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# Effect of pre and post-harvest application of chitosan on physical and physiological parameters 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-harvest spray and post-harvest dipping of chitosan on physical and physiological parameters of grape (*Vitis vinifera* L.) Cv. Manik Chaman" was conducted in the Department of Post-Harvest Management of Fruit, Vegetable and Flower Crops, P.G. Institute of P.H.M., Killa-Roha during the year 2017-2018. The experiment was conducted in Factorial Completely Randomized Design (FCRD) 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 physical and physiological parameters. It was observed that the pre-harvest spray and post-harvest dipping of chitosan treatments recorded delay in increase in physiological loss of weight (PLW) and delay in decreasing colour value *viz*. L*, a*, b* of grape Cv. Manik Chaman irrespective of treatments. As regards the physical and physiological parameters, the grape clusters with 0.1 per cent pre-harvest spray and 1.0 per cent post-harvest dipping of chitosan treatment obtained superior at 45 days of storage at 0 °C temperature condition as compared to control. 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, plw and colour

## 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) [3]. India ranks 7th position in grape production (Shikamany, 2001; Gade *et al*., 2014) [35, 15]. It is one of the most important crops in India, generally grown in the subtropical regions of India (Shinde, 2016) [36]. Grape is believed to have originated in Armenia near the Black and Caspian seas in Russia, and belong to the *Vitaceae* family.

India ranks 7th in the world with total production of 2,922 thousand metric tonnes from about 137 thousand ha area and productivity is 14.9 tonnes/ha. Maharashtra is leading state in area under cultivation (90.91 thousand ha) and total production (2048.11 thousand metric tonnes); followed by Karnataka (23.35 thousand ha; 429.78 thousand metric tonnes), Tamilnadu (2.44 thousand ha; 34.10 thousand metric tonnes), Mizoram (4.47 thousand ha; 22.55 thousand metric tonnes) and Kerala (1 thousand ha; 15.50 thousand metric tonnes) (Anon., 2017a) [4]. Maharashtra is the biggest producer of grapes in the nation and holds the 1st position. Over 80 per cent of the total grapes exported past years were from Maharashtra. Nasik, Satara, Solapur, Sangli, Pune and Ahmednagar are major grape growing belts in the state (Anon., 2018) [4].

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° 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 Gibberellic acid application than Thompson Seedless (Anon, 2017e) [4]. 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) [14].

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) [34].

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) [8, 37]. 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) [10, 23]. 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) [1, 27, 29, 33] and *in vivo* studies showed that chitosan treatment could control or delay postharvest decay of fruits and vegetables (Bautista-Banos *et al.*, 2006) [5].

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-Banos et al., 2006) [5]. It is regarded as a promising material for an edible coating on fruit (Olivas and Barbosa-Canovas, 2005) [23].

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) [31, 30]. There are no reports about the effect of the combination of pre-harvest and postharvest treatment on the physiological responses and quality during storage. Keeping this in view, the present investigation was carried out with the entitled objective.

## Materials and Methods

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

The Department laboratory of Post-Harvest Management of Fruit, Vegetable and Flower Crops, Post Graduate Institute of Post-Harvest Management (PGI-PHM), Killa-Roha is located at 18°25'35.54'', North latitude and 73°10'45.01'', East longitude and at an elevation of 17.50 meters above MSL. The climate of Killa-Roha is warm and humid with the mean annual rainfall 2000-3000 mm, mostly received from 1st June to 15th October.

### 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 |

### Treatments details

**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% |

**Factor B:** Storage period

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

### 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 $16^0$B and sugar acid ratio of 20:1.

### Pre-harvest preparation and application of chitosan

For experimental purpose, 2000 vines were selected (80 ares 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.

### Maturity indices for harvesting

As grape is a non-climacteric fruit, it was harvested at

minimum TSS of 16° B and sugar acid ratio of 20:1.

**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.

**Pre-cooling**

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

**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 percent 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.

**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.

**Evaluation of effect of pre and post-harvest application of chitosan on physical parameters of grape Cv. Manik Chaman during storage at 0 °C temperature**

**1. Colour**

The colour of grapes with has pre-harvest and post-harvest chitosan treatment was measured by using colour reader (make Konica Minolta, Japan CR-400) during storage and the colour values were expressed in terms of $L^*$, a* and b* values i.e. 'L*' (lightness), 'a*' (redness and greenness) and 'b*' (yellowness and blueness).

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

**1. Physiological Loss of Weight (PLW) (%)**

Twenty four clusters were selected from each treatment for studying physiological loss in weight. The loss in weight was calculated by noting down the difference between two consecutive weights recorded from initial day and every alternate day at $0^o$ temperature.

The individual berries were weighed on monopan electronic balance and average weight of these fruits was recorded in grams. The PLW was then calculated by vary the formula as given below and it was express in terms of percentage.

$$\text{PLW (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \text{ X } 100$$

**Result and Discussion**

The present investigation was undertaken to study the effect of pre and post-harvest application of chitosan on the storage behavior and shelf life of grapes Cv. Manik Chaman. The experiment consisted of six treatments, comprising different levels of chitosan concentration used for pre and post-harvest application i.e. control, 0.1% pre-harvest spray only, 0.1% pre-harvest spray and 0.5% post-harvest dipping, 0.1% pre-harvest spray and 1.0% post-harvest dipping, 0.1% pre-harvest spray and 1.5% post-harvest dipping and 0.1% pre-harvest spray and 2.0% post-harvest dipping. The experimental data was analysed statistically using Factorial Completely Randomized Design (FCRD). The observations on the changes in physical and physiological parameters of chitosan treated grape Cv. Manik Chaman during storage were recorded at 0, 15, 30 and 45 days of storage at $0^0$C temperature. The results obtained from the investigation are presented and discussed in this chapter with following headings.

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

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

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

**1. Colour value (L*, a* and b* value)**

Colour is one of the most important quality parameter of product. The colour parameters represented by L* (lightness), a* (redness) and b* (yellowness) values.

**1.1. L* value for colour-**

The data on effect of pre and post-harvest application of chitosan on L* value for colour of grape berry Cv. Manik Chaman are presented in Table 1 and graphically depicted in Fig 1.

The L* value was recorded to determine lightness of grape berry Cv. Manik Chaman which slowly decreased significantly with corresponding increasing in the level of chitosan concentration. The treatment T4 (0.1% pre-harvest spray and 1.0% post-harvest dipping of chitosan) recorded the highest (54.45) L* value, followed by the treatment $T_2$ and $T_5$ which here at par with each other. Treatment $T_2$ (0.1% Pre-harvest spray of chitosan) which was to be higher mean (52.84) as compared to control i.e. $T_1$ (50.77) during 45 days storage. The treatment T1 (control) recorded the lowest (50.77) L* value for colour and it was at par with the treatments T6 (0.1% pre-harvest spray and 2.0% post-harvest dipped in chitosan) and T3 (0.1% pre-harvest spray and 0.5% post-harvest dipped in chitosan) with 51.73 and 51.79 L* value for colour, respectively. Thus, the pre harvest spraying of 0.1 per cent along with1.0 per cent post-harvest chitosan

treatment recorded the investigated treatment as compared to all other treatments.

The colour L* value varied significantly during storage irrespective of treatments. A decreasing trend was seen during the 45 days storage period at 0 °C temperature. The highest (56.30) mean colour L* value, was recorded at initial day of storage and the lowest (49.68) mean colour L* value was observed after 45 days of storage.

Interaction effect between pre and post-harvest application in different levels of chitosan concentration and storage period was found to be statistically significant for mean L* value for colour of the grape berry Cv. Manik Chaman at 5 per cent level of significance. As per result, the highest (58.00) colour value for L* was recorded in treatment $T_4$ but at par with all other treatments except the control ($T_1$) at initial day and the lowest (47.38) colour value for L* was observed in Treatment $T_1$ however, it was at par with the treatment $T_2$ and $T_3$ at end of 45 days of storage.

Fruit colour change involves combinations of chlorophyll breakdown and the synthesis and degradation of carotenoids and phenolic pigments such as anthocyanins (Lancaster *et al.* 1997) [20]. The chlorophyll content of fruit peel decreases slowly with ripening of fruit as result of chlorophyllase action (Cano *et al.* 1997) [6]. The increase in carotenoide pigments results into decline in L* value for colour of the grape berries during storage.

Similar trend of lower L* value in uncoated strawberry fruit than in chitosan-coated (1% and 2%) fruits was noticed by Petriccione (2015) [26], Po-Jung *et al.* (2013) [28] reported the L value of the sliced papayas decreased with storage time. The results indicate that chitosan coating had the ability to maintain the lightness of the sliced papayas. Ali *et al.* (2011) reported the control and 0.5% chitosan coated fruit showed a faster change in colour compared to higher chitosan coatings. Kittur *et al.* (2001) [18] stated that during storage, chitosan coating delayed colour changes in banana. Romanazzi *et al.* (2005) [32] reported that the chitosan treatment on grape delayed the changes in the peel colour during 5 weeks of storage.

**Table 1:** Effect of pre and post-harvest application of chitosan on L* value for colour of grape Cv. Manik Chaman during storage at 0 °C temperature

| Treatments | L* value for colour | | | | Mean |
|---|---|---|---|---|---|
| | Storage period (Days) | | | | |
| | 0 | 15 | 30 | 45 | |
| T1 | 53.01 | 51.96 | 50.73 | 47.38 | 50.77 |
| T2 | 57.22 | 52.79 | 51.16 | 48.92 | 52.84 |
| T3 | 57.03 | 51.28 | 49.53 | 49.31 | 51.79 |
| T4 | 58.00 | 54.12 | 53.03 | 52.62 | 54.45 |
| T5 | 56.24 | 52.46 | 50.81 | 50.17 | 52.42 |
| T6 | 56.29 | 51.12 | 49.81 | 49.68 | 51.73 |
| Mean | 56.30 | 52.50 | 50.85 | 49.68 | |
| | | S.Em ± | | CD at 5% | |
| Treatments (T) | | 0.45 | | 1.29 | |
| Storage (S) | | 0.40 | | 1.15 | |
| Interaction (T×S) | | 0.78 | | 2.21 | |

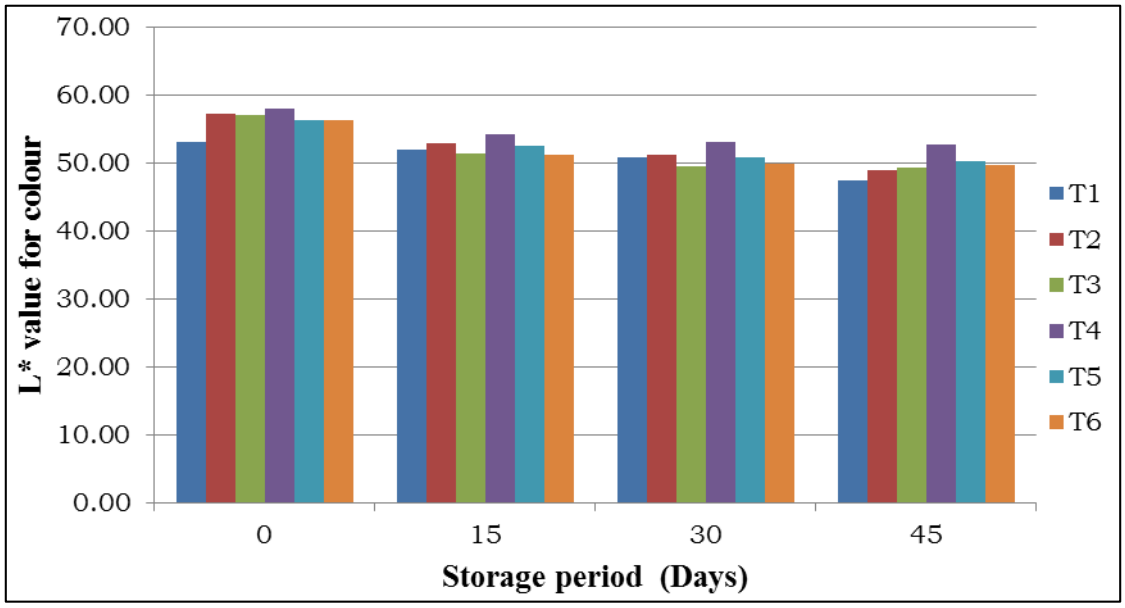


**Fig 1:** Effect of pre and post-harvest application of chitosan on L* value for colour of grape Cv. Manik Chaman during storage at 0 °C temperature

### 1.2. a* value for colour-

The data on effect of pre and post-harvest application of chitosan on a* value for colour of grape berry Cv. Manik Chaman are presented in Table 2 and graphically depicted in Figure 2.

The redness of the grape berry Cv. Manik Chaman was determined from a* value for colour of grape. The present data indicated that the redness of pre and post-harvest application in different chitosan levels changed significantly due to the treatments as well as storage period. Maximum mean a* value for colour (12.75) of grape berry Cv. Manik Chaman was observed in the treatment $T_4$ (0.1% pre-harvest spray and 1.0% post-harvest dipping in chitosan), followed by the treatment $T_5$ (0.1% pre-harvest spray and 1.5% post-harvest dipping of chitosan) and $T_6$ (0.1% pre-harvest spray and 2.00% post-harvest dipping in chitosan). However, treatment $T_5$ and $T_6$ were at par with each other all the chitosan treatment were significantly superior to the control ($T_1$).

It is observed from the data that the redness of grape berry decreased slowly due to increase in the chitosan concentration 1.5 to 2.0 percent for pre harvest application. The chitosan

concentration effect on redness was probably caused by an increase in the respiration rate and the promotion of enzymatic processes that were responsible for a drop in quality of the fruit, which involved browning and other reactions (Chien *et al.* 2013) [7].

As regards storage, there was decrease in the a* value for colour as the storage period increased. The highest mean value of a* (11.73) was recorded at 0 day of storage and the lowest mean value of a* was (10.1) recorded at 45 days of storage.

The changes in fruit colour are associated with the combinations during storage of chlorophyll breakdown and the synthesis and degradation of carotenoids and phenolic pigments such as anthocyanins (Lancaster *et al.* 1997) [20]. The chlorophyll content of fruit peel decreases slowly as result of chlorophyllase action (Cano *et al.* 1997) [6]. And degradation of colour pigment resulted into reduced a* value for colour during storage.

Similar trend of decreasing a* value was found in the uncoated and chitosan-coated sliced samples at 0, 1, 3, 5 and 7 d but resulted were were not significantly different (Jangchud and Nongtaodum, 2009) [16]. Kittur *et al.* (2001) [18] stated that during storage, chitosan coating delayed colour changes in banana. Romanazzi *et al.* (2005) [32] reported that the chitosan treatment on grape delayed the changes in the peel colour during 5 weeks of storage.

Interaction effect between different levels of pre and post-harvest application of chitosan to grape Cv. Manik Chaman and storage period was found to be statistically non-significant for mean a* value for colour of the grape berry at 5 percent level of significance.

**Table 2:** Effect of pre and post-harvest application of chitosan on a* value for colour of grape Cv. Manik Chaman during storage at 0 °C temperature

| Treatments | a* value for colour Storage period (Days) | | | | Mean |
|---|---|---|---|---|---|
| | 0 | 15 | 30 | 45 | |
| T1 | 9.20 | 9.15 | 8.81 | 7.80 | 8.74 |
| T2 | 11.90 | 11.75 | 8.94 | 8.68 | 10.32 |
| T3 | 11.58 | 11.02 | 9.72 | 9.59 | 10.48 |
| T4 | 13.06 | 12.92 | 12.62 | 12.41 | 12.75 |
| T5 | 12.55 | 11.78 | 11.06 | 10.81 | 11.55 |
| T6 | 12.09 | 10.91 | 10.81 | 10.74 | 11.14 |
| Mean | 11.73 | 11.26 | 10.33 | 10.1 | |
| | | S.Em ± | | CD at 5% | |
| Treatments (T) | | 0.36 | | 1.03 | |
| Storage (S) | | 0.32 | | 0.92 | |
| Interaction (T×S) | | 0.62 | | NS | |

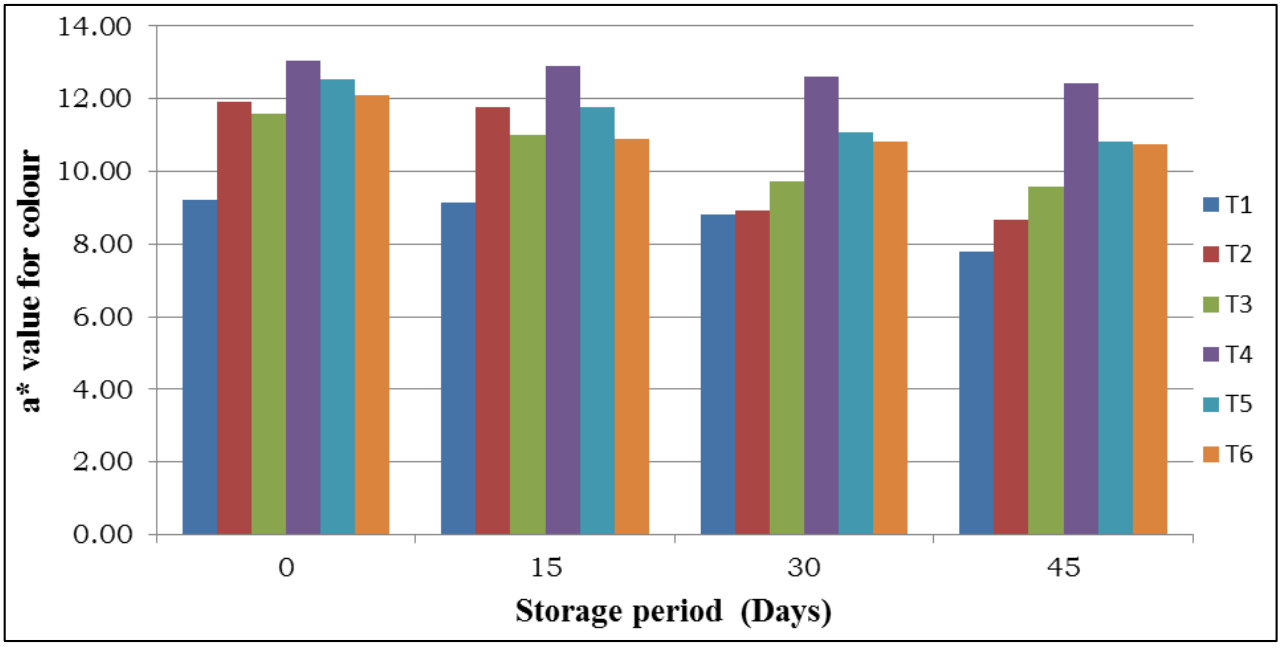


**Fig 2:** Effect of pre and post-harvest application of chitosan on a* value for colour of Grape Cv. Manik Chaman during storage at 0 °C temperature

### 1.3. b* value for colour

The data on effect of pre and post-harvest application of chitosan on b* value for colour of grape Cv. Manik Chaman are presented in Table 3 and graphically depicted in Figure 3.

The yellowness of the grape berry Cv. Manik Chaman was determined from b* value for colour of berry. The present data indicated that the yellowness of grape berries varied significantly due to the treatments as well as storage period. Maximum mean b* value for colour (32.09) of grape berry Cv. Manik Chaman was observed in the treatment $T_4$ (0.1% pre-harvest spray and 1.0% post-harvest dipping of chitosan) which was followed by the treatment $T_3$ (0.1% pre-harvest spray and 0.5% post-harvest dipping in chitosan) and $T_2$ (0.1% pre harvest spray only) with 30.22 and 30.09 of mean b* value respectively. However, they at par with the treatments $T_5$ and $T_6$. Minimum mean b* value for colour (28.51) of the grape berry Cv. Manik Chaman was observed in the treatment $T_1$ (control). But at par with the treatments $T_6$. It was observed from the data that yellowness of grape berry decreased when the concentration of chitosan increased to 1.5 or 2.0 per cent for post-harvest dipping treatment. Chutichudet and Chutichudet (2014) also reported that the papaya fruit treated with 2.5 percent chitosan recorded the lowest (34.27) value b* value for colour as compared other treatment.

Data on b* value for colour revealed that the yellowness of

grape berry decreased significantly during storage period of 45 days at 0 °C temperature. The highest mean value of b* (33.34) was recorded at 0 day of storage and lowest mean value of b* was (27.91) recorded at 45 days of storage.

Similar trends of slowly decreasing b* value for colour reported in different fruit by Kittur *et al.* (2001) [18]; whereas Cano *et al.* (1997) [6] stated that during storage, chitosan coating delayed color changes in banana.

Interaction effect between different levels of pre and post-harvest application of chitosan to grape Cv. Manik Chaman and storage period was found to be statistically significant for mean b* value for colour of the grape berry at 5 per cent level of significance. As per result, the highest (34.74) and colour value for b* was recorded in treatment $T_3$, but at par with all other chitosan treatment except the control i.e. $T_1$ at initial day and the lowest (27.36) was observed in Treatment $T_1$ at end of 45 days of storage. But at par with all other treatment expect the treatment $T_4$.

**Table 3:** Effect of pre and post-harvest application of chitosan on b* value for colour of grape Cv. Manik Chaman during storage at 0 °C temperature

| Treatments | b* value for colour | | | | |
|---|---|---|---|---|---|
| | Storage period (Days) | | | | |
| | 0 | 15 | 30 | 45 | Mean |
| T1 | 30.27 | 29.28 | 29.13 | 27.36 | 28.51 |
| T2 | 34.31 | 29.86 | 28.26 | 27.93 | 30.09 |
| T3 | 34.74 | 29.55 | 28.43 | 28.13 | 30.22 |
| T4 | 34.70 | 32.12 | 31.38 | 30.16 | 32.09 |
| T5 | 33.05 | 29.33 | 29.12 | 27.51 | 29.75 |
| T6 | 32.97 | 28.85 | 27.50 | 27.36 | 29.23 |
| Mean | 33.34 | 29.87 | 28.80 | 27.91 | |
| | | S.Em ± | | CD at 5% | |
| Treatments (T) | | 0.41 | | 1.19 | |
| Storage (S) | | 0.37 | | 1.07 | |
| Interaction (T×S) | | 0.72 | | 2.04 | |

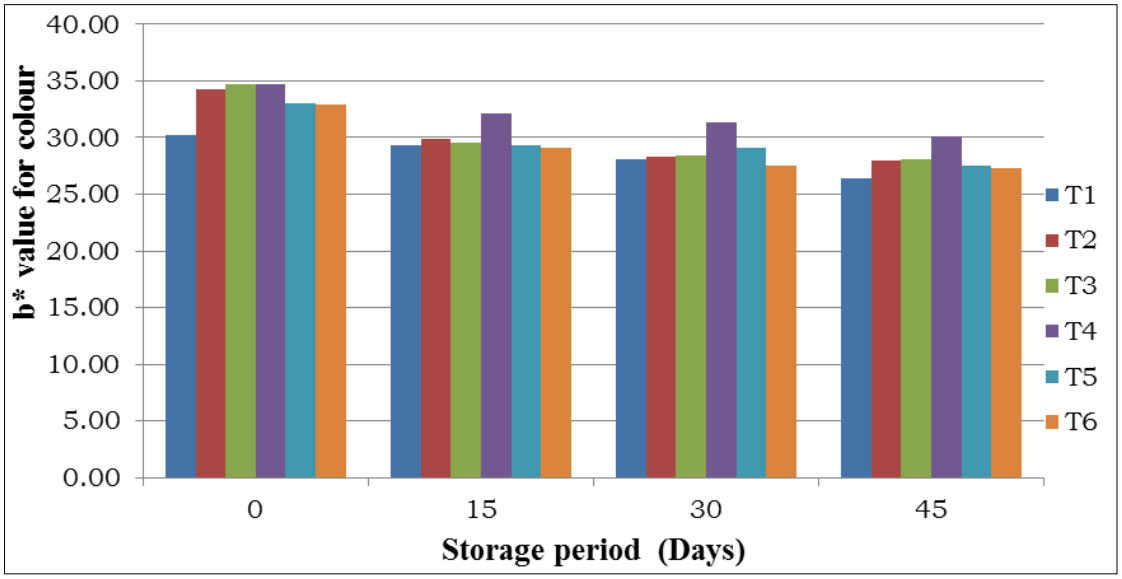


**Fig 3:** Effect of pre and post-harvest application of chitosan on b* value for colour of grape Cv. Manik Chaman during storage at 0 °C temperature

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

**2.1. Physiological loss of weight (PLW)-**

The data on effect of pre and post-harvest application of chitosan on changes in physiological loss of weight (PLW) of grape Cv. Manik Chaman are presented in Table 4 and graphically depicted in Figure 4.

The chitosan treatment and storage interaction exhibited significant impact on physiological loss in weight of grape clusters.

It is observed from the data that the treatment $T_1$ i.e. control treatment recorded maximum (4.70%) mean physiological loss in weight, followed by the treatments $T_2$ (2.30%) and $T_3$ (1.53%). The treatment $T_6$ (0.58%) recorded the lowest mean physiological loss in weight as followed by $T_5$ (0.82%) and $T_4$ (0.97%) of grape cluster Cv. Manik Chaman. Thus, it is clear from the data that the physiological loss in weight decreased significantly with increase in chitosan levels for post-harvest application with 0.1 per cent pre-harvest chitosan spray.

Chitosan coating form a selective permeable film on fruit surface, which result in limiting respiration and transpiration (Bautista-Banos *et al.* 2006) [5], there by checking the PLW during storage.

As regards storage, there was an increase in the physiological loss in weight with advancement of the storage period. At initial stage of storage, the mean physiological loss in weight was 0.00 per cent however, it was increased to 3.77 per cent irrespective of the treatments at 45$^{th}$ day during storage at 0 °C temperature.

The interaction effects between the treatments and storage period were found to be statistically significant. The minimum (0.30%) physiological loss in weight of grape berries was recorded in the treatment $T_6$ at 15 days of storage whereas it was maximum (9.72 percent) in the treatment $T_1$ i.e. control at 45 days of storage of grape berries at 0 °C temperature. The fastest and maximum increase in physiological loss in weight was observed in grape berries from control treatment. The continuous increase in physiological loss in weight values during storage condition could be due to loss of moisture from the fruit peel through respiration and transpiration process.

As per result, noticed treatment $T_2$ (0.1% pre-harvest spray) also showed minimum weight loss (2.30%), as compared to

control (4.70%) during 45 days of storage at 0 °C temperature.

Chitosan forms a semi permeable film that regulates the gas exchange and reduces transpiration loses and fruit ripening is slowed down. This effect has been reported for numerous horticultural commodities such as tomatoes, strawberries, longan, apples, mangoes, bananas, bell peppers, etc. (El Ghaouth *et al.* 1991a; Du *et al.* 1997, 1998; Jiang and Li, 2001 and Kittur *et al.* 2001) [11, 17, 18].

Similar trend of increase in the physiological loss in weight values of grape clusters during storage and decrease in physiological loss in weight of grape clusters with increase in concentration of chitosan was observed by El-Ghaouth *et al.* (1991) [10], Kittur *et al.* (2001) [18], Romanazzi *et al.* (2005) [32], Xu, S. *et al.* (2007), Meng *et al.* (2008) [22], Papachatzis *et al.* (2013) [25] and Elwahab, (2014) [13].

<table>
<tr><td>  </td><td>  </td></tr>
<tr><td>T1: Control</td><td>T2: 0.1% Pre-harvest spraying</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>T3: 0.1% Pre-harvest spraying and 0.5% Post-harvest Dipping</td><td>T4: 0.1% Pre-harvest spraying and 1.0% Post-harvest Dipping</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>T5: 0.1% Pre-harvest spraying and 1.5% Post-harvest Dipping</td><td>T6: 0.1% Pre-harvest spraying and 2.0% Post-harvest Dipping</td></tr>
<tr><td colspan="2">Plate 1: Effect of pre and post-harvest application of chitosan on grape Cv. Manik Chaman during 0 day storage at 0 °C temperature</td></tr>
</table>

| | |
|---|---|
|  |  |
| $T_1$: Control | $T_2$: 0.1% Pre-harvest spraying |
|  |  |
| $T_3$: 0.1% Pre-harvest spraying and 0.5% Post-harvest Dipping | $T_4$: 0.1% Pre-harvest spraying and 1.0% Post-harvest Dipping |
|  |  |
| $T_5$: 0.1% Pre-harvest spraying and 1.5% Post-harvest Dipping | $T_6$: 0.1% Pre-harvest spraying and 2.0% Post-harvest Dipping |

**Plate 2:** Effect of pre and post-harvest application of chitosan on grape Cv. Manik Chaman after 15 days of storage at 0 °C temperature

| | |
|---|---|
|  |  |
| $T_1$: Control | $T_2$: 0.1% Pre-harvest spraying |
|  |  |
| $T_3$: 0.1% Pre-harvest spraying and 0.5% Post-harvest Dipping | $T_4$: 0.1% Pre-harvest spraying and 1.0% Post-harvest Dipping |
|  |  |
| $T_5$: 0.1% Pre-harvest spraying and 1.5% Post-harvest Dipping | $T_6$: 0.1% Pre-harvest spraying and 2.0% Post-harvest Dipping |

**Plate 4:** Effect of pre and post-harvest application of chitosan on grape Cv. Manik Chaman after 45 days of storage at 0 °C temperature

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

| Treatments | Physiological loss of weight (%) Storage period (Days) | | | | Mean |
|---|---|---|---|---|---|
| | 0 | 15 | 30 | 45 | |
| T1 | 0.00 | 3.01 | 6.06 | 9.72 | 4.70 |
| T2 | 0.00 | 1.52 | 3.01 | 4.65 | 2.30 |
| T3 | 0.00 | 1.03 | 2.00 | 3.08 | 1.53 |
| T4 | 0.00 | 0.61 | 1.53 | 1.91 | 0.97 |
| T5 | 0.00 | 0.52 | 1.00 | 1.77 | 0.82 |
| T6 | 0.00 | 0.30 | 0.50 | 1.51 | 0.58 |
| Mean | 0.00 | 1.17 | 2.32 | 3.77 | |
| | | S.Em ± | | CD at 5% | |
| Treatments (T) | | 0.012 | | 0.034 | |
| Storage (S) | | 0.010 | | 0.031 | |
| Interaction (T×S) | | 0.021 | | 0.059 | |

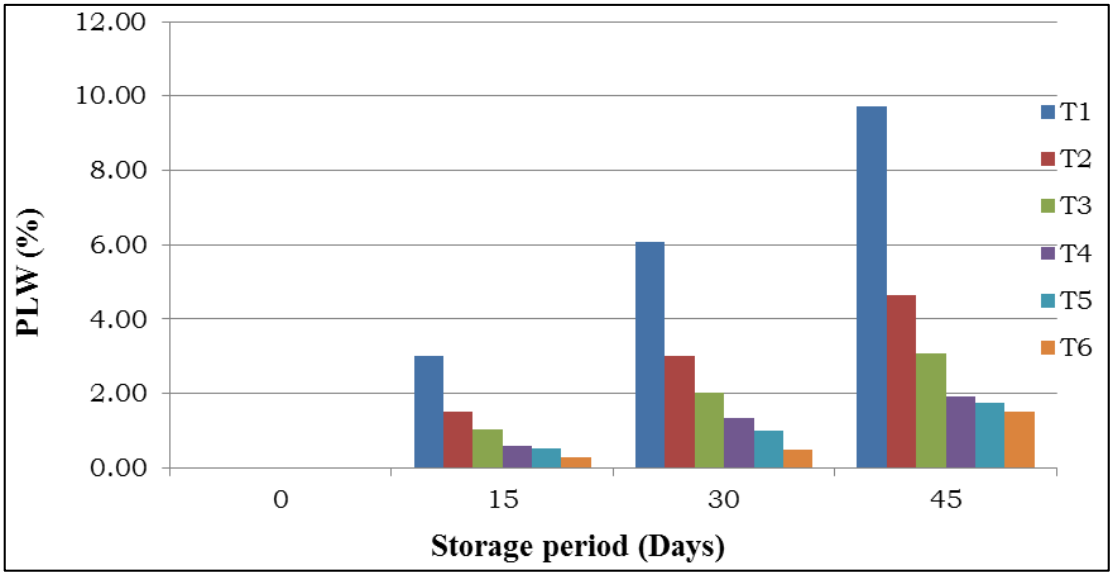


**Fig 4:** Effect of pre and post-harvest application of chitosan on physiological loss of weight (PLW) (%) of grape Cv. Manik Chaman during storage at 0 °C temperature

## 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 physiological loss of weight (PLW) and physical 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 physiological loss of weight (PLW) and physical parameters, the Grape clusters treated with 0.1% pre-harvest spray and 1.0% post-harvest dipping of chitosan got maximum appreciation as compared to control treatment. Thus, it is suggested that 0.1% pre-harvest spray and 1.0% post-harvest dipping of chitosan is optimum for grape.

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