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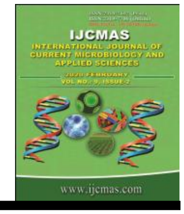

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Chitosan, Calcium Chloride and Low Temperature Storage (2℃) Effect on Organoleptic and Bio-chemical Changes during Storage of Strawberry cv. Camarosa

Ashwini Kumar[1], Kumari Karuna[1*], Feza Ahmad[1] and Abhay Mankar[2]

[1]*Department of Horticulture (Fruit & Fruit Tech.), Bihar Agricultural College, Sabour, Bihar, India*
[2]*Directorate of Extension Education, Bihar Agricultural University, Sabour, Bihar, India*

**Corresponding author*

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A B S T R A C T

The trial was conducted in the year 2017 to show the physical and biochemical properties of strawberry cv. Camarosa by the treatment of chitosan, calcium chloride and low temperature storage (2℃). Biochemical properties (T. S. S., Titrable acidity, anthocyanins, antioxidant and ascorbic acid) and organoleptic score of strawberry fruits were recorded at storage temperature (2 °C) after per harvest treatment with chitosan and calcium chloride. The highest length of fruit (42.88 mm), width (30.23 mm), weight (18.30 g), volume (22.72 ml), TSS (11.10°Brix) and total antioxidant capacity (21.13 µmol TE g^{-1} FW) was found maximum with the application of Chitosan 6 g/L + 1.00% $CaCl_2$. The highest anthocyanin content (39.91 mg/100gm pulp) was observed with the application of Chitosan 5 g/L + 1.50% $CaCl_2$. However, the lowest value of titrable acidity (0.64 per cent) and less PLW (6.20 per cent) were also recorded with treatment T_{11}. In conclusion, strawberry fruits stored at 2℃ retained an acceptable quality for the longer storage duration of around 13 days.

Introduction

Strawberry is one of the most delicious and nutritious among soft fruits of the world. Basically, it is herbaceous perennial and short-day plant grows predominantly in temperate climate. The fruit of strawberry grows rapidly and take 20-60 days for ripening, depending upon fruit habit of a cultivar and environmental condition. The red colour pigment is due to anthocyanin (Sharma, 2002 and Chadha, 2001). It has adapted well too many different climates viz. moderate, Mediterranean, sub-tropical even at high altitudes of tropical climates (Bose *et. al.;* 1991). Its cultivation is subjected to the specific regional adaptations due to critical photoperiod and thus the cultural systems are highly variable (Larson, 1994). Strawberry (*Fragaria ananassa* Duch.), a member of family Rosaceae, which is a hybrid of two largely dioecious octaploid American species (*F. chiloensis* X *F. verginiana*).

All the cultivated varieties of strawberry are ocatploid (2n = 8x = 56) in nature with basic chromosome number equal to seven (Sharma 2002; Chadha 2001; Bose *et. al.* 1991). Strawberry fruits are extremely fragile and highly perishable which require minimal handling after harvest (Mitcham and Mitchell, 2002). It is amongst the few crops, which give quick and very high returns per unit area on capital investment, as the crop is ready for harvesting within six months of planting. At present, consumer's demands are more natural, environmentally friendly with high quality and an extended shelf-life and without any chemical preservatives (Gol *et al.,* 2013). Being a non-climacteric fruit, strawberry do not ripen during postharvest and therefore, it must be harvested at the nearly full-ripe stage (Cherian *et al.,* 2014).

Chitosan is a natural polymer from the exoskeletons of various species of crustaceans. It is also found in cuticles of insects as well as in the cell walls of fungi and some algae (Sandford and Hutchings, 1987 and EPA, 1995). It's structure and composition is similar to both cellulose and chitin (Freepons, 1991 and Hadwiger and Mc. Bride, 2006). Chitosan has been used in agriculture as a coating material for vegetables and fruits (Zhang and Quantick, 1998; Jiang and Li, 2001; and Photchanachai *et al.,* 2006). Chitosan is an ideal preservative coating for fresh fruit and vegetables because it has a disease suppressive effect resulting from both physical and biochemical mechanisms (Muzzarelli, 1986). Edible coatings as a pre-harvest or post-harvest 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). These peculiarities of chitosan to be considered as biodegradable, non-toxic and biocompatible product (Azevedo *et al*., 2007).

Calcium is the most important mineral element determining fruit quality. The multiple roles of Ca are associated with the plant cell. Soluble Ca is involved in protein phosphorylation via Ca-Ca modulin binding. A large portion of the Ca in plant cells is located in the cell wall and plasma membrane where it plays a major role in senescence and ripening. Concentrations of 1-5 mm Ca^{2+} occur in the cell wall region (Poovaian *et al*., 1988). Cell wall-bounded Ca is involved in maintaining cell wall integrity by binding carboxyl groups of polygalacturonate chains, which are mainly present in the middle lamella and primary cell wall (Chardonnet *et al*., 2003). Pre-harvest Ca treatments used to increase Ca content of the cell wall were effective in delaying senescence, resulting in firmer and higher fruit quality (Serrano *et al*., 2004; Kluter *et al.,* 2006 and Raese and Drake, 2006).

Growers need to produce high-quality fruit that has the maximum possible storage or shelf-life to be competitive in the market place. Fruit Ca has been found to be related to fruit firmness by strengthening the cell wall, which in turn, improves shelf-life (Van-Buren, 1979). Foliar Ca applied to strawberries has been shown to delay fruit harvest, reduce incidence of fruit rot and improve fruit firmness (Cheour *et al*., 1990; Singh *et al*., 2007; Wojcik and Lewandowski, 2003). After harvest, refrigeration is most commonly used to slow decay in strawberries and maintain quality (El Ghaouth *et al*., 1991; Maas, 1980; Nunes *et al*., 2002). Most fungicides cannot maintain strawberry quality without the aid of refrigeration (Blacharski *et al*., 2001). To circumvent the losses associated with handling and storage of strawberry, and other small fruits, some postharvest conditions, such as low temperature or high CO_2 concentration, as well as controlled atmosphere or a combination of both processes, are widely used to extend the shelf-life (Gil *et al.*, 1997; Pelayo *et al.*, 2003). Fruit quality is evaluated in terms of its main sensorial attributes, in order to maintain consumer acceptance. Keeping the above facts in view the present experiment was laid out to study the "Chitosan, calcium chloride and low temperature storage (2^{o}C) effect on shelf-life of strawberry cv. Camarosa".

Materials and Methods

The experiment was conducted on the strawberry cv. Camarosa which was collected from Horticulture nursery of Bihar Agricultural University, Sabour, Bhagalpur. The pre-harvest spray of calcium chloride and chitosan solution along with the low temperature storage (at 2 ^{o}C) was analyzed on several biochemical parameters. The double row raised bed method of planting was adopted with the plastic mulch and poly-tunnels imposition was given during first week of December to the first fortnight of February to protect the plants from severe cold. The analysis of post-harvest biochemical parameters (i.e PLW, TSS, anthocyanin, titrable acidity, total antioxidant activity) was recorded at 3 days interval of storage at 2^{o}C. Different chitosan concentrations of 5 and 6 g/L were prepared in water. Calcium chloride as a source of calcium was taken and solutions of 0.5%, 1.0% and 1.5% were prepared in water. The spraying was done once in a time of all treatments. A set of plants were also sprayed with water as control and treatment details are as follows. T_1 (control), T_2 (0.05 % $CaCl_2$), T_3 (1.00% $CaCl_2$), T_4 (1.50% $CaCl_2$), T_5 (Chitosan 5 g/L), T_6 (Chitosan 5 g/L + 0.50% $CaCl_2$), T_7 (Chitosan 5 g/L + 1.00% $CaCl_2$), T_8 (Chitosan 5 g/L + 1.50% $CaCl_2$), T_9 (Chitosan 6 g/L), T_{10} (Chitosan 6 g/L + 0.50% $CaCl_2$), T_{11} (Chitosan 6 g/L + 1.00% $CaCl_2$) and T_{12} (Chitosan 6 g/L + 1.50% $CaCl_2$)

Fruit physical properties

Fruit weight (g)

The weight of fruit from each tagged plants was taken using an electronic balance and the mean was expressed as weight of fruit in gram.

Fruit volume (ml)

Volume of the same five fruits from each treatment was measured by water displacement method (Gustafson, 1926) and the average was recorded.

Fruit length and width (mm)

Fully matured fruits having uniform colour and size were selected from each treatment. Fruit length of 5 fruits from each treatment was taken with the help of digital slide calipers. The average length was then calculated in millimeter. The fruit breadth was recorded on same 5 fruits in which fruit length was recorded, with help of slide calipers. The average breadth was then calculated in millimeter.

Physiological loss in weight (PLW %)

The initial weight of fruits under each treatment was recorded replication wise at the time of storage. The weight of the same fruits under each treatment was recorded at three days interval and change in weight was recorded. The cumulative weight loss was estimated in per cent on the basis of initial fruit weight. To determine the weight loss of the fruit during post-harvest storage, fruits will be weighed at different sampling intervals. Then weight loss will be calculated by using the following formula.

PLW (%) = Initial weight – final weight /Initial weight X 100.

Organoleptic taste

To assess the consumers' acceptability the organoleptic evaluation was conducted by score card system with a panel of five judges of normal habits on a 9 point Hedonic scale given below as mentioned by Amerine *et al.,* (1965). The assessment of criteria was on colour, texture and flavor of fruit. The overall final rating was obtained by averaging the marks. Scores of 5.5 and above were noted as acceptable. This method is followed for fruits and beverages.

	Rating	Score
1.	Like extremely	9
2.	Like very much	8
3.	Like moderately	7
4.	Like slightly	6
5.	Neither like nor dislike	5
6.	Dislike slightly	4
7.	Dislike moderately	3
8.	Dislike very much	2
9.	Dislike extremely	1

Fruit chemical properties

Total Soluble Solids

Total soluble solids (TSS °Brix) were recorded with the help of digital refractometer. Fully ripe fruits of each treatment were taken and few (2-3) drops of juice from 5 fruits was taken separately and dropped in the clean glass on the prism base of the refractometer. Then pressed 'ON' button and took the reading displayed on the screen of digital refractometer. The mean of TSS of the taken fruits were taken as TSS of the respective treatments.

Titrable Acidity

The titrable acidity is determined by titrating the juice against standard alkali solution (0.1 N NaOH). 2 g of sample of pulp was taken in distilled water and crushed the pulp was homogenized and diluted up to 100 ml with distilled water. 10 ml aliquot of diluted sample was pipette out and transferred in 250 ml beaker. 1-2 drops of phenolphthalein indicator was added to the solution. The juice of conical flask was titrated against 0.1 N NaOH solution. The alkali was added drop by drop to the conical flask with constant stirring until the end point was reached with disappearance of pink colour. The percentage of acidity was calculated from the following formula.

$$\text{Titrable acidity (\%)} = \frac{\text{Volume of .01 N NaOH X 64}}{\text{Weight of juice taken X 1000}} \text{ X } 100.$$

Anthocyanin

Aliquots (5.00 g) of the homogenized strawberry samples were dissolved in 25 ml methanolic hydrochloric acid (85:15) solution. The samples were kept fort 24 hours at cool temperature (4-5°C) for the extraction of anthocyanin pigment. The flocculate was filtered off by a Whattman paper 1 and the absorbance of the resulting clear liquid was measured at 535nm in Spectrophotometer. Anthocyanin content was calculated using the following formula

$$\text{Anthocyanin (mg/100g pulp)} = \frac{\text{OD (abs 535Å)} \times \text{volume of soln'} \times 100}{\text{Weight of sample} \times 98.2} \text{ X } 100$$

Total Antioxidant activity

Cupric reducing antioxidant capacity (CUPRAC) assay was performed according to the method of Apak *et al.,* (2004). For this, 100 µl of sample aliquot and 1 ml each of copper (II) chloride solution, Neocuproine solution, ammonium acetate buffer solution and distilled water were mixed in a test tube.

The tubes were then capped and after 1 h, the absorbance was recorded at 450 nm in a spectrophotometer, against a reagent blank. The antioxidant capacity was estimated by using following formula and expressed as µmol Trolox equivalent g^{-1} FW.

$$\text{Total antioxidant capacity} = \frac{\text{O.D. X 4.1 X volume made up X 1000 X 100}}{\text{Weight of sample X 1.67 X 10000 X 0.1}} \text{ X 100}$$

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 DMRT. Post-harvest analysis was done at 3 days interval at low temperature storage condition at 2˚C.

Results and Discussion

Fruit physical properties

Fruit weight, volume, length and width

The statistical analysis of the data clearly indicates that the fruit length and fruit diameter was non-significant. The maximum length and width was observed in treatment with application of calcium chloride @1.00 % alongwith the combination of chitosan @ 6 g/L (table no. –2). The fruit weight and fruit volume was significant in nature with highest recorded value in the same treatment (T_{11}). The possible reasons for increased size, weight and volume of fruits might be due to more growth of fruits by accelerated rate of cell enlargement (increase in cell size) & cell division (increase in number of cells) and larger intercellular space.

It also might be due to increasing the photo-synthetic activities & accumulation of more carbohydrate by large size of plants and leaves. Similar findings with respect to fruit size, weight and volume of strawberry fruits were also reported by Chitu *et al.,* (2002) on strawberry.

Physiological loss in weight (PLW %)

Strawberry fruits have a short harvest life mainly due to softening. In general, fruits treated with chitosan and calcium maintained a higher level of firmness and showed significant retention of fruit firmness proposing that the high percentage of water loss by uncoated versus treated fruits.

The loss of texture is one of the main factor which limits quality and post-harvest shelf-life (Figueroa *et. al.,* 2012). With regard to the effect of the tested pre-harvest treatments, data reported in table no.– 1 demonstate that treatment chitosan @ 6 g/L + $CaCl_2$ @ 1.00 % treated fruits showed to be the superior one in reducing physiological loss in weight (T_{11}-6.20%) as compared to the control (T_1-7.88%).

The loss in fruit weight is mainly due to water loss as a result of evaporation and transpiration and the amount of dry matter was lost by respiration. Chitosan coatings act as barriers, thereby restricting water transfer and protecting fruit skin from mechanical injuries, as well as sealing small wounds and thus delaying dehydration (Ribeiro *et al.,* 2007). The effects of $CaCl_2$ on fruit weight loss percentage go in line with earlier studies of Choudhury *et al.,* (2003).

Organoleptic taste

A panel of five members rated the strawberry fruits judging on 9-point Hedonic scale from point scoring 1 to 9. The scoring was done with the fresh harvested fruits and the score was given in respect to colour, texture and flavor. Untreated fruits were having the least score, the highest score was seen in the fruits treated with chitosan @ 6 g/L + calcium chloride @ 1.00 % (T_{11}) with mean value of 8.90 on Hedonic scale of point 9 (table no.- 3).

Sensory attributes such as appearance, colour, texture, aroma or some of the most important criteria used by a consumer to evaluate the immediate quality of fruits and vegetables (Nunes *et. al.,* 2007). Many researchers have found positive relationship between the biochemical analysis and the panel, especially concerning the sweetness of the fruits and their TSS (Azodanlou *et. al.,* 2003), Mun˜oz *et. al.,* (2008).

Biochemical properties of strawberry fruit total soluble solids

Referring to the effect of pre-harvest treatments, obtained data during post-harvest observation shows significant difference. Data in table no.- 4, indicate the longer storage period (16 days), the increase pattern was observed in the fruit total soluble solid with a declining pattern on last day. The maximum value of TSS (T_{11}- 11.10˚ B) was found in treatment chitosan @ 6 g/L alongwith calcium chloride @ 1.00 % while the minimum was found in control (T_1- 8.14˚B).

Due to the application of calcium and chitosan, the function of number of enzymes might have been stimulated the physiological processes in terms of hydrolyzed starch and polysaccharides. Metabolic activity during the change of available starch, organic acid into soluble sugars and enhanced solubilization of insoluble starch and protein present in the cell wall and middle lamella, thus TSS might have been increased. Qureshi *et al.,* (2013) on strawberry found similar results with respect to TSS.

Anthocyanin content

According to the literature, the biosynthesis pathway for anthocyanin is still operative after strawbeery harvest, and storage at low temperatures does not inhibit this process (Holkroft & Kader, 1999; Kalt & Macdonald, 1996). However, low temperature, combined with modified atmosphere, produces an inverse relationship between CO_2 concenteration anthocyanin content (Gil *et al.,* 1997).

Since, modified atmosphere was not used in the experiment, the profile of anthocyanin content (table no.– 5) during the storage period can be attributed only to the low temperature. In this respect, the camarosa cultivar of strawberry with different concenteration of pre-harvest application of chitosan and calcium shows the different value of anthocyanin content in different treatments. The maximum value of anthocyanin (T_8- 39.91 mg/100gm pulp) content over storage period was observed in treatment with chitosan @ 5 g/L + $CaCl_2$ @ 1.50 % and the minimum was observed in control (T_1- 37.58 mg/100gm pulp).

Antioxidant activity

Total antioxidant activity of the strawberry fruits had shown an increasing trend over storage period, however, with the application of calcium and chitosan also had an increasing effect on antioxidant activity. Under control treatment (T_1- 19.07 µmol TE g^{-1} FW), lowest antioxidant activity was observed while the highest antioxidant activity was observed in treatment comprising chitosan @ 6 g/L + calcium chloride @ 1.00 % (T_{11}- 21.13 µmol TE g^{-1} FW). Antioxidant capacity of plant produce is mainly because of the presence of pigments, vitamins (mainly ascorbic acid) and tannins.

The reasons for higher retention of total antioxidant activity may be explained by lowering losses of anthocyanins, ascorbic acid and tannins. Kulkarni *et al.*, (2004) reported that anthocyanins, ascorbic acid and phenolics are responsible for the antioxidant activity, either alone or in combination. Barman *et al*., (2011) also reported that antioxidant capacity of plant produce is mainly contributed by the presence of pigments, vitamins and polyphenolic compounds.

Titrable acidity

The main compound accounting for titrable acid (TA) is citric acid, which is predominant in strawberry. However, there is little published information about changes of pH and TA content in strawberry fruit stored at low temperature.

The result presented here (table no.-7) clearly indicate the changes in titrable acidity was least in T_{11} (0.64%) and maximum in T_1 (0.71%), due to pre-harvest application of calcium and chitosan over storage at low temperature (2℃). Decrease in acidity might be due to involvement of growth substances at metabolic level in regulating vital physiological and biochemical processes seems to have decreased total acidity in fruits. Naradisorn *et al*., (2006), Singh *et al*., (2009) and Qureshi *et al.*, (2013) found similar results with respect to titrable acidity of strawberry.

Table.1 Effect of calcium chloride and chitosan on weight, volume, length and width of strawberry fruit

Treatments	Fruit length	Fruit width	Fruit weight	Fruit volume
Control	36.58	26.08	12.19^{c}	17.40^{bc}
0.50% $CaCl_2$	38.20	28.78	15.94^{ab}	17.89^{bc}
1.00% $CaCl_2$	38.30	27.40	16.40^{ab}	18.01^{bc}
1.50% $CaCl_2$	39.43	28.24	16.75^{ab}	18.32^{bc}
Chitosan 5 g/L	36.68	23.51	12.42^{c}	16.00^{c}
Chitosan 5 g/L + 0.50% $CaCl_2$	38.63	28.79	16.10^{ab}	18.76^{b}
Chitosan 5 g/L + 1.00% $CaCl_2$	38.74	29.07	16.48^{ab}	18.87^{b}
Chitosan 5 g/L + 1.50% $CaCl_2$	38.73	28.70	16.02^{ab}	18.79^{b}
Chitosan 6 g/L	38.67	27.60	14.72^{bc}	18.72^{b}
Chitosan 6 g/L + 0.50% $CaCl_2$	39.66	27.41	17.56^{ab}	18.85^{b}
Chitosan 6 g/L + 1.00% $CaCl_2$	42.88	30.23	18.30^{a}	22.72^{a}
Chitosan 6 g/L + 1.50% $CaCl_2$	37.77	29.25	17.24^{ab}	18.81^{b}
CD (P = 0.05)	–	–	2.953	2.691

Table.2 Effect of calcium chloride and chitosan on PLW (%) in storage condition at 2˚C of strawberry fruit

Treatments	Day 1	Day 4	Day7	Day 10	Day 13	Day 16	Pooled
Control	0.00	2.80 [a]	5.02 [a]	11.12 [a]	13.65 [a]	14.73 [a]	7.88 [a]
0.50% $CaCl_2$	0.00	2.42 [b]	4.56 [b]	9.30 [b]	11.67 [b]	13.74 [b]	6.95 [b]
1.00% $CaCl_2$	0.00	2.14 [c]	4.24 [c]	9.21 [b]	11.60 [bc]	13.30 [cd]	6.75 [c]
1.50% $CaCl_2$	0.00	2.16 [c]	4.03 [d]	8.97 [cd]	11.22 [fg]	13.14 [de]	6.58 [e]
Chitosan 5 g/L	0.00	2.00 [cd]	4.06 [d]	9.13 [bc]	11.49 [cd]	13.47 [c]	6.69 [d]
Chitosan 5 g/L + 0.50% $CaCl_2$	0.00	1.86 [de]	3.83 [ef]	8.83 [def]	11.41 [de]	13.32 [c]	6.54 [e]
Chitosan 5 g/L + 1.00% $CaCl_2$	0.00	1.84 [de]	3.78 [efg]	8.68 [fg]	11.33 [ef]	13.00 [ef]	6.44 [f]
Chitosan 5 g/L + 1.50% $CaCl_2$	0.00	1.86 [de]	3.81 [ef]	8.75 [ef]	11.33 [ef]	13.05 [ef]	6.46 [f]
Chitosan 6 g/L	0.00	1.84 [de]	3.92 [de]	8.91 [de]	11.14 [g]	13.08 [e]	6.48 [f]
Chitosan 6 g/L + 0.50% $CaCl_2$	0.00	1.82 [e]	3.71 [fgh]	8.74 [efg]	10.94 [h]	12.88 [fg]	6.35 [g]
Chitosan 6 g/L + 1.00% $CaCl_2$	0.00	1.76 [e]	3.55 [h]	8.57 [g]	10.63 [i]	12.71 [g]	6.20 [i]
Chitosan 6 g/L + 1.50% $CaCl_2$	0.00	1.77 [e]	3.64 [gh]	8.79 [ef]	10.72 [i]	12.80 [g]	6.28 [h]
CD (P = 0.05)	0.00	0.159	0.165	0.178	0.125	0.177	0.057

Table.3 Effect of pre-harvest application of calcium chloride and chitosan on organoleptic taste before

Treatments	Texture	Flavor	Colour	Mean
Control	7.5	7.6	7.0	7.36
0.50% $CaCl_2$	8.3	8.4	8.1	8.27
1.00% $CaCl_2$	8.2	8.4	8.5	8.37
1.50% $CaCl_2$	8.6	8.3	8.4	8.43
Chitosan 5 g/L	8.3	8.4	8.6	8.43
Chitosan 5 g/L + 0.50% $CaCl_2$	8.8	8.4	8.7	8.63
Chitosan 5 g/L + 1.00% $CaCl_2$	8.7	8.5	8.7	8.63
Chitosan 5 g/L + 1.50% $CaCl_2$	8.6	8.6	8.7	8.63
Chitosan 6 g/L	8.5	8.4	8.6	8.50
Chitosan 6 g/L + 0.50% $CaCl_2$	8.7	8.8	8.9	8.80
Chitosan 6 g/L + 1.00% $CaCl_2$	9.0	8.8	8.9	8.90
Chitosan 6 g/L + 1.50% $CaCl_2$	8.6	8.7	8.8	8.70

Table.4 Effect of pre-harvest application of calcium chloride and chitosan on TSS (˚B) in storage condition at 2˚C

Treatments	Day 1	Day 4	Day7	Day 10	Day 13	Day 16	Pooled
Control	8.11 ^{d}	8.19 ^{e}	8.30 ^{e}	8.38 ^{e}	8.34 ^{f}	7.51 ^{d}	8.14 ^{f}
0.50% $CaCl_2$	9.45 ^{c}	9.60 ^{d}	9.76 ^{d}	9.93 ^{d}	9.95 ^{e}	9.52 ^{c}	9.70 ^{e}
1.00% $CaCl_2$	10.21 ^{ab}	10.64 ^{ab}	10.84 ^{ab}	11.08 ^{ab}	11.09 ^{abc}	10.34 ^{ab}	10.70 ^{b}
1.50% $CaCl_2$	10.22 ^{ab}	9.83 ^{cd}	10.04 ^{cd}	10.16 ^{cd}	10.19 ^{de}	9.64 ^{bc}	10.01 ^{d}
Chitosan 5 g/L	10.21 ^{ab}	10.27 ^{bcd}	10.40 ^{bcd}	10.52 ^{bcd}	10.56 ^{cd}	10.04 ^{abc}	10.33 ^{c}
Chitosan 5 g/L + 0.50% $CaCl_2$	9.88 ^{bc}	9.96 ^{bcd}	10.12 ^{cd}	10.28 ^{bcd}	10.30 ^{de}	9.73 ^{bc}	10.04 ^{d}
Chitosan 5 g/L + 1.00% $CaCl_2$	10.38 ^{ab}	10.49 ^{abc}	10.61 ^{abc}	10.70 ^{abcd}	10.75 ^{bcd}	10.17 ^{abc}	10.52 ^{bc}
Chitosan 5 g/L + 1.50% $CaCl_2$	10.35 ^{ab}	10.44 ^{abc}	10.57 ^{abc}	10.71 ^{abcd}	10.53 ^{cde}	10.04 ^{abc}	10.44 ^{bc}
Chitosan 6 g/L	10.48 ^{ab}	10.52 ^{ab}	10.65 ^{abc}	10.72 ^{abcd}	10.77 ^{bcd}	10.22 ^{abc}	10.56 ^{bc}
Chitosan 6 g/L + 0.50% $CaCl_2$	10.44 ^{ab}	10.44 ^{abc}	10.56 ^{abc}	11.06 ^{ab}	11.17 ^{ab}	10.56 ^{a}	10.70 ^{b}
Chitosan 6 g/L + 1.00% $CaCl_2$	10.88 ^{a}	11.04 ^{a}	11.21 ^{a}	11.36 ^{a}	11.37 ^{a}	10.77 ^{a}	11.10 ^{a}
Chitosan 6 g/L + 1.50% $CaCl_2$	10.49 ^{ab}	10.63 ^{ab}	10.74 ^{abc}	10.93 ^{abc}	10.97 ^{abc}	10.31 ^{ab}	10.68 ^{b}
CD (P = 0.05)	0.717	0.688	0.707	0.803	0.569	0.739	0.269

Table.5 Effect of pre-harvest application of calcium chloride and chitosan on total antioxidant capacity in storage condition at 2˚C

Treatments	Day 1	Day 4	Day 7	Day 10	Day 13	Day 16	Pooled
Control	18.54	18.83	19.07	19.17	19.29 ^{d}	19.55 ^{f}	19.07 ^{h}
0.50% $CaCl_2$	19.05	19.26	19.37	19.46	19.59 ^{cd}	19.74 ^{ef}	19.41 ^{gh}
1.00% $CaCl_2$	19.32	19.40	19.51	19.57	19.70 ^{cd}	19.88 ^{def}	19.56 ^{fgh}
1.50% $CaCl_2$	19.41	19.55	19.65	19.67	19.82 ^{cd}	19.99 ^{def}	19.68 ^{efg}
Chitosan 5 g/L	19.35	19.46	19.57	19.65	19.74 ^{cd}	19.87 ^{def}	19.61 ^{efgh}
Chitosan 5 g/L + 0.50% $CaCl_2$	19.60	19.68	19.76	19.83	19.95 ^{bcd}	20.12 ^{cdef}	19.82 ^{defg}
Chitosan 5 g/L + 1.00% $CaCl_2$	19.92	20.09	20.23	20.35	20.52 ^{abc}	20.72 ^{abcd}	20.30 ^{cd}
Chitosan 5 g/L + 1.50% $CaCl_2$	19.78	19.87	19.95	20.07	20.17 ^{bcd}	20.57 ^{bcde}	20.07 ^{cdef}
Chitosan 6 g/L	19.77	19.89	20.03	20.16	20.31 ^{abcd}	20.47 ^{bcdef}	20.10 ^{cde}
Chitosan 6 g/L + 0.50% $CaCl_2$	20.25	20.41	20.47	20.60	20.79 ^{abc}	20.96 ^{abc}	20.58 ^{bc}
Chitosan 6 g/L + 1.00% $CaCl_2$	20.74	20.90	20.98	21.20	21.41 ^{a}	21.54 ^{a}	21.13 ^{a}
Chitosan 6 g/L + 1.50% $CaCl_2$	20.66	20.79	20.82	20.97	21.06 ^{ab}	21.24 ^{ab}	20.92 ^{ab}
CD (P = 0.05)	–	–	–	–	1.210	0.938	0.542

Table.6 Effect of pre-harvest application of calcium chloride and chitosan on anthocyanin in storage condition at 2˚C

Treatments	Day 1	Day 4	Day7	Day 10	Day 13	Day 16	Pooled
Control	37.12	37.43	37.64	37.91	38.09	37.29	37.58 d
0.50% $CaCl_2$	38.62	38.92	39.29	39.46	39.64	38.70	39.10 abc
1.00% $CaCl_2$	39.19	39.50	39.77	40.01	40.31	38.98	39.62 ab
1.50% $CaCl_2$	39.65	39.92	39.95	40.09	40.36	39.32	39.88 a
Chitosan 5 g/L	38.32	38.52	38.84	39.15	39.36	38.11	38.72 c
Chitosan 5 g/L + 0.50% $CaCl_2$	38.81	39.08	39.29	39.42	39.61	38.37	39.09 abc
Chitosan 5 g/L + 1.00% $CaCl_2$	39.48	39.66	39.87	39.94	40.20	38.63	39.63 ab
Chitosan 5 g/L + 1.50% $CaCl_2$	39.66	39.96	40.22	40.35	40.60	38.69	39.91 a
Chitosan 6 g/L	38.45	38.65	38.87	39.08	39.37	38.24	38.78 bc
Chitosan 6 g/L + 0.50% $CaCl_2$	38.86	39.08	39.41	39.52	39.85	38.30	39.17 abc
Chitosan 6 g/L + 1.00% $CaCl_2$	39.32	39.46	39.68	39.84	40.19	38.56	39.51 abc
Chitosan 6 g/L + 1.50% $CaCl_2$	39.42	39.57	39.84	40.02	40.36	38.62	39.64 ab
CD (P = 0.05)	–	–	–	–	–	–	0.887

Table.7 Effect of pre-harvest application of calcium chloride and chitosan on titrable acidity in storage condition at 2˚C

Treatments	Day 1	Day 4	Day7	Day 10	Day 13	Day 16	Pooled
Control	0.69 a	0.70 a	0.70 a	0.71 a	0.72 a	0.72 a	0.71 a
0.50% $CaCl_2$	0.67 b	0.67 b	0.68 b	0.68 b	0.69 bc	0.70 bcd	0.68 b
1.00% $CaCl_2$	0.66 bc	0.67 bc	0.68 bc	0.68 b	0.69 bc	0.70 bc	0.68 b
1.50% $CaCl_2$	0.65 cd	0.66 cd	0.66 def	0.68 bc	0.70 b	0.71 b	0.68 bc
Chitosan 5 g/L	0.66 bc	0.66 bcd	0.67 bcd	0.67 bcde	0.68 cd	0.69 cde	0.67 c
Chitosan 5 g/L + 0.50% $CaCl_2$	0.65 de	0.65 de	0.66 def	0.67 cdef	0.68 de	0.68 def	0.66 d
Chitosan 5 g/L + 1.00% $CaCl_2$	0.63 f	0.64 fg	0.65 g	0.66 fg	0.67 efg	0.67 fg	0.65 f
Chitosan 5 g/L + 1.50% $CaCl_2$	0.64 ef	0.64 ef	0.65 fg	0.67 defg	0.67 def	0.68 efg	0.66 e
Chitosan 6 g/L	0.65 de	0.66 d	0.67 cde	0.68 bcd	0.67 efg	0.68 efg	0.66 d
Chitosan 6 g/L + 0.50% $CaCl_2$	0.63 f	0.64 ef	0.66 efg	0.67 cdef	0.66 fg	0.67 fg	0.65 ef
Chitosan 6 g/L + 1.00% $CaCl_2$	0.63 f	0.63 g	0.65 g	0.66 g	0.65 h	0.65 h	0.64 g
Chitosan 6 g/L + 1.50% $CaCl_2$	0.64 ef	0.64 ef	0.65 fg	0.66 efg	0.66 g	0.67 gh	0.65 f
CD (P = 0.05)	0.010	0.011	0.010	0.012	0.013	0.016	0.005

Flavor plays an important role in consumer satisfaction and influences further consumption of fruits and foods in general. The results indicated that low temperature (2^oC) used to increase the shelf-life (13 days) of strawberry fruits which have hardly a shelf-life of 1-2 days at room temperature. Among different treatments the effect of pre-harvest application of calcium chloride, chitosan and their combinations on storability and quality attributes of strawberry cv. Camarosa fruits was investigated for this study.

The study was depicted that treatment T_{11} (Chitosan 6 g/L + 1.00% $CaCl_2$) was recorded as the best treatment in terms of quality parameters like TSS, total antioxidant capacity, titrable acidity and physical parameters. However, the higher dose of calcium chloride and chitosan (Chitosan 5 g/L + 1.50% $CaCl_2$) was found best in respect of anthocyanin retension in the fruit. Further investigation is required for validation of these above chemicals as well as storage temperature in relation to facts cited in this research during storage period for better health.

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