Journal of Pure and Applied Agriculture (2021) 6(2): 55-64
ISSN (Print) 2617-8672, ISSN (Online) 2617-8680
http://jpaa.aiou.edu.pk/

Enhancing the quality of grape fruit using bunch bagging and chitosan coating against biotic factors

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Abstract

Grape fruit quality is greatly affected by the attack of insect pests, diseases and use of synthetic chemicals and hence reduces the yield. Therefore farmers uses various applications of insecticides and pesticides to reduce yield damage that are costly and somewhat affect the nutritional quality of the fruits. So, using pre harvest bunch bagging will not only protect the fruit from insect pest attacks, fungal diseases but will enhance the quality and firmness of the fruits. In this regard a field study was conducted at Rawat orchard yards, Rawalpindi, Pakistan during 2013. Chinese bunch bagging, muslin cloth bunch bagging, cement bunch bagging, brown paper bunch bagging, 0.5% chitosan, 1.0% chitosan and 1.5% chitosan were used as treatment combinations. Statistical results of the experiment showed that all the treatments were significantly ($p \leq 0.05$) different. The maximum average bunch weight (468.64 g), fruit firmness (1.33 kgf), pH of juice (4.82), total soluble solid (17.08 ºBrix), reducing sugars (2.79%), non-reducing sugars (57.62%) and total sugars (63.3%) were from the plot having Chinese bunch bagging. It is concluded from the results that the use of pre harvest bunch bagging material and application of chitosan based sprays improved and enhanced the quality of grape fruit that helped in minimizing the damage caused by biotic factors on grape yield. © 2021 Department of Agricultural Sciences, AIOU

Keywords: Bunch bagging, Chitosan, Fruit firmness, Grapes, TSS

To cite this article: Usman, T., Ahmad, Z., Noman, M., Kasana, M. I., Tariq, S., & Khan, T. N. (2021). Enhancing the quality of grape fruit using bunch bagging and chitosan coating against biotic factors. *Journal of Pure and Applied Agriculture, 6*(2), 55-64.

Introduction

Grapes (*Vitis vinifera* L.) is a fruiting berry of the deciduous woody vines belongs to family Vitaceae and genes Vitis and is considered to be the first cultivated among fruits by man. Among perishable fruits grapes has a prominent position because of its enormous taste, nutritional value and multipurpose daily worldwide (Ali et al., 2021). In many countries of the world different grapes species are being grown on a limited area special significance in developing food products for human consumption. Increasing food demand of human population compelled the scientists to increase the yield productivity of grapes so that to overcome food requirement challenges of the world population (Babalik et al., 2020). A minimal upsurge has been ensued in this regard under favorable conditions. Though, a substantial room for improvement in grapes productivity under biotic stress conditions is present that is characterized by different abiotic constrains like premature harvesting from insects, pest and birds (Ahmad et al., 2020).

Grape yield is greatly affected by several factors like premature harvesting, attack of insect pests, diseases and application of heavy dosage of pesticides for enhancing productivity. To increase the yield and commercial value of grape fruit, farmers practice different types of bunch paper bagging and use of pesticide sprays to limit the attack of insect, wasp, flies and birds (Kumarihami et al., 2021). In some countries various types of paper bags that include black paper bagging and cellulose bagging are wrapped around the fruits for enhancing color of the grapes and to give protection against atmospheric events and attack of insect pests on the fruit (Buthelezi et al., 2020). The technique of bunch bagging can be used as a primary source of protection from various biotic factors like insect pests and fungus. Beside this, it may also amplify the microenvironment during fruit development that will alternately lead to enhanced quality of the fruit. The pre harvest bagging technique may also increase color uniformity and delay the ripening process in grape that will consequently in lead to increase grapes yield (Abdelsattar et al., 2020).

Chitosan is an ideal preservative material for fresh fruit and vegetables because of having disease suppressive effect resulting from both physical and biochemical mechanisms (Jemilakshmi, 2020). Chitosan has the potential of becoming a powerful alternative mean for the control of different diseases in fruits. Furthermore, chitosan has been subjected to various toxicological tests and permitted as a food additive by the United States Food and Drug Administration (USFDA) (Kumar et al., 2021). Chitosan has been extensively used as coating material for prolonging postharvest shelf life because if forms a semi-permeable film on the exterior surface thus encompasses storage life fruits and reduces post-harvest fungal rots. Apart from that chitosan has an antimicrobial activity that inhibits spore germination and mycelial growth of phytopathogenic fungi. Post-harvest field application of chitosan proved to be very effective in controlling various diseases in certain fruits (Zhou et al., 2020). Pre-harvest or post-harvest treatment of chitosan may provide the fruitful results in limiting biotic factors and may enhance plant resistance to various infections and thus can achieve an increase fruit yield in grapes. Similarly in this regard, the current experiment was plan to investigate the use and selection of pre harvest proper bunch bagging materials and useful concentration of chitosan for improving quality and yield of grape fruit.

Material and Methods

The present experiment was carried out on thirty grape fruit plants with the aim to enhance the quality and yield of "Perlette' grape fruit (*Vitis vinifera* L.) in complete randomize block design (CRD) with three replications during grape fruit growing season 2013 at Rawat orchard yards, Rawalpindi, Pakistan. The material was compromised a total of 08 treatment combinations viz T1 = Chinese bunch bagging, T2 = muslin cloth bunch bagging, T4 = cement bunch bagging, T4 = brown paper bunch bagging treatment combinations. Beside this, different concentrations (T5 = 0.5% chitosan, T6 = 1.0% chitosan T7 = 1.5% chitosan and T8 = control) of chitosan chemical with medium molecular weight (normal molecule Shripm) were also used as treatment combinations. Chitosan chemical was applied separately on bunches of grape fruit in the form of a foliar spray using hand manual sprayer. First foliar application on grape fruit was done at bunch hanging stage while second application was made about 15 days earlier of harvesting the fruit. Date was recorded on the following various parameters.

Average bunch weight (g)

Data regarding bunch weight was calculated using ten lots from each treatment and then measured their weight on electric weight balance individually.

Damage bunch (%)

Percent damage was estimated by counting the total infected bunches divided by total number of bunches which were then multiplied by 100 showing in the formula as:

$$\text{Bunch damage (\%)} = \frac{\text{Total no.of inected bunches}}{\text{Total No.of bunches}} \times 100$$

Fruit firmness (kgf)

Data regarded firmness was calculated on ten berries in each treatment using automatic firmness tester (FT – 327 Model).

pH of fruit juice

Knick-646 model digital pH meter was used to measure the pH level of grape fruit juice.

Total soluble solids (°Brix)

From the extracted juice of the grape fruit from each treatment, a drop was put on the prism of the hand refractometer to measure total soluble solids in grape fruit juice.

Titratable acidity (%)

A solution containing 40 mL water, 10 mL juice extract from grapes and 2-3 drops of phenolphthalein was made to estimate percent titratable acidity. Titration flask was filled up to 10 mL of aliquot and titrated alongside (0.1 N NaOH) till the appearance of light pink color. This process was repeated three times consecutively and obtained the readings for percent tartaric acidity by using the formula:

$$\text{Titratable acidity (\%)} = \frac{(0.0075 \times \text{N/10 NaOH})}{\text{Volume of sample}} \times 100$$

Reducing sugars (%)

Hortwitz, (1960) proposed a method for calculating reducing sugars in grapes by adding 100 mL water, 10 mL grape juice extract, 10 mL potassium oxalate and 25 mL lead acetate solution for making a volume into 250 mL volumetric flask. A burette was then filled with a sample of aliquot and endorsed to trip drop by drop into the 10 mL Fehling's solution taken in a pointed flask. During the process, the volume was continuously boiled till the appearance of brick red color. Then a few drops of methyl were added to it and resumed the titration process until the desirable color achieved again. Various readings were noted and averaged by the formula:

$$\text{Reducing sugars (\%)} = \left[6 \times \frac{A}{B}\right]$$

Where
A = standard solution in mL
B= sample aliquot in mL

Non-reducing sugars (%)

Data pertaining to percentage of non-reducing sugars was estimated as:
Non-reducing sugars (%)

$$= [\text{Total sugars (\%)} - \text{Reducing sugars (\%)}] \times [0.95]$$

Total sugars (%)

Total sugars of juice extract were predicted using the technique defined by Hortwitz, (1960).
Data regarding total sugars was calculated according to the same method suggested by Hortwitz (1960) for the calculation of reducing sugars discussed above by formula:

Total sugars (%) = $\left[25 \times \frac{A}{B}\right]$

Where

A = standard sugar solution in mL

B = sample of aliquot in mL

Statistical analysis

Collected data from field and lab was subjected to analysis of variance statically in RCB design with factorial design followed by Least Significant difference test at 5% level of probability (Steel and Torrie 1997).

Results and Discussion

Average bunch weight (g)

Data regarding bunch weight was significantly affected and ranged from 236.10 to 478.64 (Table1). Maximum bunch weight (468.64 g) was produced by grape fruit preserved with Chinese bunch bagging while lowest bunch weight (236.10 g) was calculated in control treatment followed by grape fruit treated with 1.5% chitosan (304.30 g) pre harvest coating (Fig. 1). Chinese bunch bagging with 0.5% chitosan application increased the average bunch weight of grapes fruits because the fruit achieved optimum maturity dwindling conditions of the bagging and chemical application. The bagged fruit bunches showed better results in weight as compared to the non-bagged fruit bunches. Equating the bunch bagged grape fruits with the non-bagged bunch fruits and chitosan application protected the fruit from injuries and harsh environmental conditions, hence gave fruitful criteria regarding quality and yield (Ali et al., 2021). Chitosan coating and bagging material helped grape fruit in proper development and maintained its proper size along with desirable weight. The results of Babalik et al. (2020) are in contradiction with our findings who reported that increasing shelf life period of fruit caused the weight loss in overall but negligible as compared to control treatment. The biological and environmental constrains might have resulted in immature and under developed fruits which then lead to lower fruit weight (Kumar et al., 2021). The vital practical guess is an alteration in permeability due to which positively alleged chitosan molecules interacts with negatively accused cell membranes thus results in outflow of proteinaceous and intercellular components (Ahmad et al., 2020).

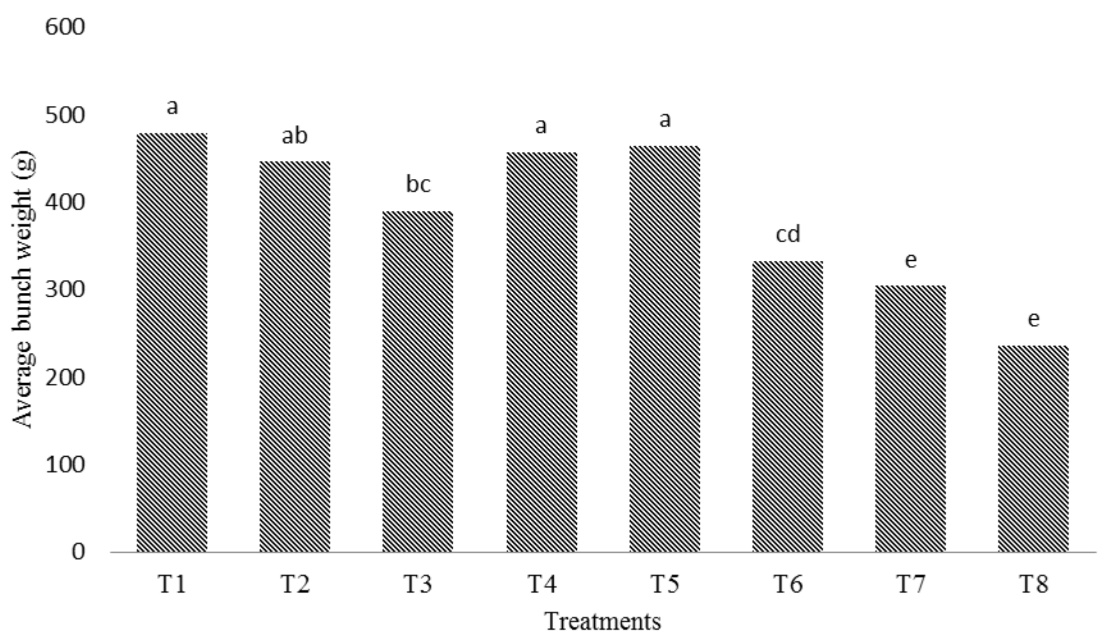

Fig. 1 Effect of bunch bagging and chitosan application on average fruit weight (g) in grape fruits

Bunch damage (%)

To decrease the damage percentage grape fruits are bagged with different types of bags to avoid yield reduction. The collected data showed significant variations and stretched from 16 to 52% (Table1). Chinese bunch bagging treatment accounted lowest number of diseased fruits (16%) whereas highest number of damage fruits was found in control treatment (52%) followed by 1.5% chitosan coating application (40%) (Fig. 2). Fruit bagging is usually done before maturity during which fruits are susceptible to damage, disease and mechanical injury allows the pathogen to enter thereby leading to rotting of the product. Present investigations disclosed that fruit yield losses were reduced due to fruit bagging. Unintended falling also results in brushing and cracking of fruits which can be protected through bagging. Furthermore, bagging also enhanced the color of various fruits and reduces the physical injury subsequently resulted in improved yield (Kuria et al., 2020). Bagging protected fruits at developmental stages from physical damage, wind, toxic effect of pesticides, insect damages, hail from storm impact and pollutants like dust and smoke etc. The wrapping of bags around various fruits decreased diseases and insects attack resulted in high value and flawless fruits (Bibi et al., 2021). Shelf life of numerous fruits like grapes, cherries and tomatoes were increased due to the pre harvest application of chitosan to them that subsequently resulted in improved storage and post-harvest life (Khalil et al., 2019). Chitosan application develop a thin layer over the fruit that alter the inner atmosphere and decline the transpiration damages hence conserve the quality of fruits.

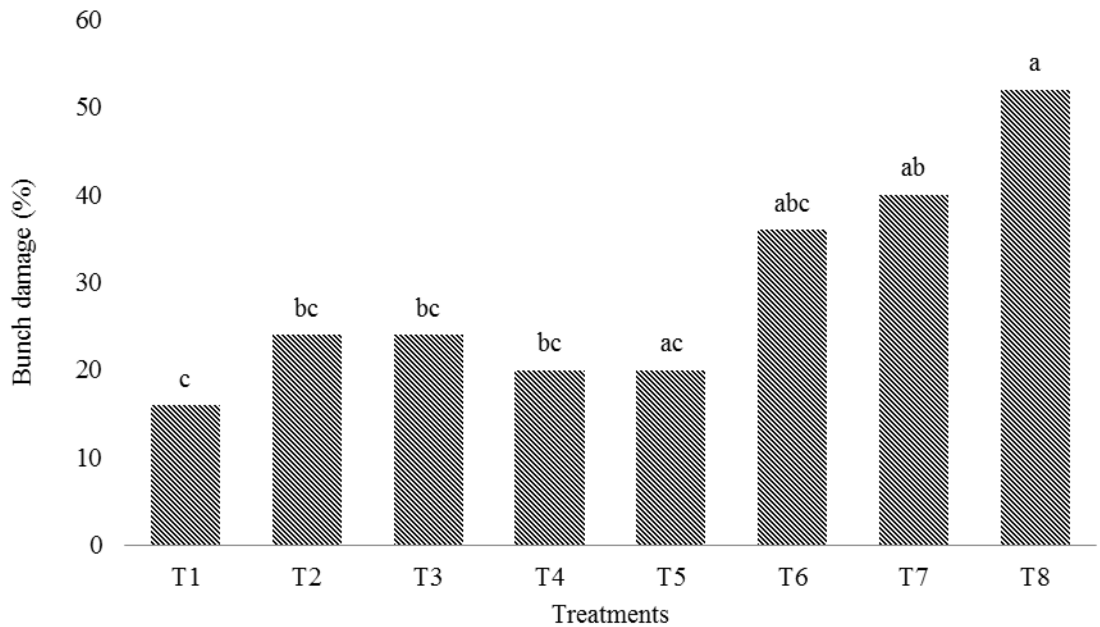

Fig. 2 Effect of bunch bagging and chitosan application on bunch damage (%) in grape fruits

Fruit firmness

Fruit texture or hardness is the quality of grape fruits that gradually declines with maturity of the fruit. Grape fruit becomes softer and changes it texture during ripening nearly maturity. Data regarding firmness displayed significant divergence and varied from 0.66 to 1.33 kgf (Table1). Maximum fruit firmness was displayed by grape fruit with Chinese bunch bagging (1.33 kgf) closely followed by 0.5%chitosan treatment while inferior fruit firmness was noted in grape fruit of control treatment (0.66 kgf) (Fig. 3). Fruit firmness adversely affects the various components of cell wall at ripening and maturity. Unlike bagging materials plays an ample role in chemical configuration of the product by modifying fractions of pectin leading to an increased in the pectin solubalization (Kumarihami et al., 2021). Cell wall and texture was studied during chitosan coating on citrus fruit at maturity that resulted in good quality high yield (Muaffaq, 2018). Similarly, Babalik et al. (2020) observed a negligible reduction in non-coated tomatoes fruits as compared to that of chitosan coated fruit. On the way forward, chitosan application on tomatoes produced firmer, less decomposed and less red pigment fruits. In addition, mangosteen fruit yield and quality was enhanced up to the considerable amount by application of 2% chitosan on the mangosteen fruits (Nelson et al., 2017).

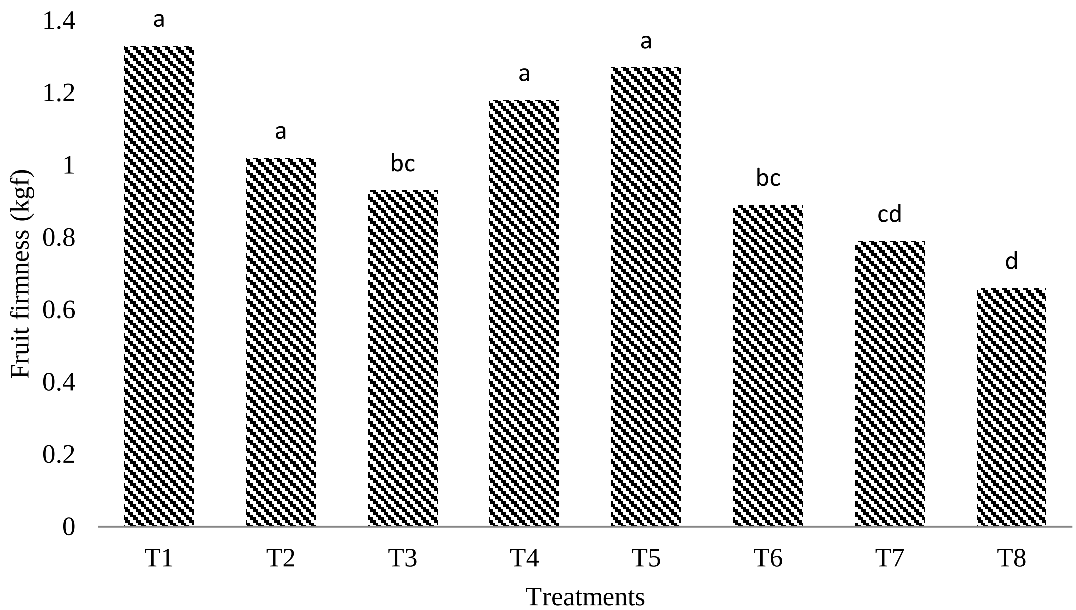

Fig. 3 Effect of bunch bagging and chitosan application on fruit firmness (kgf) in grape fruits

pH of fruit juice

The pH value of grape fruit is a vital parameter because it controls the microbial activities and contributes to the increase shelf life of the fruit. The current data pattern indicated significantly growing trend with the ripening grape fruits and ranged from 3.92 to 4.57 (Table1). The least acidic with more pH was recorded for grape fruits covered with Chinese bunch bags (4.82) whereas more acidic with least pH value (3.92) was obtained from control treatment (Fig. 4). Hydrogen ion concentration in fruit solution plays a vital role in controlling microbial activities. High or low pH determines the shelf life of fruit. High formation of organic acid during maturity indicated an increase in pH level of mandarins that affected the quality of fruits (Kumar et al., 2021). More respiration in tomato caused breakdown of organic acids in the fruit that lead to the increase in pH values over storage (Ramirez and Pena 2020). Furthermore, Reduction of the respiration rate, control of decay and preservation of firmness as a result of chitosan treatment has also been stated for apples, Citrus and banana (Zhou et al., 2020).

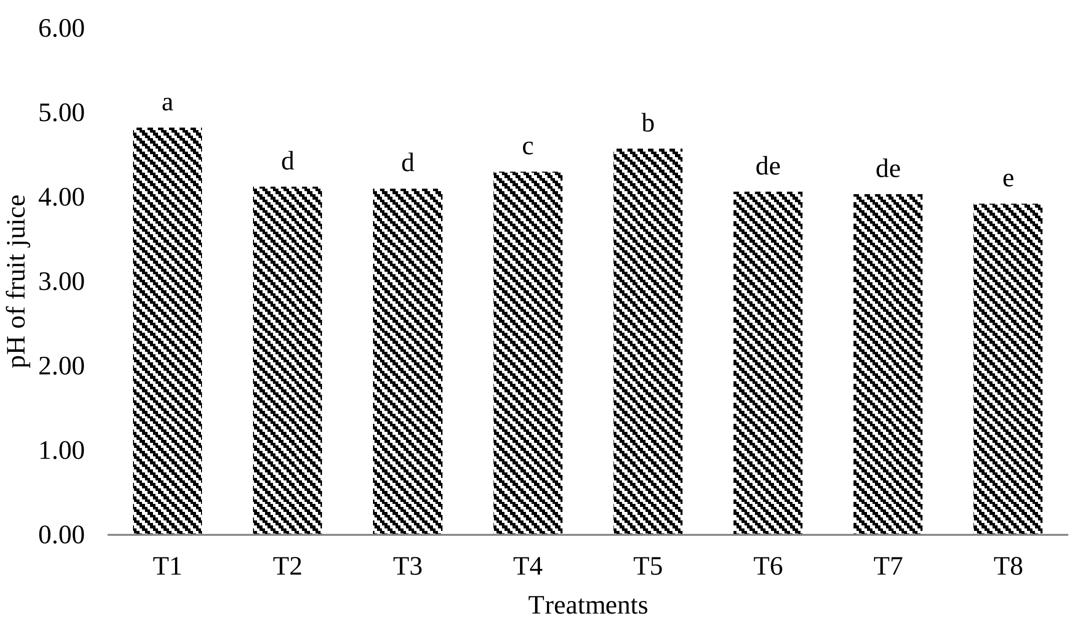

Fig. 4 Effect of bunch bagging and chitosan application on pH of juice in grape fruits

Total soluble solids (°Brix)

A solution that includes Sugars, proteins, acids and soluble salts is known as total soluble solids. Current studies revealed significant results for total soluble solids (TSS) and varied from 13.86 to 17.08 °Brix (Table 2). Highest amount of total soluble solids was observed in grape fruit covered with Chinese bunch bagging (17.08 °Brix) while least value was noted in control treatment (13.86 °Brix) (Fig.5). Grape fruit value and quality is determined by various factors like total soluble solids, firmness, titratable acidity, size and color. The use of cellulose bags at pre harvest greatly affected the titratable acidity and sugar content thus increased the total soluble solids. Beside this, sufficient decrease was also noted in fruit flesh firmness as the grapes fruits experienced considerable changes in sugar content at maturity (Roselli et al., 2020). The increase in total soluble solids was might be due to solubilization of hemicelluloses and cell wall polyuronides in grape fruit as a result of chitosan coating (Sen and Khalil et al., 2019). In control the minimum total soluble solids could be due to the low biochemical activities which took part in the hydrolysis of starch into sugars. The verdicts are in confirmatory with (Zhou et al., 2020) who concluded positive results from the foliar application of different levels of chitosan on fruits.

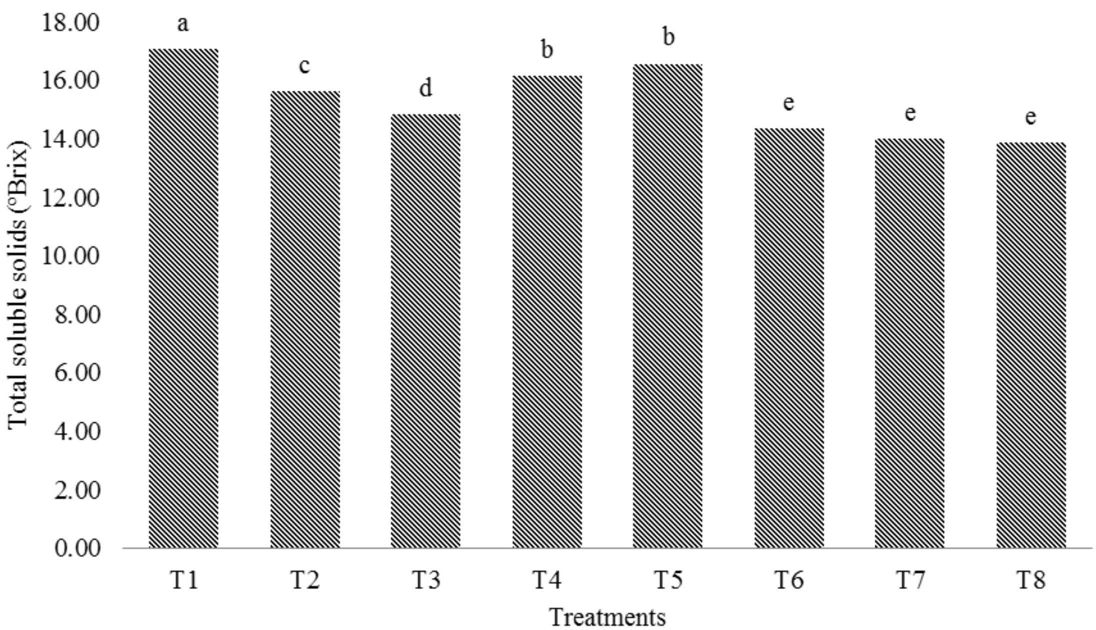

Fig. 5 Effect of bunch bagging and chitosan application on total soluble solids (°Brix) in grape fruits

Titratable acidity (%)

The concentrations of weak organic acids like citric acid, oxalic acid malic acid fumaric acid, quinic and tartaric acid present in the fruits plays a quite important role in determining flavor of the grape fruit. Titratable acidity showed significant differences and ranged from 0.20 to 0.29% (Table 2). Superior value in terms of Titratable acidity (0.29 %) was estimated in control closely followed by 1.5% chitosan treatment (0.27%) while inferior value (0.20%) was determined for Chinese bunch bagging treatment (Fig. 6). As the two main sugars glucose, fructose and two organic acids tartaric acid and malic acid are found in grapes that significantly increased total soluble solids and decreased titratable acidity due to cellulose bagging. On the opposite bagging with various materials might have changed the chemical conformation of grapes (Pisciotta et al., 2020). Shah et al. (2019) disclosed in their experiment that titratable acidity did not affect various bunch bagging treatment combinations. Moreover, Zhou et al. (2020) enhanced the storage life and quality of raspberries and strawberries due to chitosan based coating that prevented weight loss and variations in pH, color and titratable acidity of the fruits. Apart from that, use of different bunch bagging material application might have alarming effects on the chemical composition of the fruit (Ahmad et al., 2020).

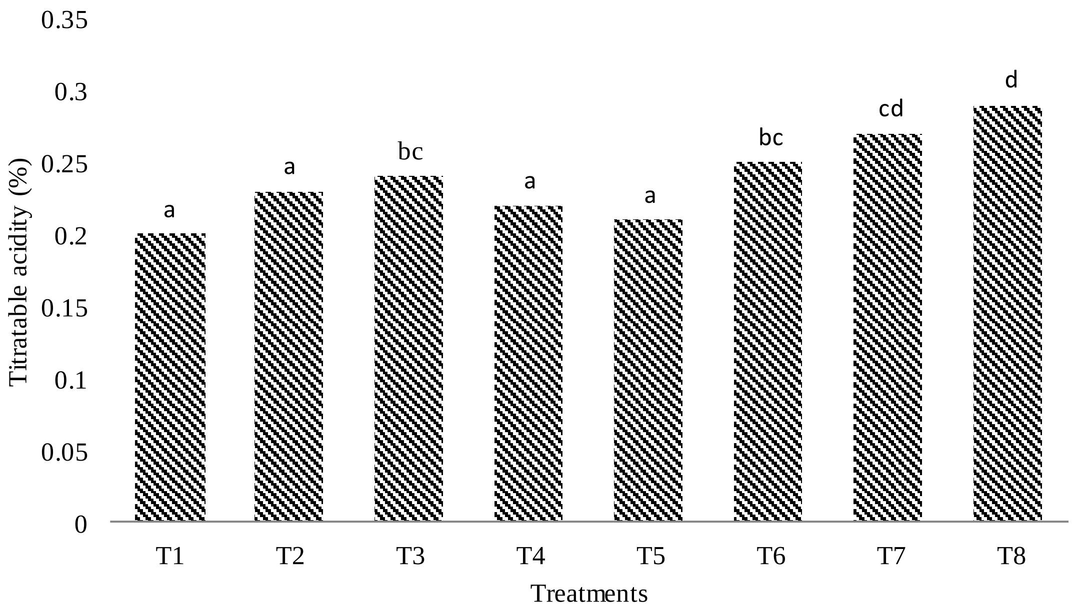

Fig. 6 Effect of bunch bagging and chitosan application on titratable acidity (%) in grape fruits

Reducing sugar (%)

Statistical analysis of reducing sugars showed significant differences and varied from 1.58 to 2.79% (Table 2). Maximum reducing sugar contents were recorded in Chinese bunch bagging treatment (2.79 %) followed by 0.5% chitosan treatment (2.67 %) whereas minimal value was estimated for control treatment (1.58 %). Total soluble solids compromised of reducing, non-reducing, total sugars and define the value and ripeness of fruit (Fig. 7). Grapes and berries are composed of various sugars like glucose, fructose, sucrose and their quantities and percentage varies with the development, growth, maturity thus determines the ripening of fruit (Abdelsattar et al., 2020). Rapid conversion of starches into sugars and then conversion of polysaccharides into water soluble sugars greatly declined the values of reducing sugars in grapes (Ali et al., 2021). Previous judgment also revealed that starch is hydrolyzed into various saccharides like fructose, glucose and sucrose during ripening and maturity (Roselli et al., 2020). These results are also in line with (Shah et al., 2019) who reported high reducing sugars in banana coated with chitosan as compared to uncoated fruits.

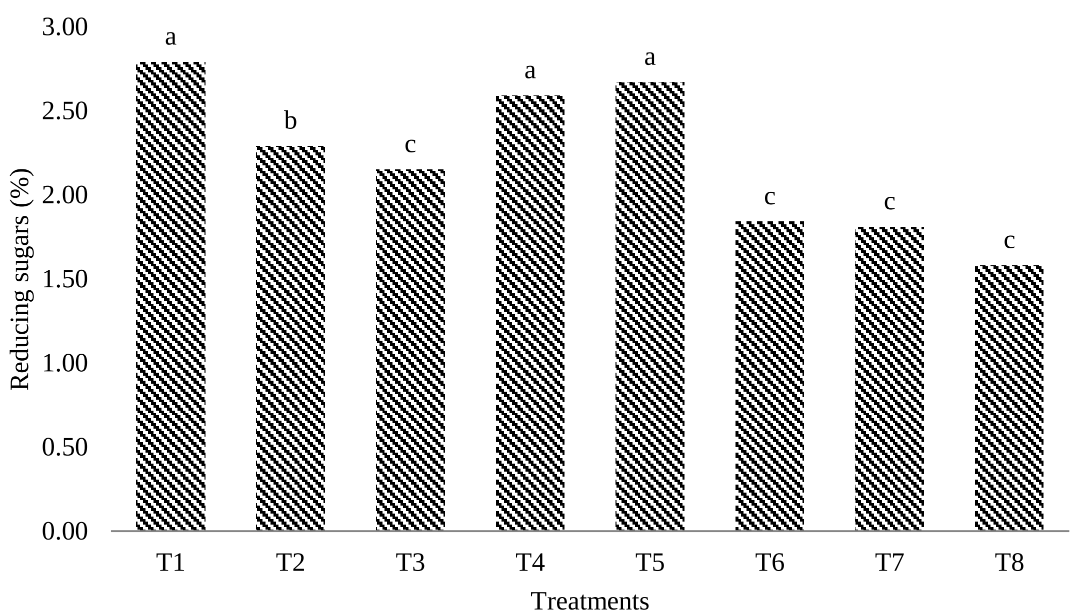

Fig. 7 Effect of bunch bagging and chitosan application on reducing sugars (%) in grape fruits

Non-reducing sugar (%)

For non-reducing sugars results existed in Table 2. Highly significant variations were observed for non-reducing sugars which ranged from 13.03 to 57.62 %. Maximum concentration of non-reducing sugars was observed in Chinese bunch bagging treatment (57.62 %) followed by 0.5% chitosan treatment (52.82 %). However, the minimum concentration of non- reducing sugars was noted in control treatment (13.03 %) (Fig. 8). As it is obvious that from development up to ripening and maturity of fruit, carbohydrates undergoes various metabolic processes and thus hydrolyzed to fructose, glucose and sucrose (Singh et al., 2020). Fruit flavor and taste can be improved if sufficient amount of availability of soluble solids, individual sugars, acidity, and organic acids are present in grapes (Bibi et al., 2021). The upsurge in reducing sugars and decline in non-reducing sugars might be due to conversion of polysaccharides into water soluble sugars (Singh et al., 2020).

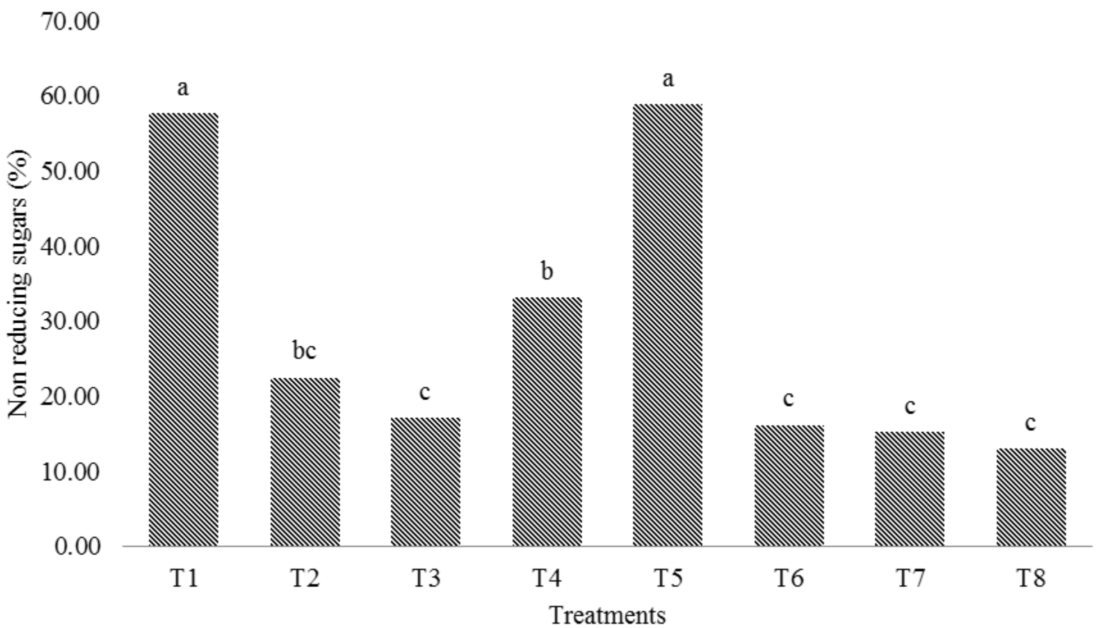

Fig. 8 Effect of bunch bagging and chitosan application on non-reducing sugars (%) in grape fruits

Total sugar (%)

Statistical analysis of total sugars exhibited significant divergence (Table 2). Mean total sugar ranged from 14.54 to 60.31%. Maximum total sugars was identified in Chinese bunch bagging treatment (60.3%) closely followed by 0.5% chitosan treatment while minimum total sugars was calculated in control treatment (14.54%) (Fig. 9). As the pH level, vitamin C content and level of total sugars and its components increases with growth and development of fruit. Thus total sugars depend on the increase or decrease of those various total soluble solvents. Earlier investigations revealed that total sugars data pattern indicated an increased trend with ripening and bagging grape fruit in various materials employed life taking effects on fruit biochemical composition (Zhou et al., 2020). Muwaffaq (2018) concluded from his results that the total sugars fluctuate substantially with the practice of contrary bagging. The grape fruit experience extensive variations in sugar content and fruit tissue firmness during ripening (Jemilakshmi et al., 2020). Likewise conclusions were drawn through maturing banana (Buthelezi et al., 2020) and Mango (Zhou et al., 2020). The pH level, Vitamin C content, the level of total sugar and its major components; glucose and fructose, increase with growth and development.

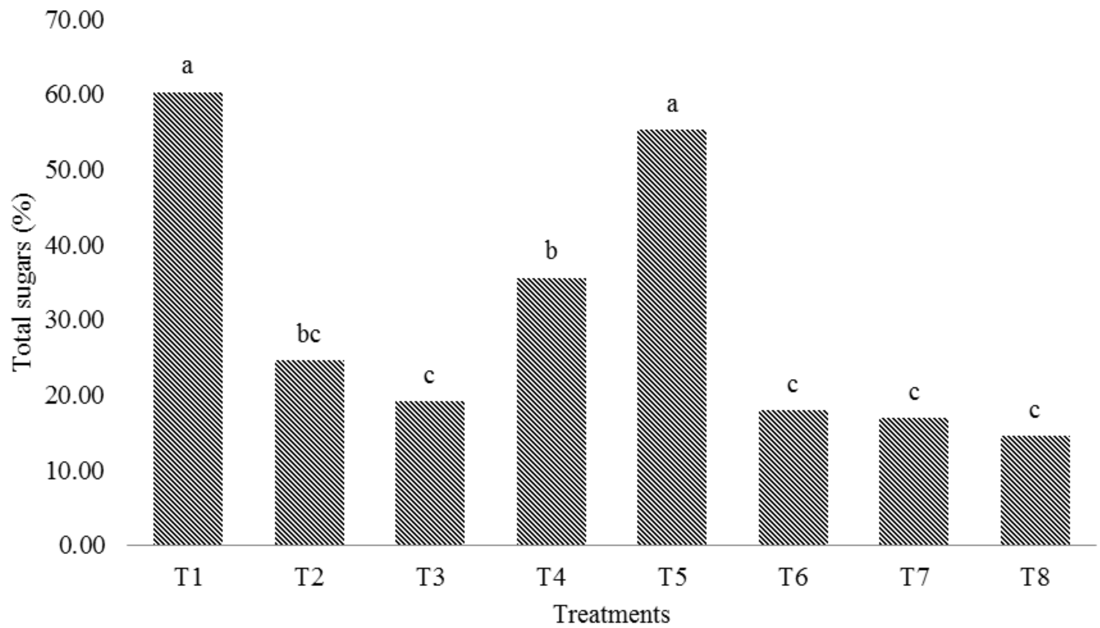

Fig. 9 Effect of bunch bagging and chitosan application on total sugar (%) in grape fruits

Conclusion

According to our present experimental work, it is concluded that the higher bunch weight (468.64 g) and total sugar contents (60.31%) were recorded from the Chinese bunch bagging treatment. However, the lower was observed from control treatment simultaneously. Similarly, the use of pre harvest bunch bagging material and application of chitosan based sprays improved the quality of grapes that helped to minimize the damage caused by biotic factors on grape yield.

Recommendation

Based on the conclusion, it is recommended that pre harvest bunch bagging especially Chinese bunch bagging produce higher grape fruit yield and yield components and enhanced the quality status of 'Perlette' grape fruits. There is a dire need of further research work to find out better treatment combination under different fruits under various ecological conditions of Pakistan to improve the fruits quality.

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[Received: 21 December 2020; Accepted: 18 May 2021]