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Pre-harvest spray and low temperature storage (2 ^{0}C) effect on quality parameters of strawberry cv. Camarosa

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Abstract
Strawberry is a temperate fruit with high demand in today's market with fresh aroma. As the shelf-life of fruits are hardly around 2 days at normal room temperature. A pre-harvest application of chitosan, calcium chloride and their combinations were evaluated with the objective to delay senescence in the conducted experiment. Low temperature (at 2 ^{0}C) to check the spoilage was given during storage condition. The spray of chemicals at pre-harvest level was made before 10 days of harvesting and harvested fruits were made to quality parameters analysis at 2 days interval at low temperature storage condition. The maximum total sugar per cent was found highest in T_{12} (Chitosan 6 g/L + 1.5% $CaCl_2$ - 6.32%) which was at par with T_{11} (Chitosan 6 g/L + 1% $CaCl_2$ - 6.04%) while the lowest total sugar per cent was found in T_1 (control - 4.22%). Ascorbic acid of strawberry fruits was found to be non-significant with the range of 55.95 mg/100g pulp to 71.05 mg/100g pulp. The minimum value of spoilage was recorded in T_{11} (3.57%). Spray of chemicals with the low temperature storage condition was quite effective in prolonging the shelf-life of strawberry fruits with fresh acceptance without deteriorating its composition and acceptance of consumer.

Keywords: Strawberry, chemicals, ascorbic acid, total sugar, spoilage, marketability

Introduction
Recent research on the characteristics of cultivation, marketing and nutritional properties of berries have attracted the interest of growers, researchers and consumers, especially because of their high value and benefits for human health when consumed fresh strawberry fruits. Strawberry fruits are very popular among berries and are reported to antioxidant, anticancerous, anti-inflammatory and anti-neurodegenerative biological properties. These are mainly attributed to high fruit poly phenolic content, especially anthocyanin – the type of poly phenols quantitatively most important in strawberry fruits as well as flavonoids, phenolic acids and vitamin C (Meyers *et. al.*, 2003; Olsson *et. al.*, 2004; Cordenunsi *et al.*, 2005) [9, 12, 4]. Strawberry fruits are very perishable in nature and highly market demanding as fresh fruits. Strawberry fruits are amongst some crops, which give quick and high returns per unit area on the capital investment, as the crop is ready for harvesting within three to four months of planting. It is a herbaceous perennial and short day plant grows predominantly in the temperate climate. Strawberries are extremely fragile and perishable necessitating minimal handling after harvest (Mitcham and Mitchell, 2002) [10]. Strawberry fruit grows rapidly and takes 20 - 60 days for ripening, depending upon fruit habit of a cultivar and environmental conditions. Pre-harvest factors such as the genetic background, the environmental conditions during culture as well as cultural practices employed influence the bio-chemical composition of the fruit. Edible coatings have been of increasing interest because of their capacity to reduce respiration and transpiration rates, and increase storage periods, firmness retention and decay control (Debeaufort *et al.*, 1998; Vu *et al.*, 2011; Velickova *et al.*, 2013) [6, 19, 18]. In spite of the wide use of low temperatures in strawberry preservation, not much is known about the effects of cool storage on chemical composition, in particular compounds with nutritional value (Montero *et al.*, 1996) [11]. When strawberry fruits are stored at low temperature, their shelf-life can be extended to at least one week. Chitosan, a high molecular polymer, nontoxic, bioactive agent has become a useful choice due to its fungicidal effects and elicitation of defense mechanisms in plants. It is able to induce host defense responses, including the accumulation of antifungal hydrolysates and phytoalexin (Li & Yu, 2001) [8]. Calcium is the most important mineral element determining fruit quality. The multiple roles of Ca are associated with the plant cell. Pre-harvest Ca treatments used to increase Ca content of the cell wall which is effective in delaying senescence, resulting in firmer and higher fruit quality (Serrano *et al.*, 2004; Kluter *et al.*, 2006 and Raese and Drake, 2006) [16, 7, 13].

Therefore, the objective of the present study was to establish the effects of pre-harvest application of chitosan and $CaCl_2$ with low temperature storage condition on biochemical attributes of strawberry fruits during postharvest storage.

Materials and Methods

Experimental strawberry plants (*Fragaria ananasa*) cultivar 'Camarosa' were grown in horticulture garden at Bihar Agricultural College, Sabour under Bihar Agricultural University, Sabour. The plants were planted in double row-raised bed method in field at a spacing of 45 cm x 30 cm in field. The beds were covered with plastic mulch and poly tunnels imposition was given during the first week of December to first fortnight of February to protect the plants from severe frost. Different concentrations of chitosan (5g/L and 6g/L), calcium chloride (@ 0.5%, 1.0% and 1.5%) and their combinations were applied to each treatment for a single time before 10 days of harvest. First of all Chitosan was dissolved in 0.1 N HCl solution. Undissolved substances and impurities were filtered. Calcium chloride was taken as a source of Calcium which was dissolved in water to make solution. The spraying of chemicals was continued until the uniform deposition of solution on the plants especially the fruits surface. The control treatment was sprayed with water. All the experimental plants were given to uniform cultural practices like irrigation, fertilization and disease pest management during the course of study. The bio-chemical analysis of harvested fresh fruits were done and stored at low temperature (2 ^{o}C) to show the effect on shelf life as well as changes in quality parameters of the fruit. Analysis of fruits was done at three days interval.

Ascorbic acid

2 g of crushed sample was taken in a conical flask and adjust volume up to 100 ml with 3% HPO_3 solution was added. This solution was kept it for 10-15 minutes and then filtered it. 10 ml filtrate solution was titrated with standard dye 2, 6-Dichlorophenol-indophenol to a pink end point appearance. Titrated rapidly and made a preliminary determination of the titre value. The ascorbic acid content of the sample calculated by the following formula:

$$\text{Ascorbic acid (mg/100g FW)} = \frac{\text{Titre value X Dye factor X Volume make up}}{\text{Weight of sample X Volume of sample taken}} \text{X100}$$

$$\text{Dye factor} = \frac{1}{\text{Titre value (burette)}}$$

Total sugar

It was determined by Lane and Eynon (1984) copper titration method. 5 ml of each Fehling's solution was taken into 250 ml conical flask and 25 ml of water was added. Prepared standard invert sugar solution was taken in a 50 ml burette. 10 ml of standard invert sugar solution was added in the conical flask containing mixture of Fehling's solution. Then conical flask containing the mixture was heated and it was boiled for 2-3 minutes on low flame and invert sugar solution was added from the burette rapidly. Then further quantity of sugar solution added to the conical flask, which turned the solution colour of conical flask into light blue. 2 to 3 drops of methylene blue indicator was added and the titration was completed within 2-3 minutes by adding further quantity of invert sugar solution. At the end point a brick red precipitate developed.

$$\text{Total sugar (\%)} = \frac{\text{Factor X Dilution X 100 X 100}}{\text{50 X Titre value X Wt. of Sample}}$$

$$\text{Factor for Fehling's solution} = \frac{\text{Titre (Burette Reading)} \times 2.5}{\text{(g of invert sugar) 1000}}$$

Spoilage

The loss due to infestation of disease, shriveling and other deformity was considered as decay loss. On each day of observation, the spoiled or decayed fruits were separated treatment wise under all the replication. The fruit so obtained were weighed and decay loss in terms of percentage of decayed fruits on the each day of observations was calculated. The spoiled fruits on the day observations will be separated in all treatments. The fruits so obtained will be weighed separately and the percentage of spoiled fruits on the day will be calculated by using following formulae

$$\text{Spoilage (\%)} = \frac{\text{Weight of spoiled fruits}}{\text{Original weight of fruits}} \text{ x 100}$$

Marketability

The marketability per cent of fruits was measured by Workneh *et al*. (2011a, b) [21, 22] with some modifications. It was determined by observing visually on different parameters like mould growth, decay, shriveling, smoothness, and shininess of fruits with (20 respondents). A 1-5 rating, with1 = unusable, 2 = usable, 3 = fair, 4 = good, 5 = excellent was used to evaluate the fruit quality. Fruits receiving a rating 3 and above were considered as marketable. The numbers of marketable fruits were used as a measure to calculate the percentage of marketable fruits during storage. After compiling the assessed data, it was calculated using the following formula.

$$\text{Marketability (\%)} = \frac{\text{Number of marketable fruit}}{\text{Total number of sampled fruit}} \text{ x 100}$$

Statistical analysis

A randomized complete block design with 12 treatments and three replications were used in this study. Each fruiting plant was experimental unit. Data were subjected to analysis of variance. Arcsine transformation was applied on percentage data prior to analysis but actual data are presented. The analysis of data is in RBD in DMRT form. Post-harvest analysis was done at 3 days interval at low temperature storage condition at 2 ^{0}C. The application of calcium chloride, chitosan and their combinations was made at pre-harvest level of around 10 days before harvest.

Result and Discussion

Ascorbic acid

It was observed that ascorbic acid of fruits was highly significant which progressively decreased under each treatment at different storage condition. The value of ascorbic acid ranged from T_1 (55.95 mg/100g pulp) to T_4 (71.05 mg/100g pulp) in table no.-1. Low temperature has a protective effect on ascorbic acid content in fruits. Minimum delay to expose to low temperature after harvest would slow down the oxidative degradation of the remaining ascorbic acid. Cordenunsi *et al*., (2003) [5] also found similar results with respect to ascorbic acid of strawberry. The variation of total ascorbic acid throughout the storage period showed that the vitamin C content can be affected not only by the cultivar, but also by the temperature (Cordenunsi *et al.*, 2005) [4].

Table 1: Effect of pre-harvest application of calcium chloride and chitosan on ascorbic acid in storage condition at 2˚C

Treatments	1st Day	4th Day	7th Day	10th Day	13th Day	16th Day	Mean
Control	59.95	57.64	56.03	52.98	50.52	45.92	53.84 e
0.50% $CaCl_2$	64.96	63.08	61.07	59.50	56.27	50.62	59.25 bcd
1.00% $CaCl_2$	67.01	65.37	63.20	61.20	59.60	54.06	61.74 b
1.50% $CaCl_2$	71.05	69.87	68.20	66.52	63.81	58.47	66.32 a
Chitosan 5 g/L	61.37	60.20	57.86	56.06	53.67	51.04	56.70 de
Chitosan 5 g/L + 0.50% $CaCl_2$	64.41	63.06	60.22	59.92	56.27	52.27	59.36 bcd
Chitosan 5 g/L + 1.00% $CaCl_2$	65.18	63.38	61.93	60.72	57.05	52.54	60.13 bcd
Chitosan 5 g/L + 1.50% $CaCl_2$	65.65	63.46	62.16	60.82	57.84	52.92	60.47 bc
Chitosan 6 g/L	61.64	60.50	57.98	56.33	54.73	51.47	57.11 cde
Chitosan 6 g/L + 0.50% $CaCl_2$	64.88	63.39	62.02	60.06	57.61	53.97	60.32 bc
Chitosan 6 g/L + 1.00% $CaCl_2$	66.55	64.97	63.43	61.67	59.28	54.22	61.69 b
Chitosan 6 g/L + 1.50% $CaCl_2$	66.83	65.16	64.25	62.50	59.96	54.47	62.20 b
C.D.(p=0.05)	-	-	-	-	-	-	3.594

Total sugar

Strawberry fruits are slightly acidic with sweet in taste. Referring to the effect of pre-harvest treatments, obtained data during post-harvest observation shows significant difference. The longer storage period (16 days), the increase pattern was observed in the fruit total sugar with a declining pattern on last day (Table-2). The maximum total sugar percent was found highest in T_{12} (6.32%) which was at par with T_{11} (6.04%) while the lowest total sugar percent was found in T_1 (4.22%). Since strawberry does not have starch to support soluble sugar synthesis after harvest, this increase may be a consequence of cell-wall degradation. There are three possible carbon sources for soluble sugar synthesis after harvest: starch, organic acids and cell-wall disassembly. Since strawberry fruit has insufficient starch (~0.1%) to support this synthesis, organic acids and cell-wall are the more likely sources. During cool-storage, cell-wall disassembly plays an important role in sugar accumulation. This supposition accords with no change in texture and no recovery of soluble sugar. Cordenunsi *et al.*, (2003) [5] found similar results with respect to total sugar of strawberry.

Table 2: Effect of pre-harvest application of calcium chloride and chitosan on total sugar during storage at 2˚C

Treatments	1st Day	4th Day	7th Day	10th Day	13th Day	16th Day	Mean
Control	4.22 d	4.35 e	4.41 e	4.49 e	4.58 f	3.61 f	4.28 h
0.50% $CaCl_2$	4.31 d	4.41 de	4.54 de	4.64 de	4.73 def	3.78 ef	4.40 g
1.00% $CaCl_2$	4.36 d	4.44 de	4.56 de	4.68 de	4.78def	3.83 e	4.44 fg
1.50% $CaCl_2$	4.47 cd	4.60 cde	4.71 cde	4.77 cd	4.90 cde	3.88 de	4.55 ef
Chitosan 5 g/L	4.33 d	4.47 de	4.56 de	4.68 de	4.70 ef	3.84 e	4.43 g
Chitosan 5 g/L + 0.50% $CaCl_2$	4.37 cd	4.52 de	4.65 de	4.75 cde	4.75 def	3.86 de	4.48 fg
Chitosan 5 g/L + 1.00% $CaCl_2$	4.54 cd	4.72 cd	4.78 cd	4.90 cd	4.99 cd	3.90 de	4.64 e
Chitosan 5 g/L + 1.50% $CaCl_2$	4.77 c	4.91 c	4.97 c	4.97 c	5.07 c	4.12 c	4.80 d
Chitosan 6 g/L	4.49 cd	4.60cde	4.72 cd	4.83 cd	4.96 cd	4.07 cd	4.61 e
Chitosan 6 g/L + 0.50% $CaCl_2$	5.46 b	5.39 b	5.51 b	5.60 b	5.71 b	4.80 b	5.41 c
Chitosan 6 g/L + 1.00% $CaCl_2$	5.96 a	6.21 a	6.30 a	6.43 a	6.51 a	5.66 a	6.18 b
Chitosan 6 g/L + 1.50% $CaCl_2$	6.35 a	6.44 a	6.52 a	6.67 a	6.76 a	5.71 a	6.41 a
C.D.(p=0.05)	0.410	0.328	0.297	0.283	0.265	0.215	0.119

Spoilage

It is likely that chitosan produces a film coating the fruit surface, which would modify its gas exchange with the atmosphere and its internal gas composition. Li and Yu (2001) [8] recorded that chitosan coating often inhibits CO_2 production; consequently ethylene production of the commodity is also reduced. With regard to the effect of the tested pre-harvest treatments, data reported to (table no.- 3) demonstate that treatment chitosan @ 6 g/L + $CaCl_2$ @ 1.00% treated fruits showed to be the superior one with least spoilage of around 3.57% in T_{11}. The data reveals that during the storage period the minimum loss due to decay was recorded in T_{11}. Both inhibitory effects were reported in peaches coated with chitosan. The gained results of pre-harvest chitosan in reducing the decay go in line with findings of Romanazzi *et al.*, (2002) [15] on table grapes, Chien *et al.*, (2007) [2] on citrus, Yu *et al.*, (2007) [23] on apples and Meng *et al.*, (2008) on grapes. Recently, pre-harvest and post-harvest chitosan treatments of table grapes, strawberries and sweet cherries reduce their decay in the field and during storage, with the best performance at the highest tested concentration usually 1% (Romanazzi, 2010) [14]. Conway *et al.*, (1993) [3] reported the effect of Ca on apple in reducing decay and maintaining fruit quality is associates with maintaining cell wall structure by dealing or modifying chemical changes in cell wall composition. The other component to tissue softening is loss of turgor pressure which falls with loss of water or desiccation due to transpiration and respiration (Bourne, 1983) [1].

Table 3(a): Effect of pre-harvest application of calcium chloride and chitosan on spoilage during storage at 2 ˚C

Treatments	1st Day	4th Day	7th Day	10th Day	13th Day	16th Day	Mean
Control	0.00	0.00	0.00	10.02 a	16.56 a	29.10 a	9.28 a
0.50% $CaCl_2$	0.00	0.00	0.00	8.78 ab	10.83 b	20.68 b	6.71 b
1.00% $CaCl_2$	0.00	0.00	0.00	8.29 b	10.00 bcd	18.06 bcd	6.05 b
1.50% $CaCl_2$	0.00	0.00	0.00	0.00 c	9.59 bcd	17.79 bcd	4.56 cd
Chitosan 5 g/L	0.00	0.00	0.00	0.00 c	10.0 bc	20.21 b	5.04 c
Chitosan 5 g/L + 0.50% $CaCl_2$	0.00	0.00	0.00	0.00 c	8.76 bcd	19.32 bc	4.68 cd
Chitosan 5 g/L + 1.00% $CaCl_2$	0.00	0.00	0.00	0.00 c	8.62 bcd	19.19 bc	4.63 cd
Chitosan 5 g/L + 1.50% $CaCl_2$	0.00	0.00	0.00	0.00 c	8.62 bcd	19.35 bc	4.66 cd
Chitosan 6 g/L	0.00	0.00	0.00	0.00 c	8.81 bcd	17.39 bcd	4.36 cde
Chitosan 6 g/L + 0.50% $CaCl_2$	0.00	0.00	0.00	0.00 c	7.47 cd	16.17 cd	3.94 de
Chitosan 6 g/L + 1.00% $CaCl_2$	0.00	0.00	0.00	0.00 c	7.06 d	14.40 d	3.57 e
Chitosan 6 g/L + 1.50% $CaCl_2$	0.00	0.00	0.00	0.00 c	7.33 cd	17.17 bcd	4.08 de
C.D.(p=0.05)	–	–	–	1.34	2.95	3.81	0.79

Table 3(b): Effect of pre-harvest application of calcium chloride and chitosan on spoilage during storage at 2˚C

Treatments	1st Day	4th Day	7th Day	10th Day	13th Day	16th Day	Mean
Control	4.05	4.05	4.05	18.38 (a)	23.99 (a)	32.61 (a)	37.58 (d)
0.50% $CaCl_2$	4.05	4.05	4.05	17.21 (ab)	19.19 (b)	27.03 (b)	39.10 (abc)
1.00% $CaCl_2$	4.05	4.05	4.05	16.72 (b)	18.36 (bc)	25.13 (bc)	39.62 (ab)
1.50% $CaCl_2$	4.05	4.05	4.05	4.05 (c)	18.00 (bcd)	24.89 (bcd)	39.88 (a)
Chitosan 5 g/L	4.05	4.05	4.05	4.05 (c)	18.40 (bc)	26.71 (b)	38.72 (c)
Chitosan 5 g/L + 0.50% $CaCl_2$	4.05	4.05	4.05	4.05 (c)	17.20 (bcd)	26.06 (bc)	39.09 (abc)
Chitosan 5 g/L + 1.00% $CaCl_2$	4.05	4.05	4.05	4.05 (c)	17.00 (bcd)	25.94 (bc)	39.63 (ab)
Chitosan 5 g/L + 1.50% $CaCl_2$	4.05	4.05	4.05	4.05 (c)	17.05 (bcd)	26.08 (bc)	39.91 (a)
Chitosan 6 g/L	4.05	4.05	4.05	4.05 (c)	17.26 (bcd)	24.58 (bcd)	38.78 (bc)
Chitosan 6 g/L + 0.50% $CaCl_2$	4.05	4.05	4.05	4.05 (c)	15.81 (cd)	23.69 (cd)	39.17 (abc)
Chitosan 6 g/L + 1.00% $CaCl_2$	4.05	4.05	4.05	4.05 (c)	15.28 (d)	22.27 (d)	39.51 (abc)
Chitosan 6 g/L + 1.50% $CaCl_2$	4.05	4.05	4.05	4.05 (c)	15.70 (cd)	24.45 (bcd)	39.64 (ab)
C.D.(p=0.05)	–	–	–	1.28	2.87	2.78	0.88

Note: Arcsine transformed data of spoilage of strawberry fruits

Marketability

In the present investigation significant effect of chemicals on marketability of fruits was noted. At 2 °C storage condition, the average marketabilty over the period of storage of 16 days range from 90.71% to 96.42%. The highest value of marketability was observed in T_{11} (96.42%) while minimum was observed in T_1 (90.71%) which can be seen in table no.-4. Chitosan reduces the respiration rate and calcium maintains the firmness of the fruit. Wojcik and Lewandowski (2003) [20] and Singh *et al*., (2009) [17] found similar results with respect to marketability of strawberry fruits.

Table 4(a): Effect of pre-harvest application of calcium chloride and chitosan on marketability during storag at 2˚C

Treatments	1st Day	4th Day	7th Day	10th Day	13th Day	16th Day	Mean
Control	100.00	100.00	100.00	89.97 c	83.44 d	70.90 d	90.71 e
0.50% $CaCl_2$	100.00	100.00	100.00	91.22 bc	89.16 c	79.32 c	93.28 d
1.00% $CaCl_2$	100.00	100.00	100.00	91.71 b	89.99 abc	81.93 abc	93.94 d
1.50% $CaCl_2$	100.00	100.00	100.00	100.00 a	90.40 abc	82.20 abc	95.43 bc
Chitosan 5 g/L	100.00	100.00	100.00	100.00 a	89.95 bc	79.78 c	94.95 c
Chitosan 5 g/L + 0.50% $CaCl_2$	100.00	100.00	100.00	100.00 a	91.23 abc	80.68 bc	95.31 bc
Chitosan 5 g/L + 1.00% $CaCl_2$	100.00	100.00	100.00	100.00 a	91.37 abc	80.81 bc	95.36 bc
Chitosan 5 g/L + 1.50% $CaCl_2$	100.00	100.00	100.00	100.00 a	91.38 abc	80.64 bc	95.33 bc
Chitosan 6 g/L	100.00	100.00	100.00	100.00 a	91.18 abc	82.60 abc	95.63 abc
Chitosan 6 g/L + 0.50% $CaCl_2$	100.00	100.00	100.00	100.00 a	92.52 ab	83.82 ab	96.05 ab
Chitosan 6 g/L + 1.00% $CaCl_2$	100.00	100.00	100.00	100.00 a	92.93 a	85.59 a	96.42 a
Chitosan 6 g/L + 1.50% $CaCl_2$	100.00	100.00	100.00	100.00 a	92.66 ab	82.83 abc	95.91 ab
C.D.(p=0.05)	–	–	–	1.340	2.951	3.817	0.799

Table 4(b): Effect of pre-harvest application of calcium chloride and chitosan on marketability during storage at 2˚C

Treatments	1st Day	4th Day	7th Day	10th Day	13th Day	16th Day	Mean
Control	85.94	85.94	85.94	71.61 (c)	66.00 (d)	57.38 (d)	19.07 (h)
0.50% $CaCl_2$	85.94	85.94	85.94	72.78 (bc)	70.80 (c)	62.96 (c)	19.41 (gh)
1.00% $CaCl_2$	85.94	85.94	85.94	73.27 (b)	71.63 (bc)	64.86 (bc)	19.56 (fgh)
1.50% $CaCl_2$	85.94	85.94	85.94	85.94 (a)	71.99 (abc)	65.10 (abc)	19.68 (efg)
Chitosan 5 g/L	85.94	85.94	85.94	85.94 (a)	71.59 (bc)	63.28 (c)	19.61 (efgh)
Chitosan 5 g/L + 0.50% $CaCl_2$	85.94	85.94	85.94	85.94 (a)	72.79 (abc)	63.93 (bc)	19.82 (defg)
Chitosan 5 g/L + 1.00% $CaCl_2$	85.94	85.94	85.94	85.94 (a)	72.99 (abc)	64.05 (bc)	20.30 (cd)
Chitosan 5 g/L + 1.50% $CaCl_2$	85.94	85.94	85.94	85.94 (a)	72.95 (abc)	63.91 (bc)	20.07 (cdef)

Chitosan 6 g/L	85.94	85.94	85.94	85.94 (a)	72.73 (abc)	65.41 (abc)	20.10 (cde)
Chitosan 6 g/L + 0.50% $CaCl_2$	85.94	85.94	85.94	85.94 (a)	74.19 (ab)	66.30 (ab)	20.58 (bc)
Chitosan 6 g/L + 1.00% $CaCl_2$	85.94	85.94	85.94	85.94 (a)	74.71 (a)	67.72 (a)	21.13 (a)
Chitosan 6 g/L + 1.50% $CaCl_2$	85.94	85.94	85.94	85.94 (a)	74.29 (ab)	65.54 (abc)	20.92 (ab)
C.D.(p=0.05)	–	–	–	1.280	2.876	2.788	0.542

Note: Arcsine transformed data of marketability of strawberry fruits

Conclusion

The findings of the present study have shown that, in general pre-harvest spray of chemical combinations with low temperature storage condition have a positive effect on post-harvest quality and reduced decay incidence. The best treatment related to biochemical parameters goes with T_{12} (Chitosan 6 g/L + 1.50% $CaCl_2$). However, in concern with the spoilage and marketability, the best performance was recorded in T_{11} (Chitosan 6 g/L + 1.00% $CaCl_2$). As an environment friendly compounds, chitosen may be proven to be one of the most effective compound in coming future to be used in the complementation or partial substitution of the chemical fungicides presently practiced in this crop and others. Thus, an increase in shelf-life of strawberry was noted by low temperature storage along with the quality parameters.

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