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Effect of pre and post-harvest application of chitosan on chemical parameters quality of grape Cv. Manik Chaman during storage at 0 °C temperature

Vishal B Yadav, Dr. Keshav H Pujari and Yogesh A Sargar

Abstract
An experiment entitled, "Effect of pre and post-harvest application of chitosan on chemical parameters quality of grape Cv. Manik Chaman during storage at 0 °C temperature" was taken in the department of PHM of Fruit, Vegetable and Flower Crops, P.G. Institute of P.H.M., Killa during the year 2017-2018. The study aimed at minimizing post harvest handling losses in table grapes by using following experiment. The experiment was taken in FCRD (Factorial Completely Randomized Design) for different parameters with six main treatments *viz*. untreated fruits (control), 0.1 % pre-harvest spray and 0.5 to 2% post-harvest dipping of chitosan, with 0, 15, 30 and 45 days storage period at 0 °C temperature and the grape berries were analyzed for the changes in chemical parameters. It was observed that the pre-harvest spray and post-harvest dipping of chitosan treatments recorded delay in increase in reducing sugars, TSS, total sugars and delay in decreasing ascorbic acid, titratable acidity content of grape Cv. Manik Chaman irrespective of treatments. As regards the chemical parameters evaluation, the grape clusters with 0.1 per cent pre-harvest spray and 1.0 per cent post-harvest dipping of chitosan treatment obtained superior results as evaluate to other treatments at 45 days of storage at 0 °C temperature condition. Thus, it is suggested that 0.1 per cent pre-harvest spray and 1.0 per cent post-harvest dipping of chitosan is optimum for grape.

Keywords: Grape, chitosan, dipping, storage and chemical parameters

1. Introduction
Grape (*Vitis vinifera* L.) is one of the most consumed fruit crops grown worldwide. Grape is the third most widely cultivated fruit after citrus and banana (Anon., 2015) [6]. India ranks 7th position in grape production (Shikamany, 2001; Gade *et al.*, 2014) [53, 21]. It is one of the most important crops in India, generally grown in the subtropical regions of India (Shinde, 2016) [55]. Grape is believed to have originated in Armenia near the Black and Caspian seas in Russia, and belong to the *Vitaceae* family.

The quality of grapes in market not only depends on various activities carried out in the vineyard, but the operations and handling during and after harvesting also play important role. The post-harvest practices are influenced by various factors like variety, market, market requirement, packaging material, handling practices etc. Now, post-harvest practices are becoming more important as quality and cost factors are making market more competitive. Involvement of labor issues, unavailability of skilled labour as per requirements etc. are creating problem and increasing cost of produces in the market. (Sharma, 2016) [52].

Manik Chaman variety is a mutant of Thompson seedless variety of grape. This variety is grown in Maharashtra, Andhra Pradesh, Tamil Nadu and Karnataka. It has wide adaptability with seedless, ellipsoidal-elongated, golden-yellow berries with medium-thin skin. The juice is straw coloured, sweet with a TSS of 20-22^0 B. This variety has a good keeping quality and is used for table purpose and raisin making. Average yield is 20-25 t/ha. Manik Chaman is also reported to respond better to G. A. application than Thompson Seedless (Anon, 2017e). As per the Vitis International Variety Catalogue, the details the variety are; Prime name- Manik Chaman, Color of berry skin- BLANC, Variety number- VIVC 16872 (Erika., 2014) [20].

Table grape is a highly perishable, non-climacteric fruit. Its shelf life is usually shortened by firmness loss, berry drop, discoloration of the stem, desiccation and fungal rots. The most common commercial method to control decay of the table grape fruit is the use of SO_2 during cold storage, either by fumigation or generators (Crisosto, *et al.*, 2002; Smilanick *et al.*, 1990) [13, 56]. As chitosan can form a semi-permeable film, a chitosan coating might be expected to modify the internal atmosphere, as well as to decrease transpiration losses and regulate the quality of the fruits (El Ghaouth, Arul and Ponnampalam, 1991; Olivas and Barbosa-Canovas, 2005) [17, 35].

Meanwhile, chitosan has broad-spectrum antimicrobial activity, which has been well documented (Ait Barka, *et al.*,2004; Plascencia-Jatomea *et al.*,2003; Reddy *et al.*,1998; Sathiyabama and Balasubramanian, 1998) [3, 40, 44, 51] and *in vivo* studies showed that chitosan treatment could control or delay postharvest decay of fruits and vegetables (Bautista-Ban˜os *et al.*,2006) [9].

Chitosan is a linear polysaccharide consisting of β-(1→4)-linked 2-amino-2- deoxy-D-glucose residues, originating from de-acetylated derivative of chitin, which is the second most abundant polysaccharide in nature after cellulose. It is non-toxic, biodegradable, bio-functional, and biocompatible. Chitosan has strong anti-microbial, anti-cracking, anti-browning, anti-stress, and anti-fungal activities that could effectively control fruit decay. It could easily form coating on fruit and vegetable, and the respiration rate of fruit and vegetable was reduced by adjusting the permeability of carbon dioxide and oxygen (Bautista-Ban˜os *et al.*,2006) [9]. It is regarded as a promising material for an edible coating on fruit (Olivas and Barbosa-Canovas, 2005) [35].

However, the previous researchers mainly focused on the control effect by treatment with chitosan inoculation and on the physiological and pathological regulation of the fruit by chitosan coating. There are a few reports on the increase of postharvest disease resistance, by preharvest chitosan spray (Reddy *et al.*, 2000; Romanazzi *et al.*, 2006) [45, 49]. There are no reports about the effect of the combination of pre-harvest and postharvest treatments of chitosan on the chemical parameters responses and quality of grapes during storage.

Keeping this in view, the present investigation entitled, "Effect of pre and post-harvest application of chitosan on chemical parameters quality of grape Cv. Manik Chaman during storage at 0 °C temperature", was carried out with the following objective.

1. To study the Effect of pre and post-harvest application of chitosan on chemical parameters quality of grape Cv. Manik Chaman during storage at 0 °C temperature.

2. Materials and Methods

The present investigation was undertaken in the Department of PHM of Fruit, Vegetable and Flower Crops, PGI of PHM, Killa-Roha. Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli (M.S.) during the winter season of 2017. The methods adopted and the material used during the investigation is as given below.

2.1 Experimental details

Experimental details

Experimental Design	:	Factorial Completely Randomized Design (FCRD)
No. of Treatments	:	Six
No. of Replications	:	Four
No. of Treatments combination	:	6×4=24
No. of plants sprayed with 0.1 % chitosan	:	2000
No. of grape clusters per treatment	:	Thirty six

2.2 Treatments details

2.2.1. Factor A

Different levels of chitosan concentration used for pre-harvest spraying and post-harvest dipping of grape

Sr. No.	Treatments	Concentrations of chitosan used for	
		Pre-harvest spraying (%)	Post-harvest Dipping (%)
1.	T_1 (control)	NIL	NIL
2.	T_2	0.1%	NIL
3.	T_3	0.1%	0.5%
4.	T_4	0.1%	1.0%
5.	T_5	0.1%	1.5%
6.	T_6	0.1%	2.0%

2.2.2 Factor B: Storage period

S-1: 0 day
S-2: 15 days
S-3: 30 days
S-4: 45 days

2.3 Plant materials and treatments

Table grapes (*Vitis vinifera*) of the cultivar Manik chaman were harvested at the ripe stage from a commercial vineyard from Yadav grape farm, At- Palsawade, Post- Devapur, Tal-Man, Dist- Satara, (M.S.) with 2.5-4.5 cm stalk from grape orchard (Plot No.- 27) located at 17.57', North latitude and 74.86', East longitude and elevation of 473 meters above MSL. The grapes were harvested at minimum T.S.S of 16^0B and sugar acid ratio of 20:1.

2.4 Pre-harvest preparationn and application of chitosan

For experimental purpose, 2000 vines were selected (0.80 Ha areas), the 0.1% chitosan solution was prepared by dissolving the purified Emulsifier chitosan which having brand name RESCUE-D (Omega Fine Chemicals, Dombivali (E). in 400 litres of de-mineralized water, with continuous stirring, When dissolved, the pH value of the chitosan solution was adjusted to 5.6 using pH balancer "Decorus" (Poorva Chemtech Pvt Ltd, Nashik.) to increase spray elements absorption. At 10 days before harvest, the chitosan solution was sprayed on grape clusters once by using a tractor mounted "Cima Low Volume Venturi Air Sprayer" until clusters were wet to runoff. The spraying of dissolved 0.1% chitosan solution was done at 4.30 pm. during evening time. After application of chitosan on clusters whole plant was allowed for full rest up to harvesting.

2.5 Maturity indices for harvesting

As grape is a non-climacteric fruit, it was harvested at minimum TSS of 16^0B and sugar acid ratio of 20:1.

2.6 Method of harvesting

Only attractive bunches fulfilling minimum quality requirement were harvested. A day prior to picking, the broken, along with decayed, deformed, undersized, and discoloured berries were removed by cutting their pedicels from the selected bunch, using a long nosed scissors. One care was taken not to injure other sound berries by the scissor. The grape bunches were harvested during the early morning hours before the berry temperature rises above 25 °C.

2.7 Pre-cooling

The grapes were pre-cooled at 2-4 °C for 4 hours in visi cooler before post harvest treatment of chitosan.

2.8 Post-harvest preparation and dipping of Chitosan

Clusters were selected for size and colour uniformity. Blemished, damaged, or diseased berries were discarded

carefully. Immediately after harvest, the fruits were brought to the laboratory for preliminary tests. The grape berries were surface-sterilized with 2% sodium hypochlorite for 2 minutes at room temperature rinsed with tap water in order to remove the heavy dirt, pesticides and fungal spores covering the fresh harvested clusters and allowed to dry them at room temperature. After preparation, the fruits were weighed to about 400 g. and then randomly distributed into 6 groups before treatment.

The emulsifier chitosan which having brand name RESCUE-D (Omega Fine Chemicals, Dombivali (E) was dissolved in de-mineralized water to prepare 0.5, 1, 1.5 and 2 per cent chitosan solution respectively under continuous stirring. The grape bunches were dipped in the solutions for 5 min and then left for 2 hrs. at room temperature for drying. The control samples were dipped in the de-mineralized water with 5.6 pH.

2.9 Packaging and storage of treated clusters

The treated grapes were packed in plastic punnet and stored in the visi cooler (Manufactured by Frigoglass India Pvt. Ltd., Marketed by Bluestar Ltd.) at a temperature of 0 °C and 85-95% relative humidity for 45 days. The qualitative traits were evaluated at 0, 15, 30, and days of storage.

Flow sheet

Pre-harvest preparation and application of chitosan

Selecting 2000 grapevines Cv. Manik chaman

↓

Hanging and tagging of cluster with supporting steel wire

↓

Preparation of 0.1% emulsifier chitosan solution with 5.6 pH adjusted by using pH balancer "Decorus"

↓

Spraying 0.1% chitosan during evening hrs with the help of tractor mounted "Cima Low Volume Venturi Air Sprayer"

Post-harvest preparation and application of chitosan

Harvesting of selected and tagged clusters 10 days after pre-harvest spray early in the morning with sterilized long nosed scissors.

↓

Pre-cooling at 2-4 ^{0}C for 4 Hrs.

↓

Surface-sterilization with 2% sodium hypochlorite for 2 minutes

↓

Ringing with tap water in order to remove the heavy dirt, pesticide residues and fungal spores on the clusters

↓

Air drying of clusters for 1 hour

↓

Blemished, damaged, or diseased berries were discarded carefully

↓

Weighted 400 gm. clusters

↓

Preparation of different levels of chitosan concentration as per treatments viz. 0.5, 1, 1.5 and 2 per cent with 5.6 pH

↓

Dipping of clusters in different levels of chitosan for 5 minutes as per the treatment and dipping of control sample in de-mineralized water having 5.6 pH

↓

Air drying of clusters for 2 hours

↓

Packing of clusters in plastic punnet

↓

Storage in visi cooler at 0°C temperature

2.10 Effect of pre and post-harvest application of chitosan on chemical parameter of grape Cv. Manik Chaman during storage at 0 °C temperature

2.10.1 Moisture (%)

The moisture content was measured directly by using moisture analyzer (model-CA-123) and expressed as per cent moisture content on electronic display directly.

2.10.2 Total soluble solids (°B)

The TSS was determined by using Hand Refractometer (Atago Japan, 0-32 °B) and the values were corrected at 20 °C by using temperature correction chart (A.O.A.C., 1975) [1].

2.10.3 Titratable acidity (%)

The sample of known quantity with 20 ml distilled water was transferred to 100 ml volumetric flask, made up the volume and filtered after giving known quantity of sample was titrated against 0.1 N NaOH solution using phenolphthalein as an indicator (A.O.A.C., 1975) [1]. A known volume of 10 ml was titrated against 0.1N sodium hydroxide (NaOH) solution using phenolphthalein as an indicator (Ranganna, 2003) [43]. The results were express as per cent anhydrous citric acid.

$$\text{Titratable acidity}(\%) = \frac{\text{Normality of alkali X Titre reading X Volume made X Equivalent weight of acid}}{\text{Weight of sample taken X Volume of sample taken for estimation X 1000}} X100$$

2.10.4 Reducing sugars (%)

The reducing sugars were determined by the method of Lane and Eynon (1923) as described by Ranganna (2003) [43]. A recognized weight of sample was taken in 250 ml volumetric flask. To this, 100 ml of distilled water was added and the contents were neutralized by 1 N sodium hydroxide. After then 2 ml of 45 per cent lead acetate was added to it. The contents were mixed well and kept for 10 minutes. Two ml of 22 per cent potassium oxalate was added to it to precipitate the excess of lead. The volume was made to 250 ml with distilled water and solution was filtered through Whatman No. 4 filter paper. This filtrate will be used for determination of reducing sugars by titrating it against the boiling mixture of Fehling 'A' and Fehling 'B' solutions (5 ml each) using methylene blue as indicator to a brick red end point. The results were expressed on per cent basis.

$$\text{Reducing sugars}(\%) = \frac{\text{Factor X Dilution}}{\text{Titre reading X Weight of sample}} \text{ X } 100$$

2.10.5 Total sugars (%)

At room temperature for inversion of a 50 ml aliquot of clarified deleaded solution was transferred to 250 ml volumetric flask, to which, 10 ml of 50 per cent hydrochloric acid was added and then allowed to stand at room temperature for 24 hrs. It was then neutralized with 40 per cent NaOH solution. The volume of neutralized aliquot was made to 250 ml by using distilled water. This filtrate was used for determination of total sugars by titrating it against the boiling mixture of Fehling 'A' and Fehling 'B' (5ml each) using methylene blue as indicator to a brick red end point. The results were expressed on per cent basis as follows,

$$\text{Total sugars}(\%) = \frac{\text{Factor X Dilution}}{\text{Titre reading X Weight of sample}} \text{X } 100$$

2.10.6 Ascorbic acid (mg/100g)

The ascorbic acid determination was done by 2, 6-dichlorophenol indophenol dye method of Johnson (1948) as described by Ranganna (2003) [43]. A recognized quantity of sample was blended with 3 per cent meta-phosphoric acid (HPO_3) to make the final volume of 100 ml by using volumetric flask and then filtered. A known quantity of filtrate was then titrated against 0.025 per cent 2, 6 dichlorophenol - indophenol dye to a pink coloured end point. From sample the ascorbic acid content was calculated taking into consideration the dye factor and expressed as mg of ascorbic acid per 100 g grape juice.

$$\text{Ascorbic acid}(\text{mg}/100\text{g}) = \frac{\text{Titre reading X Dye factor X Volume made up}}{\text{Aliquot taken for estimation X Weight of sample}} \text{X}100$$

2.11 Statistical analysis

A data composed on the changes in the chemical parameters of grapes berries were statistically analyzed by the standard procedure given by Panase and Sukhatme (1985) [36] and Amdekar (2014) [5] using FCRD (Factorial Completely Randomized Design) and valid conclusions were drawn only on significant differences between treatments mean at 5 per cent level of significance.

3. Result and Discussion

3.1 Effect of pre and post-harvest application of chitosan on chemical parameters of different grape Cv. Manik Chaman during storage at 0 °C temperature

3.1.1 Moisture (%)

The data related to the effect of pre and post harvest application of chitosan on changes on total moisture content of grape cluster Cv. Manik Chaman are presented in Table 1 and graphically depicted in Figure 1.

The chitosan treatment and storage interaction exhibited significant impact on total moisture content of grape clusters. It is noticed from the results that the moisture content was increasing with increasing levels of pre and post-harvest application of chitosan on grape berries during storage period at 0 °C temperature.

Table 1: Effect of pre and post-harvest application of chitosan on moisture (%) of grape Cv. Manik Chaman during storage at 0 °C temperature

Treatments	Moisture (%)				Mean
	Storage period (Days)				
	0	15	30	45	
T1	81.49	79.38	77.28	75.19	78.34
T2	81.32	79.80	78.29	76.76	79.05
T3	81.26	80.23	79.20	78.17	79.71
T4	81.26	80.66	80.05	79.44	80.35
T5	81.28	80.76	80.24	79.72	80.50
T6	81.20	80.91	80.61	80.31	80.76
Mean	81.30	80.29	79.28	78.27	
		S.Em ±		CD at 5%	
Treatments (T)		0.09		0.27	
Storage (S)		0.08		0.24	
Interaction (T×S)		0.16		0.46	

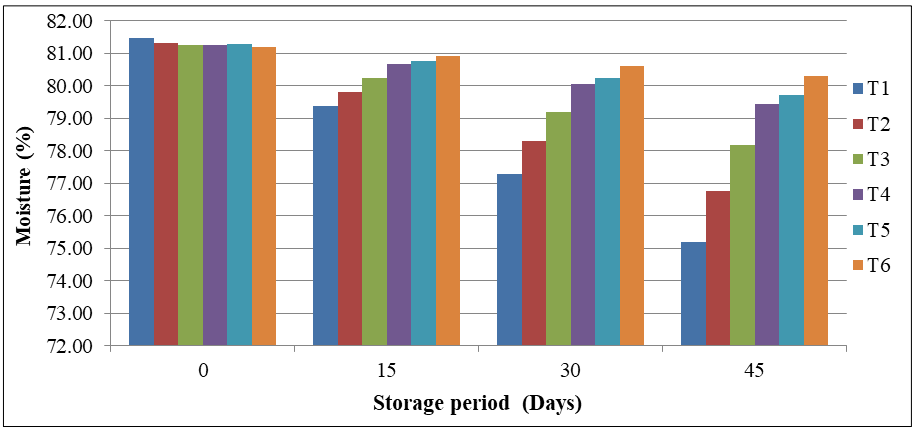


Fig 1: Effect of pre and post-harvest application of chitosan on moisture (%) of grape Cv. Manik Chaman during storage at 0 °C temperature

It was perceived from the data that the treatment T_1 i.e. control treatment recorded minimum (78.34%) of mean total moisture content, followed by the treatments T_2 (79.05%) and T_3 (79.71%). The treatment T_6 (80.76%), recorded the highest mean total moisture content, but at par with T_5 (80.50%). Higher level of chitosan for post harvest dipping treatment resulted into better retention of moisture in the grape berries during storage at 0 °C temperature.

As regards storage, there was decreased in the total moisture content as the storage period was increased. At initial stage of storage, the mean total moisture content was 81.30 per cent however and at 45th day, it was decreased loss to 78.27 per cent irrespective of the treatments.

Chitosan can modify the internal atmosphere (by altering the permeability to oxygen, water and carbon dioxide), thereby decreasing the reducing respiration rate, transpiration loss (Li and Yu, 2000). Chitosan can form an edible film when applied to the surface of fruit and vegetables and act as a physical barrier to delaying de-hydration, moisture loss and fruit shriveling. (Chaiprasart *et al.*, 2006; Ribeiro *et al.*, 2007) [11, 46].

Similar trend of decrease in the total moisture content loss values of grape clusters during storage and also due to decrease in concentration of chitosan was observed by Youwei and Yinzhe (2013) [64] and Hashemi *et al.*, (2014) [22].

3.1.2 Total soluble solids (°B)

The data on the changes in TSS of grape Cv. Manik Chaman influenced by pre and post-harvest application of chitosan are presented in Table 2 and graphically depicted in Figure 2.

It was noticed from the records that the TSS of grape berry increased with increase in the storage period and decreased with increase in concentration of chitosan. The chitosan treatment and storage interaction exhibited significant impact on TSS levels of grape berry.

Table 2: Effect of pre and post-harvest application of chitosan on total soluble solid content (^{0}B) of grape Cv. Manik Chaman during storage at 0 °C temperature

Treatments	Total soluble solid content (°B)				Mean
	Storage period (Days)				
	0	15	30	45	
T1	18.30	20.5	22.7	24.90	21.60
T2	17.40	19.20	21.00	22.80	20.10
T3	17.25	18.95	20.65	22.35	19.80
T4	17.55	18.65	19.75	20.85	19.20
T5	17.35	18.35	19.35	20.35	18.85
T6	17.65	18.00	18.60	19.20	18.36
Mean	17.58	18.94	20.34	21.74	
		S.Em ±		CD at 5%	
Treatments (T)		0.13		0.37	
Storage (S)		0.11		0.33	
Interaction (T×S)		0.22		0.63	

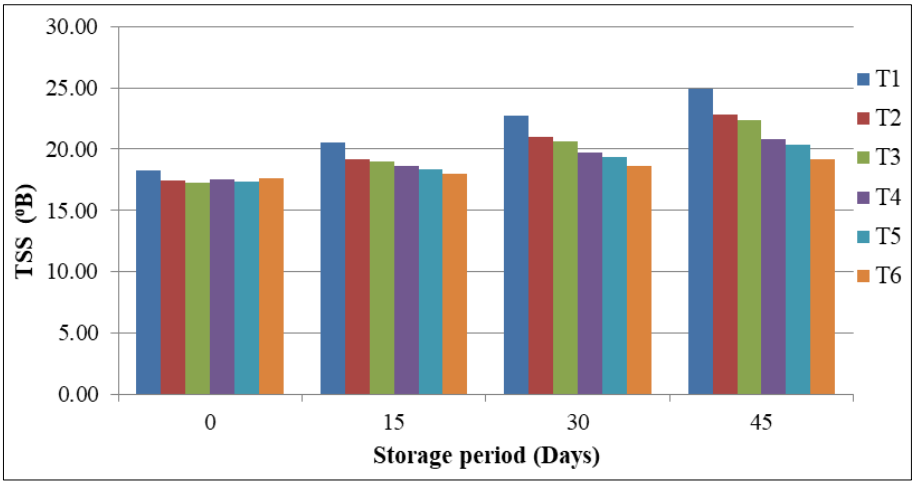


Fig 2: Effect of pre and post-harvest application of chitosan on total soluble solid content (°B) of grape Cv. Manik Chaman during storage at 0 °C temperature

Amongst all the treatments, the highest mean TSS was noticed in the treatment T_1 (21.60°B) i.e. Control, which was significantly better to rest of the treatments which was followed by treatment T_2 (20.10°B), however it was at par with the treatment T_3 (19.80°B). However, the chitosan treatments recorded low levels of total soluble solids content in the treatment T_6 (18.36°B), followed by T_5 (18.85°B). Thus, it is clear from the data that the total soluble solids decreased with increase in chitosan concentration.

The effect of chitosan coating on soluble solids content of fruit was probably due to the slowing down of respiration and metabolic activity, hence retarding the ripening process. A suppressed respiration rate slows down the synthesis and the use of metabolites, which resulted in to lower soluble solids due to the slower hydrolysis of carbohydrates to sugars (Ali *et al*., 2011; Das *et al*., 2013) [15]. Results showed that increase in chitosan concentration significantly decrease the TSS content of grape berries.

During the end of storage, there was a significant increase in the TSS content of grape berry. At initial stage i.e. initial stage, the lowest mean TSS (17.58°B) be noticed, while the highest mean total soluble solids (21.74°B) was noticed at 45th day of storage period at 0 °C temperature.

The chitosan had exhibited significant effect on TSS content of grape berry. All the pre and post-harvest application of chitosan treated grapes berry showed lower mean TSS content than that of untreated grape berry treatment. It could be due to suppressed respiration rate that slowed down the synthesis and the use of metabolites, which resulted in lower soluble solids due to the slower hydrolysis of carbohydrates to sugars.

Similar trends of increase in the TSS values of grape during storage and decrease in the TSS with increase in chitosan concentrations was observed by Romanazzi *et al.*, (2005) [48] and Meng *et al.*, (2008) [33], Elwahab, (2014) [19].

Identical trend of other fruit similar trends of increase in the TSS values during storage and decrease in the TSS with increase in chitosan concentrations levels was observed by Ribeiro *et al.*, (2007) [46] and Munoz *et al.*, (2008) [65] in strawberries. Thommohaway *et al.*, (2007) [58] in fresh-cut guava, Abbasi *et al.*, (2009) [2], Jangchud and Nongtaodum (2009) [25], Medeiros *et al.*, (2011) [32], Jafarizadeh *et al.*, (2011) [24], Wongmetha and Ke (2012) [62], Shinde (2014) [54] and Mansute (2016) [31] in mangoes. Ali *et al.*, (2011) reported in papaya. Jafarizadeh *et al.*, (2011) [24], Salunkhe (2015) [66], Iqbal and Hossain (2016) [23] in banana. Das *et al.*, (2013) [15], Sucharitha *et al*., (2018) [57] in tomato, Patil (2016) [38] in pomegranate.

3.1.3 Titratable acidity (%)

The data related to the effect of pre and post-harvest application of chitosan on changes in the titratable acidity of grape Cv. Manik Chaman are presented in Table 3 and graphically depicted in Figure 3.

Among every one treatments, the treatment T_1 i.e. control recorded the lowest (0.53%) mean titratable acidity, while the pre and post-harvest application of chitosan exhibited higher mean acidity significantly in grape berries than that of control treatment. The highest mean of titratable acidity (0.70%) was noticed in the treatment T_6 (0.1% Pre-harvest spray and 2.0% post-harvest dipping of chitosan) which was superior significantly to all the treatments, followed by the treatment T_5 (0.68%), T4 (0.65%), T3 (0.59%) and T_2 (0.55%).

The pre and post-harvest application of chitosan and storage interaction exhibited significant impact on the titratable acidity levels of grape berry. The significantly decreasing trend in the acidity of the grape berries was observed with the progression of storage period.

At initial stage of storage i.e. 0 day, the highest mean titratable acidity (0.77%) was noticed while the lowest mean titratable acidity (0.47%) was observed at 45th day of storage at 0 °C temperature.

Table 3: Effect of pre and post-harvest application of chitosan on Titratable acidity of grape Cv. Manik Chaman during storage at 0 °C temperature

Treatments	Titratable acidity (%) Storage period (Days)				Mean
	0	15	30	45	
T1	0.770	0.609	0.444	0.300	0.530
T2	0.772	0.622	0.470	0.322	0.550
T3	0.770	0.650	0.530	0.410	0.590
T4	0.780	0.680	0.600	0.550	0.650
T5	0.770	0.710	0.640	0.580	0.680
T6	0.768	0.730	0.680	0.640	0.700
Mean	0.770	0.670	0.560	0.470	
		S.Em ±		CD at 5%	
Treatments (T)		0.005		0.016	
Storage (S)		0.005		0.014	
Interaction (T×S)		0.009		0.027	

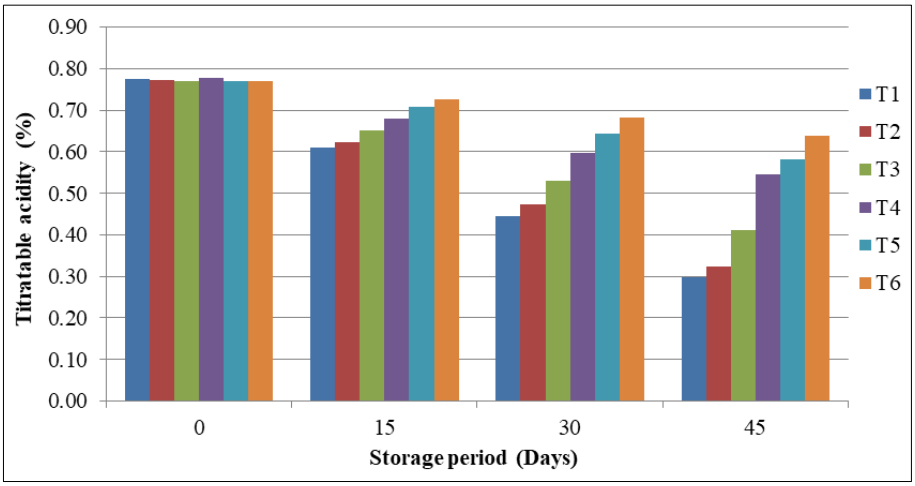


Fig 3: Effect of pre and post-harvest application of chitosan on Titratable acidity of grape Cv. Manik Chaman during storage at 0 °C temperature

The effect on titratable acidity chitosan has exhibited significant of grape berry. All the pre and post-harvest chitosan treated grape berry showed utmost mean titratable acidity compared to untreated grape. Thus, it is clear from the data that the titratable acidity increasing with increasing in the concentration of chitosan. It could be due to slower respiration rate by chitosan coating and less water loss in the fruits influenced by chitosan coating.

Chitosan coatings could provide a semi permeable film around the fruit surface, which modifies the internal atmosphere by reducing oxygen and/or elevating carbon dioxide levels, which decrease the fruit respiration level and metabolic activity. Hence, retards the fruit ripening and senescence process (Vargas *et al.*, 2008) [67], there by retains of the acid levels in the grape berries.

Similar decreasing trend in the titratable acidity of grape during storage and increase in the titratable acidity with use in chitosan concentrations was observed by Romanazzi *et al.*, (2005) [48] and Meng *et al.*, (2008) [33], Elwahab, (2014) [19].

Identical observations here also recorded by Ribeiro *et al.*, (2007) [46], Munoz *et al.*, (2008) [65], in strawberries. Thommohaway *et al.*, (2007) [58] reported in fresh-cut guava. Abbasi *et al.*, (2009) [2], Jangchud and Nongtaodum (2009) [25], Medeiros *et al.*, (2011) [32], Jafarizadeh *et al.*, (2011), Wongmetha and Ke (2012) [62], Shinde (2014) [54], Mansute (2016) [31] reported in mango. Ali *et al.*, (2011) in papaya. Jafarizadeh *et al.*,(2011) [24], Salunkhe *et al.*, (2015) [66], Iqbal and Hossain (2016) [23] in banana. Das *et al.*, (2013) [15], Sucharitha *et al.*, (2018) [57] in tomato and Patil (2016) [38] in pomegranate.

3.1.4 Reducing sugars (%)

The data of changes in reducing sugar related to the content of grape Cv. Manik Chaman influenced by pre and post-harvest application of chitosan are presented in Table 4 and graphically depicted in Figure 4.

Table 4: Effect of pre and post-harvest application of chitosan on reducing sugars (%) of grape Cv. Manik Chaman during storage at 0 °C temperature

Treatments	Reducing sugars (%) Storage period (Days)				Mean
	0	15	30	45	
T1	13.03	14.21	15.62	18.09	15.24
T2	12.79	13.93	15.51	17.70	14.99
T3	12.49	13.72	15.22	17.11	14.64
T4	12.35	13.25	14.30	15.52	13.86
T5	12.49	13.21	14.01	14.91	13.65
T6	12.49	12.84	13.74	14.32	13.35
Mean	12.61	13.53	14.73	16.27	
		S.Em ±		CD at 5%	
Treatments (T)		0.17		0.47	
Storage (S)		0.15		0.42	
Interaction (T×S)		0.29		0.80	

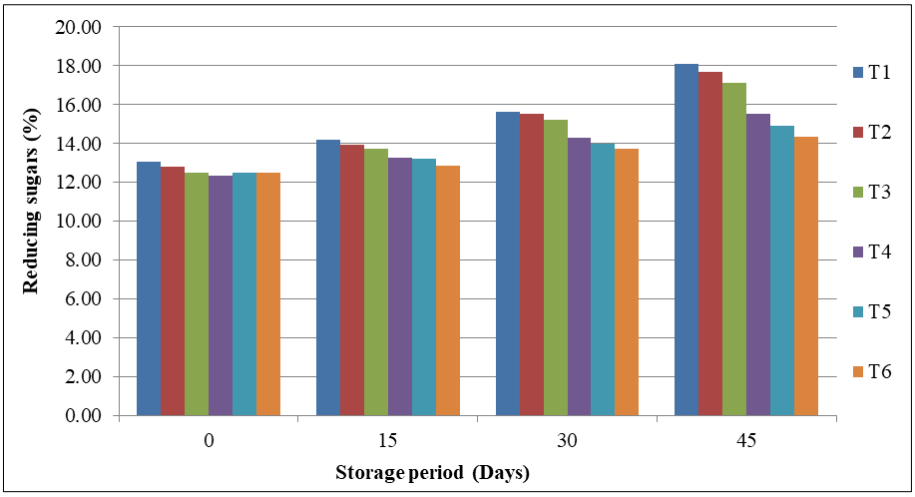


Fig 4: Effect of pre and post-harvest application of chitosan on reducing sugars (%) of grape Cv. Manik Chaman during storage at 0 °C temperature

The data shows that there was an increasing trend in the reducing sugar content of grape berry with decrease in the level of chitosan concentration during 45 days of storage period at 0 °C temperature. The chitosan treatment and storage exhibits significant impact on reducing sugar content of grape.

Among every one of the treatments, the uppermost mean reducing sugar content was found in the treatment T_1 (15.24%) which was significantly superior to the rest of the treatments except the T_2 which was at par with T_1. However, treatment T_6 (0.1% pre-harvest spray and 2.0% post-harvest dipping of chitosan) exhibited the lowest (13.35) mean reducing sugar content, but at par with treatment T_5. The treatments T_2 (14.99%) and T_3 (14.64%) were at par with each other.

The highest (15.24%) content of reducing sugar was recorded in the treatment T_1 at 45th day of storage period and lowest (13.35%) was in the treatment T_6. Thus, it is clear from the data that the reducing sugars decreased with increase in the concentration of chitosan.

During the end of storage, there was an increase in significant of reducing sugar level of grape berry. At preliminary stage i.e. 0 day, the lowest mean reducing sugar (12.61%) was noticed, while the highest mean reducing sugar (16.27%) was recorded at 45th day of the storage.

It is manifest from the data that higher in chitosan concentration retarded the reducing sugars synthesis during storage. This is due to filmogenic property of chitosan coatings that provide a semi permeable film around the fruit surface, which modifies the internal atmosphere by reducing

oxygen and/or elevating carbon dioxide levels, which decrease the fruit respiration level and metabolic activity. Hence, retards the fruit ripening and senescence process (Vargas *et al.*, 2008) [67]. A suppressed respiration rate slows down the synthesis and the use of metabolites, resulting in lower reducing sugars due to the slower hydrolysis of carbohydrates to sugars (Das *et al.*, 2013) [15].

The reducing sugars Gradual increase in treated fruits as compared to control treatment might be due to its slow ripening process.

The results related to the present findings were reported by Dang *et al.*, (2010) [14] in sweet cherries. Das *et al.*, (2013) [15] in tomatoes. Salunkhe (2015) [66] and Venkateswerlu *et al.*,(2017) [59], in banana. Patil (2016) [38] in pomegranate, Mango fruits were also reported by Abbasi *et al.*, (2009) [2], Shinde (2014) [54], Purohit (2015) [42] and Mansute (2016) [31] in mango.

3.1.5 Total sugars (%)

The data related to the effect of pre and post-harvest application of chitosan on changes in total sugar content of grape Cv. Manik Chaman are presented in Table 5 and graphically depicted in Figure 5.

It is observed that the total sugar content of grape berry increase with decrease in the level of chitosan concentration during 45 days storage period at 0 °C temperature. The chitosan treatment and storage exhibited significant impact on total sugar content of grape.

Among all the treatments, the highest mean total sugar content was noticed in the treatment T_1 (17.39%) which was significantly superior to rest of the treatments and it was followed by T_2, T_3 and T_4. However, the treatments T_4 and T_5 were at par with each other. The lowest (14.03%) total sugar content was recorded in the treatment T_6 (0.1% pre-harvest spray and 2.0% post-harvest dipping) Thus, it is cleared from the data that the total sugars decreasing with increasing concentration of chitosan. Thus, it is cleared from the data that the total sugars increasing with decreasing concentration of chitosan for post harvest application.

It is observed that increase in chitosan concentration reduced the total sugars content of grape berries. The chitosan coating forms a semi permeable film around the berries surface, thereby retarding the respiration and metabolic activity (Vargas *et al.*, 2008) [67]. A suppressed respiration rate slows down the synthesis and the use of metabolites, resulting in lower total sugars due to the slower hydrolysis of carbohydrates to sugars (Das *et al.*, 2013) [15].

Table 5: Effect of pre and post-harvest application of chitosan on total sugar (%) of grape Cv. Manik Chaman during storage at 0 °C temperature

Treatments	Total sugar (%)				Mean
	Storage period (Days)				
	0	15	30	45	
T1	14.62	16.18	18.13	20.61	17.39
T2	13.79	15.31	17.21	19.64	16.49
T3	13.19	14.40	15.86	17.65	15.28
T4	13.01	14.02	15.19	16.59	14.70
T5	13.05	13.92	14.92	16.07	14.49
T6	13.00	13.64	14.35	15.13	14.03
Mean	13.44	14.58	15.94	17.61	
		S.Em ±		CD at 5%	
Treatments (T)		0.080		0.229	
Storage (S)		0.071		0.205	
Interaction (T×S)		0.139		0.391	

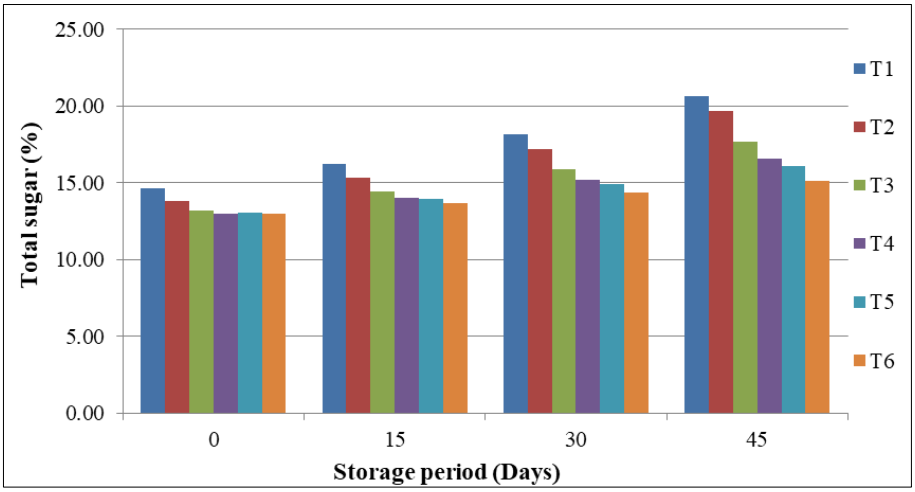


Fig 5: Effect of pre and post-harvest application of chitosan on Total sugar (%) of grape Cv. Manik Chaman during storage at 0 °C temperature

At the end of storage, here was a significant increase in total sugar level of grape berry. At initial stage i.e. 0 day, the lowest mean of total sugar (13.44%) was noticed, while the highest mean total sugar (17.61 %) was recorded at 45th day of storage. The increase in total sugars at ripening could be attributed to hydrolysis of starch into sugars.

Total sugars of the fruit are considered as one of the basic criteria to evaluate the fruit ripening. It is clear from the results that the total sugars were very low at the time of harvest but with the passage of time, the ripening process enhances and ultimately total sugars increased (Gul *et al.*, 1990).

The similar results were reported by several workers i.e. Dang *et al.*, (2010) [14] in sweet cherries. Das *et al.*, (2013) [15] in tomatoes. Salunkhe (2015) [66], Venkateswerlu *et al.*, (2017) [59], in banana. Patil (2016) [38] in pomegranate. Abbasi *et al.*, (2009) [2], Shinde (2014) [54], Purohit (2015) [42] and Mansute, (2016) [31] in mango fruit.

3.1.6 Ascorbic acid (mg/100g)

The data pertaining to the changes in ascorbic acid content of grape fruit Cv. Manik Chaman influenced by pre and post-harvest application of chitosan are presented in Table 6 and graphically depicted in Figure 6.

It is noticed from the data that there was a decreasing trend in the ascorbic acid content of grape berry as storage period increased. The pre and post-harvest application of chitosan exhibited significant impact on ascorbic acid content of grape berry.

Table 6: Effect of pre and post-harvest application of chitosan on Ascorbic acid (Vitamin C) (mg/100g) of grape Cv. Manik Chaman during storage at 0 °C temperature

Treatments	Ascorbic acid (Vitamin C) (mg/100g) Storage period (Days)				Mean
	0	15	30	45	
T1	6.35	5.35	4.35	3.35	4.85
T2	6.25	5.35	4.45	3.55	4.90
T3	6.19	5.39	4.58	3.79	4.99
T4	6.19	5.49	4.79	4.09	5.14
T5	6.18	5.59	4.99	4.39	5.29
T6	6.18	5.69	5.19	4.69	5.44
Mean	6.23	5.48	4.73	3.98	
		S.Em ±		CD at 5%	
Treatments (T)		0.12		0.33	
Storage (S)		0.10		0.29	
Interaction (T×S)		0.19		NS	

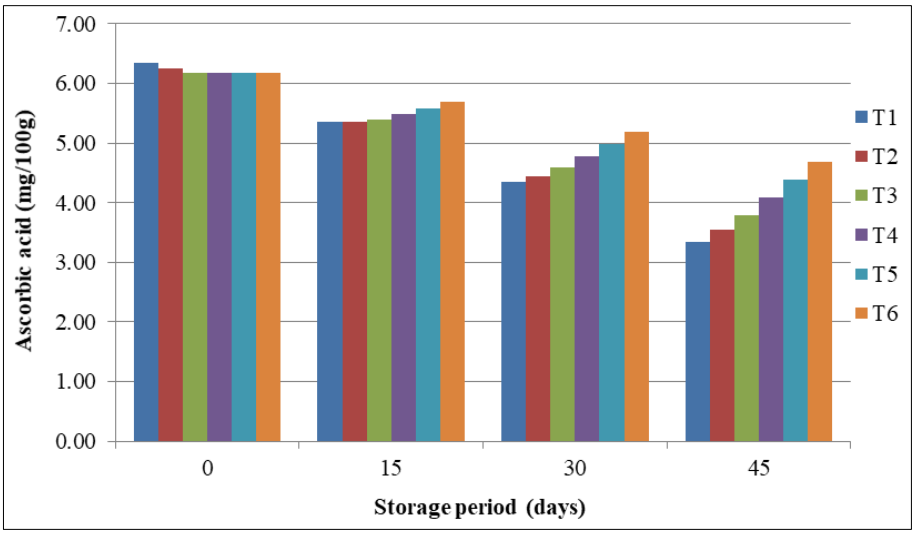


Fig 6: Effect of pre and post-harvest application of chitosan on Ascorbic acid (Vitamin C) (mg/100g) of grape Cv. Manik Chaman during storage at 0 °C temperature

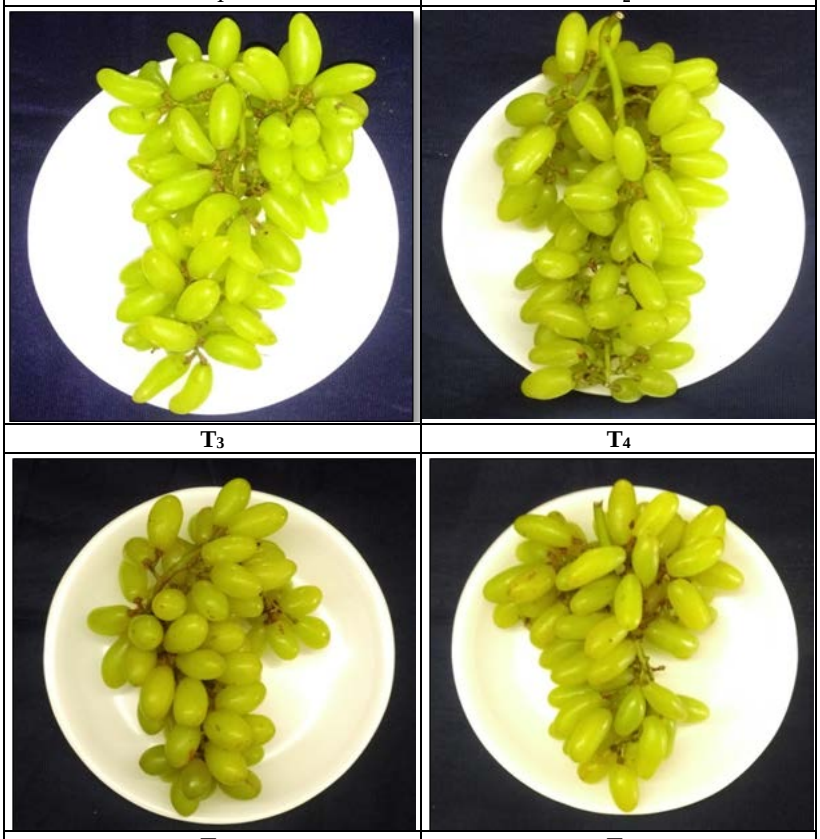
Among all the treatments, the highest mean ascorbic acid was recorded in the treatment T_6 (5.44mg/100g) which was significantly superior to rest of the treatments, but at par with the treatment T_5 (5.29 mg/100g) and T_4 (5.14mg/100g). However, the lowest mean ascorbic acid content recorded in treatment T_1 (4.85 mg/100g) i.e. control, however it was at par with the treatment T_3 (4.99 mg/100g) and T_2 (4.90 mg/100g).

At the end of storage, there was a significant decrease in the ascorbic acid level with respect to the treatments. At initial stage i.e. 0 day, the highest mean ascorbic acid (6.23 mg/100g) was noticed while the lowest mean ascorbic acid (3.98 mg/100 g) was observed at 45th day of storage at 0 °C temperature.

Chitosan coatings slowed down the loss of ascorbic acid during storage. Slowing down of the ascorbic acid was attributed to the low O_2 permeability of the coatings. Keeping oxygen away from the food delays the deteriorative oxidation reaction of vitamin C (Ayranci and Tunc, 2004) [8]. The phenolic substances have been reported to have a protective effect on the ascorbic acid as reported by Miller and Rice-Evans, (1997) [34].

The similar trends of decrease in ascorbic acid when increase in the levels of chitosan concentration to grape was observed by Elwahab *et al.*, (2014) [19]. Moreover, the identical observation were also observed by Cordenunsi *et al.*, (2005), in grand fruit, Abbasi *et al.*, (2009) [2], Shinde (2014) [54], Khaliq *et al.*, (2016) [27] in mango fruit. Dang *et al.*, (2010) [14] in sweet cherries. Ali *et al.*, (2011) in banana. Kumar and Sucharitha (2013) [58] in guava. Petriccione *et al.*, (2015) [39] in strawberry, Sucharitha *et al.*, (2018) [57] in tomato.

T_1	T_2



T_3	T_4

T_5	T_6

Plate 1: Grape Cv. Manik Chaman during 0 day storage at 0 °C temperature

T_1	T_2

T_3	T_4

T_5	T_6

Plate 2: grape Cv. Manik Chaman after 15 days of storage at 0 °C temperature

T_1	T_2

T_3	T_4

T_5	T_6

Plate 3: Grape Cv. Manik Chaman after 30 days of storage at 0 °C temperature

T_1	T_2

T_3	T_4

T_5	T_6

Plate 4: Grape Cv. Manik Chaman after 45 days of storage at 0 °C temperature

4. Conclusion

From the present investigation, it could be concluded that the admirable effect of 0.1 % pre-harvest spray and 0.5 to 2% post-harvest dipping of chitosan on chemical parameters of Grape Cv. Manik Chaman during 45 days of storage period at 0 °C temperature. The pre and post-harvest application in chitosan in Grapes can modify the internal atmosphere (by altering the permeability to water, oxygen and carbon dioxide), thereby decreasing the transpiration loss, reducing respiration rate, reducing microbial growth and delay's in senescence process of clusters an compared to untreated Grape Cv. Manik Chaman. As regards the chemical parameters evaluation, the Grape clusters treated with 0.1 % pre-harvest spray and 1.0 % post-harvest dipping of chitosan got superior results as compared to other treatments. Thus, it is suggested that 0.1 % pre-harvest spray and 1.0 % post-harvest dipping of chitosan is optimum for grape. Future scope also that chitosan define not only maintains firmness but also improves the postharvest quality during cold storage and also suggests that chitosan is promising as an eco-friendly edible coating to be used in commercial postharvest applications for prolonging the storage life of grapes.

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