tends to shrivel and deteriorates in flavor. Deterioration is arrested by low temperature (Redit and Hamer, 1959). For maximum life (about 5 to 7 days), fruits should be pre-cooled immediately after harvest and placed at 0° C. Witting strawberry fruits by hydro-cooling is generally not advocated. Therefore, Ryall and Pentzer (1982) did not recommend hydro-cooling as a commercial practice. Pre-cooling of strawberries is highly recommended immediately after harvest using precooking rooms or forced air coolers (Ryall and Pentzer, 1982; Ferreira *et al*, 1994). The desired cooling temperature (1° C) can be obtained within 1 hour by forced air cooling, whereas room cooling takes a bout 9 hours to reach such temperature (Ryall and Pentzer, 1982). Prompt removal of field heat extends the marketable life of the fruit by about a week if low temperature is provided (Maxie *et al.*, 1959). Lutz and Hardenburg (1968) and Gesson and Browne (1982) have recommended 0-2° C as the optimum temperature and RH of 90 - 95% to extend strawberries shelf life by about a week. The need for rapid initial cooling and maintaining this temperature during storage and distribution - the so-called "cool chain" has been emphasized by Jarvis and Topping (1973) and Robinson (1977). Low temperature also reduces fruit respiration since the rate of strawberry respiration reduces significantly by about 7.2 times when temperature was reduced from 20 to 0° C (Lutz and Hardenburg, 1968).

The major diseases causing storage losses in strawberries are gray mold rot, rhizopus rot and leather rot. Prompt pre-cooling to temperature of 5° C or below and holding at such temperature in transit, storage and during marketing will minimize such losses to the least level (Mitchell et al., 1963; Sommer *et al.*, 1973). In Egypt, strawberries are mostly produced in hot seasons (during late spring and early summer which may indicate the necessity of pre-cooling and cold storage of strawberries. The purpose of this work, therefore, is to extend strawberries shelf life with keeping quality by using low temperatures for either improving local marketing quality and shelf life or increasing the chance of exportation. This work was designed based on different suggested cooling temperatures (different cool chains) required for strawberry fruits during transportation, transit, exportation and local or overseas marketing.

2. MATERIAL AND METHODS

Plant material

Strawberry (*Fragaria x ananassa*) seedlings cvs. Sequoia, Chandler Pajaro, Parker and Selva (American imported commercial cultivars) were obtained from the Vegetable Research Department, Ministry of Agriculture, Giza, Egypt. Seedlings were then transplanted at Seds Experimental Station on September 1994 and September 1995. All agricultural management was carried out as usually recommended for strawberry production under open field conditions.

On April 1995 and April 1996, strawberry fruits of ¾ colored stage were carefully picked and directly packed in perforated 4 kg carton boxes of 40x30x10 cm dimensions and transported immediately to the laboratory of the above mentioned research department. As soon as they arrived to the laboratory, fruits were sorted and re-graded in terms of size and colour with caps (calyx) and stem (pedicle) being attached. Fruits were then carefully packed into 250 gm plastic baskets and every 16 baskets were re-packed inside perforated 4 kg carton box of the above mentioned dimensions. Strawberry boxes were then equally distributed among the below described cool chains.

Strawberry cool chains and storing conditions

Strawberry boxes of each cultivar were divided into 3 groups and each group consisted of 5 carton boxes. The first group (control) was held at room temperature (22°C $\pm$ 2 and 70% + 5 RH) for 4 days following a similar pattern of local marketing conditions in Egypt. Physiological and chemical analysis were daily carried out for 4 days in 5 replicates. Each was 075 kg (3 plastic baskets from each carton box were used for both analyses). Fruits of the second and third group, however, were pre-cooled by cooling at 0°C and 95% RH for 18h (room cooling), transferring to 15°C and 80% $\pm$ 2 RH for 6 h (transportation or airplane temperature) and then kept at 5°C and 90% %H for 24 h (transit or wholesale market re-cooling). Fruits of the second group (pre-cooled) were then moved to room temperature (the above mentioned room conditions of unequipped consumer market0 while fruits of the third group (cooled) were transferred to 0°C and 98% RH (as in equipped consumer market) each for 8 days. During these 8 days all physical and chemical analysis were carried out in 5 replicates as previously described in control fruits but every other day.

Fruit physical analysis

One basket of strawberry fruits of 0.25 kg weight was used in each replicate to carry out the first and second analysis while another basket was used for the third analysis.

1. Percentage of fruit weigh loss (% WL) was calculated according to the following equation:

1. % WL = [Fruit initial weight-Fruit weight at sampling date)+Fruit initial weight] x 100.
2. Fruit firmness: Shatillon penetrometer was used for measuring strawberry fruit firmness and all data were recorded as g/cm^2. Each replicate was the mean readings of fruits presented in each basket.
3. Fruit decay percentage: It was recorded in relation to the total initial number of stored fruits.

Fruit chemical analysis

Fruits of 0.25 kg weight (3rd basket) were homogenized as one replicate in a stainless steal blender. The mixture was then centrifuged at 1000 rpm and the supernatant decanted. A liquats (clear strawberry juice) was used for the following analysis:

1. Total soluble solids (% TSS). A Zeiss hand refractometer was used and data were recorded as % TSS.
2. Titratable acidity (% TA). 10 ml of strawberry clear juice was titrated against 0.1 N NaOH solution and data were recorded as % TA (A.O.A.C., 1970).
3. L-ascorbic acid content 9LAA). It was determined using 2,6 di-chlorophenol endophenol according to the method of A.O.A.C. (1970) and data were recorded as mg/100 fresh fruit tissues.

Fruit panel taste

At the day of harvest, 45 fruits of each cultivar were exposed to the taste of 15 persons in red lighted room (Mizrahi et al., 1982), to distinguish between cultivars in their fruit taste. At the end of the storage periods, each separate cultivar was exposed to the same test using the same number of fruits and tasters to differentiate between control, pre-cooled and cooled fruit taste. For this test, control fruits were harvested 4 days later and the test was carried out after 4 days of storage for control fruit but after 8 days for pre-cooled and cooled fruits. Data were recorded as taste quality descending order starting with "a" as the best taste quality grade.

Experimental design and statistical analysis

Experiments were designed as factorial arrangements in completely randomized designs in 5 replicates. Data were analysed for statistical significant differences using the L.S.D. test at 5% level (Little and Hills, 1978).

3. RESULTS AND DISCUSSION

Physical properties of strawberries

Post-harvest storing of strawberries at room temperature for 4 day without cooling (control treatment) strongly accelerated the rate of fruit deterioration in terms of their physical properties (Table 1), i.e. percentage of fruit weight loss (Fig. 2) and percentage of decayed fruits (Fig. 3). Pre-cooling such fruits by exposing them to 0°C C/18h (room cooling), followed by 15°C / 6h (transporting) and then to 5°C / 24 h (transit or whole-sale market re-cooling) before keeping at room temperature (as in unequipped consumer market) for 8 days (pre-cooling treatment), reduced fruit deterioration by about 50% in all tested physical properties. This was indicated in Table 1 as well as in Figures 1, 2 and 3 in both seasons since double time was required for pre-cooled fruits to reach the same deterioration level of control fruits. When fruits were cooled, after exposing to the above described pre-cooling treatment, by keeping at 0°C (as in equipped local or overseas market) for 7 days, a remarkable reduction in fruit deterioration was obtained since such fruits were strongly firmer and significantly lower in the percentage of fruit weight loss and in the percentage of decayed fruits than those of other treatments (Table 1). Pre-cooled strawberries need double storage time at room temperature to reach the control fruit approximate values of weight loss percentage, firmness and decay percentage (Table 1). Further reduction in fruit weight loss and decay percentage (49% and 36% reduction, respectively) were obtained by keeping strawberries at 0°C after pre-cooling. Such fruits were 11% higher in their firmness values than pre-cooled ones (Table 1).

It is well known that reducing fruit temperature increases its atmospheric relative humidity (Ferreira et al., 1994), which will inhibit water vapor immigration from the fruit to the surrounding ambient and, as a result, fruit water loss decreases. In addition, cooling inhibits fruit respiration (Ryall and Pentzer, 1982) and as a result, sugars consumption by respiration decreases. Reducing fruit water loss and respiration by cooling, therefore, are the reasons behind the reduction in fruit weight loss. Keeping pre-cooled fruits at low temperature will cause further reduction in fruit weight loss which has been evident in Table 1 and Figure 1.

The activity of hydroloysis enzymes, responsible for fruit softness, is significantly reduced by cooling (Lutz and Hardenburg, 1968) and this may be the reason behind higher and highest firmness values of pre-cooled and cooled fruits, respectively (Table 1 and Figure 2).

On the other hand, all micro-organisms reduce their activity by cooling which may explain the delay in fruit decay when pre-cooled (Table 1 and Figure 3). Further cooling, therefore, will cease most of the micro-organisms activity and will limit the percentage of decayed fruits to the least level (Sommer, 1982). This has also been evident in both seasons, as indicated from Table 1 and Figure 3.

Among all tested cultivars, both Selva and Parker cultivars have been proved to be the highest quality in terms of their fruit physical properties, followed by Pajaro and then Chandler, while Sequoia cultivar is the lowest (Table 1). These cultivars followed the same significant descending order in their firmness (Figure 2), but significant and remarkable ascending orders in fruit weight loss and in the percentage of decayed fruits, respectively (Figure 1 and 3). The percentage of decayed fruits found in Selva or Parker cultivar was only 1/6 of that found in

Sequoia and 1/4 of that detected in other cultivars (Table 1 and Figure 3). These differences in fruit physical properties may be due to the variability between cultivars in their genetic background as well as fruit structure and post-harvest behavior (Al-Shaibani and Greig, 1979).

Physical properties of strawberries strongly reduced when prolonging the storage time (Table 1). This reduction became more significant with each additional day during storage at room temperature but every other day when fruits were stored at 0° C. The percentages of fruit weight loss and decayed fruits showed significant positive correlation with the time of storage (Figure 1 and 2), while a negative correlation was observed for fruit firmness (Figure 3). Dennis and Mountford (1975) reported that strawberries have a very limited post-harvest life and cannot be stored except briefly. Several hours at room temperature was enough to drop the marketability of strawberries (Mitchell et al., 1964), while 5-7 days was the maximum storage life when fruits were kept at 0° C (Redit and Hamer, 1959)

Chemical properties of strawberries

Exposing strawberries to different cool chains did not affect fruit content of TSS or titratable acidity (TA) since there were no significant differences detected in both seasons between control, pre-cooled and cooled fruits (Table 2). It is well known that respiration level of harvested fruit remain high if kept without cooling, and as a result, sugars and organic acids contents are strongly consumed which may cause significant reduction in fruits content of TSS and TA. In this work, however, such fruits lost more weight in 4 days than those pre-cooled or cooled which were kept for 8 days (Table 1) and this may concentrate TSS and TA content in such fruits to the same level of pre-cooled and cooled ones. In terms of L-ascorbic acid (LAA) content, however, a significant ascending order was evident since control fruits contained the lowest level followed by pre-cooled, while cooled fruits had the highest level (Table 2). During fruit ripening, oxidation process increased and LAA may change to other vitamin "C" forms such as dehydroascorbic acid and gluonic acid (Gonzalez and Brecht, 1978). As the temperature increases, oxidation process increases, and this may explain the significant ascending order of LAA content in strawberries as the cooling chain became more intensive.

In contrast to their physical properties, both Selva and Parker cultivars took the last 2 places (4^{th} and 5^{th} places, respectively) in their LAA content while Sequoia (the last physical properties cultivar) being the first followed by Pajaro and then Chandler in the 3^{rd} place (table 2 and 5). It seems that there was a negative correlation between fruit physical properties and their LAA content. Sequoia cultivar was also the highest TSS content followed by Chandler while Selva and Parker took the 3^{rd} and 4^{th} place, respectively, and Pajaro being the lowest (Table 2 and 3). In terms of TA content, however, Chandler and Parker showed the highest levels followed by Sequoia and Selva while Pajaro cultivar took the 3^{rd} place (Table 2 & 4). The genetic variability between cultivars are the main reason behind their different chemical composition (Al-Shaibani and Greig,1979).

As previously found in physical properties, strawberries' chemical properties also showed gradual reduction with the time of storage in all cultivars of both seasons (Table 2). This reduction became significant in TSS content after 1 – 4 days at room temperature, 2 – 4 days in precooled and 4 – 6 days in cooled one based on cultivars (Table 3). The significant reduction in TA content occurred after 2 days at room temperature, 4 days in precooled and 4 – 6 in cooled fruits (Table 4), while it occurred in LAA content after one day at room temperature and 2 days in precooled and cooled fruits (Table 5).

Strawberries panel taste

When fruits were exposed to panel taste at the day of at the day of harvest, cultivars taste quality took the same presenting order as presented in all tables and figures in both seasons starting with Sequoia as the highest taste quality cultivars. The only exception is Selva and Parker cultivars which change their places since Selva took the 4th place after Pajaro while Parker took the last and 5th place. Fruits of Chandler cultivar occupied the second taste quality place. These findings are positively correlated with fruit content of TSS. Comparing fruits panel taste in each cultivar at the and of storage period resulted that, in each cultivar in both seasons, cooled fruits were the best taste quality followed by pre-cooled while control fruits gave the lowest taste quality values. It is indicated by these data that the positive correlation between fruit panel taste and their TSS content was established again and the differences in fruit taste became significant with each 0.1% increase in TSS content. Fruit texture (physical properties) may also play an important role in improving fruit taste quality since with cooling fruits were firmer and had less or undetected decay symptoms (Table 1 and Figure 2 and 3).

4. CONCLUSION AND RECOMMENDATION

Based on the data presented in this work, it could be concluded that Selva and Parker cultivars are recommended for exportation if cooled and for local marketing with or without pre-cooling due to their highest physical properties and their intermediate chemical properties which reduced the pot-harvest deterioration rage. In addition, it was also indicated that storage time is negatively correlated with fruit physical and chemical quality and that post-harvest cooling or pre-cooling retarded strawberry fruits physical and chemical quality losses. Data presented in this work, therefore, emphasize on the necessity of post-harvest pre-cooling and/or cooling for strawberries, and different cool chains can be used for successful local and overseas marketing based on required quality standard and on final marketing destination. In addition, and since strawberries are very perishable fruit, the presence of cooling facilities in wholesale, retail and consumer markets are highly recommended for keeping quality and reducing the remarkable postharvest losses in such delicate fruit.

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Table 1. Effect of cultivars (V), days in store (T) and cooling treatments (different cool chains of A, B and C) on the percentage of strawberry fruits weight loss (% WL), firmness(Firm.), as g/cm^2 and the percentage of decayed fruits (% DEC.) during storage. The different used cool chains were as follows; (A): Fruits kept at room temperature for 4 days without any cooling (control). (B): Fruits were room pre-cooled (O°C/18h), and then exposed to short transporting similar conditions (15°C/6h), followed by transit cooling (5°C/24h), before storing at room temperature for 7 days (pre-cooled) and (C): Fruits were exposed to the same cool chain as in (B) but stored for 8 days at O°C after transit cooling (Cooled).

Effective factors		First season 1995			Second season 1996		
		%WL	Firm.	% Dec.	% WL	Firm.	% Dec.
	V1*	9,39	37.1	44.7	9.43	38.6	43.0
	V2	5.86	61.0	37.4	5.82	59.2	36.0
Cultivars	V3	4.82	71.8	30.7	4.80	71.0	30.3
	V4	3.37	83.0	8.79	3.04	84.7	8.80
	V5	3.13	86.9	7.70	2.78	86.1	7.65
L.S.D. at	5%	0.26	1.91	4.80	6.29	1.98	4.50
	TO**	-	83.9	-	-	84.5	-
Days	T1	2.97	74.6	12.1	2.76	74.5	12.4
in	T2	3.94	66.6	21.7	3.79	67.8	21.1
store	T3	5.34	60.7	31.3	5.45	61.4	30.0
	T4	8.64	54.2	38.2	8.53	54.8	37.2
L.S.D. at	5%	0.21	1.97	3.20	0.25	2.03	3.70
Cool	A	6.02	65.2	27.8	6.80	65.3	28.2
Chains	B	5.83	66.4	27.9	5.40	67.2	26.4
	C	3.06	74.4	20.5	2.50	75.2	19.0
L.S.D. at	5%	0.26	1.87	2.92	0.29	1.98	2.90

* V1 = Sequoia, V2 = Chandler, V3 = Pajaro, V4 = Parker and V5 = Selva

** All analyses were carried out on fruits of approximate physiologically equal ages, i.e. every day for control fruits (A), but every other day for pre-cooled (B) and cooled (C) fruits [i.e. T4= 4 days for (A) but 8 days for (B) and (C)].

Table2. Effect of cultivars (V), days in store (T) and cooling treatments (different cool chains of A, B and C) on strawberry fruits content of total soluble solids (%TSS), titratable acidity (%TA) and L-ascorbic acid (LAA mg/100 fresh fruit tissues) during storage. A, B and C treatments (cool chains) were carried out as previously described in table 1.

Effective factors		First season 1995			Second season 1996		
		%TSS	% TA	LAA	%TSS	%TA	LAA
	V1*	9.29	0.80	82.2	9.48	0.79	79.2
	V2	8.99	0.88	79.8	9.07	0.88	77.7
Cultivars	V3	8.32	0..68	81.4	8.36	0.68	77.4
	V4	8.43	0.87	60.9	8.50	0.86	58.0
	V5	8.61	0.81	75.5	8.64	0.80	74.0
L.S.D. at	5%	0.13	0.03	0.72	0.14	0.02	0.70
	TO**	8.89	0.86	81.5	8.97	0.85	78.6
Days	T1	8.78	0.89	77.4	8.87	0.82	74.7
in	T2	8.71	0.82	75.6	8.81	0.81	71.8
store	T3	8.65	0.80	73.7	8.74	0.79	71.7
	T4	8.61	0.77	71.5	8.69	0.76	60.9
L.S.D. at	5%	0.11	0.02	0.62	0.13	0.02	0.68
Cool	A	8.80	0.80	75.4	8.77	0.79	71.4
Chains	B	8.71	0.81	76.9	8.80	0.80	72.9
	C	8.77	0.82	77.6	8.87	0.81	74.8
L.S.D. at	5%	0.14	0.02	0.64	0.12	0.02	0.71

* V1 = Sequoia, V2 = Chandler, V3 = Pajaro, V4 = Parker and V5 = Selva

** All analyses were carried out on fruits of approximate physiologically equal ages as previously described in Table 1.

Table 3. Effect of exposiing strawberry fruits of different cultivars (V) to different cool chains(A, B and C), as previiously described in table 1, on fruit TSS content during storage.

Cool Chains	Day in Store	% Total soluble solids (% (TSS)											
		1st season						2nd season					
		V1*	V2	V3	V4	V5	LSD	V1	V2	V3	V4	V5	LSD
	0	9.32	9.11	8.83	8.24	8.66	0.12	9.10	8.37	8.49	8.62	8.62	0.13
	1	9.29	9.06	8.33	8.43	8.62	0.11	9.20	9.08	8.33	8.44	8.58	0.11
A	2	9.25	8.93	8.27	8.40	8.58	0.11	9.15	9.05	9.29	8.40	8.55	0.13
	3	9.21	8.87	8.21	8.38	8.53	0.14	9.11	8.90	8.25	8.36	8.50	0.14
	4	9.13	8.82	8.15	8.30	8.50	0.12	8.93	8.80	8.16	8.31	8.46	0.14
	0	9.40	9.20	8.48	8.59	8.76	0.12	9.60	9.30	8.52	8.63	8.79	0.12
	2	9.35	9.06	8.33	8.43	8.62	0.11	9.54	9.20	8.37	8.52	8.68	0.11
B	4	9.25	8.93	8.27	8.40	8.58	0.13	9.44	9.10	8.31	8.48	8.64	0.13
	6	9.21	8.87	8.21	8.35	8.53	0.13	9.40	8.90	8.25	8.42	8.59	0.12
	8	9.13	8.82	8.12	8.30	8.50	0.14	9.35	8.85	8.19	8.37	8.55	0.13
	0	9.40	9.20	8.48	8.59	8.76	0.13	9.60	9.30	8.52	8.63	8.79	0.12
	2	9.38	9.14	8.42	8.50	8.70	0.12	9.58	9.24	8.49	8.60	8.73	0.13
C	4	9.33	9.00	8.36	8.46	8.64	0.11	9.53	9.20	8.40	8.55	8.68	0.11
	6	9.28	8.98	8.31	8.41	8.59	0.12	9.48	8.18	8.35	8.50	8.63	0.14
	8	9.21	8.93	8.27	8.35	8.56	0.12	9.39	8.10	8.31	8.45	8.58	0.12
LSD at 5%	-	0.12	0.11	0.13	0.13	0.14	-	0.12	0.12	0.14	0.12	0.13	-

Table 4. Effect of exposing strawberry fruits of different cultivrs (V) to different cool chains (A, B and C), as previously described in table 1, on fruit content of titratable acidity (% TA) during storage.

Cool Chains	Day in Store	% Total soluble solids (% (TSS)											
		1st season						2nd season					
		V1*	V2	V3	V4	V5	LSD	V1	V2	V3	V4	V5	LSD
	0	0.83	0.93	0.74	0.92	0.86	0.02	0.81	0.93	0.68	0.88	0.86	0.01
	1	0.82	0.91	0.71	0.90	0.84	0.03	0.77	0.91	0.66	0.87	0.85	0.01
A	2	0.80	0.89	0.69	0.88	0.81	0.03	0.75	0.89	0.63	0.84	0.81	0.02
	3	0.78	0.86	0.65	0.85	0.79	0.03	0.73	0.86	0.61	0.81	0.79	0.01
	4	0.75	0.82	0.61	0.81	0.78	0.02	0.71	0.82	0.59	0.78	0.76	0.01
	0	0.84	0.93	0.85	0.91	0.85	0.02	0.83	0.93	0.74	0.90	0.84	0.03
	2	0.82	0.91	0.71	0.90	0.84	0.02	0.81	0.91	0.70	0.89	0.83	0.02
B	4	0.82	0.89	0.69	0.88	0.81	0.02	0.81	0.89	0.68	0.87	0.80	0.02
	6	0.78	0.86	0.65	0.85	0.79	0.03	0.77	0.86	0.64	0.84	0.78	0.03
	8	0.75	0.82	0.61	0.81	0.78	0.03	0.74	0.82	0.60	0.80	0.77	0.03
	0	0.84	0.92	0.75	0.91	0.85	0.02	0.83	0.93	0.74	0.90	0.84	0.02
	2	0.83	0.92	0.73	0.90	0.84	0.03	0.82	0.92	0.72	0.89	0.83	0.02
C	4	0.82	0.91	0.71	0.89	0.83	0.02	0.81	0.91	0.70	0.88	0.82	0.03
	6	0.80	0.89	0.70	0.87	0.80	0.03	0.79	0.89	0.69	0.86	0.79	0.03
	8	0.78	0.87	0.68	0.85	0.78	0.02	0.77	0.87	0.67	0.84	0.77	0.02
LSD at 5%	-	0.02	0.03	0.03	0.02	0.02	-	0.01	0.02	0.01	0.02	0.02	-

Table 5. Effect of exposing strawberry fruits of different cultivrs (V) to different cool chains (A, B and C), as previously described in table 1, on fruit content of L-ascorbic acid during storage.

Cool Chains	Day in Store	% Total soluble solids (% (TSS)											
		1st season						2nd season					
		V1*	V2	V3	V4	V5	LSD	V1	V2	V3	V4	V5	LSD
	0	87.1	85.4	85.0	64.6	79.1	0.72	85.1	83.4	82.3	62.2	77.5	0.68
	1	84.2	81.6	82.4	61.6	77.3	0.66	80.3	79.5	78.1	59.4	73.1	0.72
A	2	81.3	79.4	80.6	60.0	74.6	0.71	78.4	76.3	75.1	57.2	71.0	0.64
	3	79.2	77.3	78.1	58.8	73.5	0.69	75.4	74.2	72.1	54.3	67.2	0.73
	4	77.6	73.1	75.4	56.4	70.7	0.71	71.2	70.0	68.1	51.5	62.6	0.69
	0	88.2	86.7	86.5	65.8	80.3	0.71	85.4	83.7	83.5	62.3	78.4	0.73
	2	84.2	81.6	82.4	61.6	77.3	0.68	81.6	79.4	78.3	58.6	75.3	0.69
B	4	81.3	79.4	80.6	60.0	74.6	0.71	78.3	77.4	76.4	57.3	73.8	0.68
	6	79.2	77.3	78.1	58.8	73.5	0.69	76.5	75.5	74.5	55.4	71.7	0.71
	8	77.6	73.1	75.4	56.5	70.7	0.68	73.1	72.3	71.4	53.6	68.3	0.69
	0	88.2	86.7	86.5	65.8	80.3	0.69	85.4	83.7	83.5	62.3	78.4	0.70
	2	85.3	82.7	84.5	63.5	79.2	0.71	82.2	80.6	80.4	60.2	77.1	0.68
C	4	82.1	81.1	83.7	62.4	77.2	0.68	79.3	79.3	78.3	59.4	76.7	0.70
	6	81.4	79.4	81.3	61.2	75.3	0.68	78.4	77.6	76.7	58.5	74.6	0.68
	8	80.5	76.4	79.4	60.5	74.2	0.69	77.1	74.7	74.3	57.5	73.4	0.69
LSD at 5%	-	0.71	0.68	0.73	0.69	0.68	-	0.73	0.69	0.68	0.71	0.69	-