Journal of Food Processing & Technology

Imlak et al., J Food Process Technol 2017, 8:1
DOI: 10.4172/2157-7110.1000648

Research Article OMICS International

Post-harvest Shelf Life Extension and Nutritional Profile of Thompson Seedless Table Grapes Under Calcium Chloride and Modified Atmospheric Storage

Imlak M*, Randhawa MA, Hassan A, Ahmad N and Nadeem M

Food Safety Laboratory, National Institute of Food Science and Technology, University of Agriculture, Faisalabad, Pakistan

Abstract

Grapes are the fruits with highest rate of phenolic substances among all other fruits and vegetables but due to its enhanced susceptibility to *Botrytis cinerea*, its postharvest losses are also very high. In a country like Pakistan that has lesser advancement in post-harvest technological skills, a significant segment of this delicate fruit is lost. This study was conducted with an aim to minimize these losses by retaining healthy and attractive nutritional profile. Freshly harvested grapes after being sorted and graded were divided in three lots, two lots were immersed in aqueous solutions of 1% and 2% calcium chloride followed by modified atmosphere storage at 5% CO_2 level, and third lot was control sample that was simply dipped in tap water at ambient conditions, 80% relative humidity and 10 ± 1°C temperature was kept same for all three lots. After being analyzed at harvest, stored grapes were then analyzed for total polyphenols, firmness, acidity, total sugars, total soluble solids and total viable count at 4th, 8th and 12th days of storage respectively. Overall results designated that grapes pretreated with 2% $CaCl_2$ stored at 5% CO_2 level retained maximum firmness, acidity and phenolic substances with minimum increase in soluble solid contents and significantly reduced incidence of browning caused by gray mold as compared to water washed control sample that was spoiled at the 8th day of storage. Grapes were stored for 12 days and the effect of storage days on differently pretreated samples was analyzed.

Keywords: $CaCl_2$; Modified atmosphere; Total phenolic compounds (TPC); Total viable count (TVC); Polypropylene perforated storage bags

Introduction

Grapes (*Vitis vinifera*) belong to the *Vitaceae* family and are amongst the largest cultivated global fruit crop due to their excessive use in winemaking and as table fruit [1] and are considered as highly perishable and delightful fruit with strong nutritional profile. Healthy berries contain fiber and folic acid that are helpful in lowering the bodyweight, blood cholesterol and chances of severe hypertension [2]. Berries contain polyphenols that are primarily confined to skin and involve anthocyanin and resveratrol that have documented biological activities as antiallergenic substances and minimizing the risks of atherosclerosis [3]. Food and Agriculture Organization of the United Nations reported that 75,866 km^2 of the world directly sanctified for grapes and practically one third of the global foodstuff manufactured for consumption is lost after being reaped [4]. In Pakistan, total grape production is 122,000 tons on an area of about 14,000 ha in 2008-09 that was recorded as the highest production of table grapes in the last nine successive years [5]. About 70% of the production of grapes in Pakistan is from Baluchistan Province with possible yield of almost 19 tons/ha only against the productive capacity of nearly 25 tons/ha, indicating poor infrastructure and postharvest technological skills [6].

Grapes experience many ripening changes during storage including biochemical and physical modifications in sugars, pH, acidity, total soluble solids, total polyphenols, and contents of vitamin C including minerals and different sensorial attributes. The ratio between sugars/acids is regarded to be the prime factor affecting taste and end quality of grapes and this ratio is highly exaggerated during prolonged storage [7]. Postharvest storage of fruits is highly susceptible to fungal infections such as *Botrytis, Aspergillus, Alternaria, Rhizopus* etc. that adversely affect the quality attributes of fruits [8]. Grey mold and stem browning caused by *Botrytis cinerea*, *is* a major biological hazard to horticultural produce as it can grow even below at -0.5°C and has the tendency to reproduce rapidly on berries skin [9]. To minimize the postharvest losses of grapes, several technologies have been introduced. The typical exercise is fumigation of the berries after being harvested with conventional sulfur dioxide gas (SO_2) but severe health issues of its residues specifically to the people that are allergic to sulfites have been reported [9]. Controlled and modified atmosphere strategies [10], use of various bio-control agents [11], different inorganic salt patterns [12], several nonchemical compounds [13] and natural antimicrobials [14] have been used as substitutes of SO_2.

Applications of calcium salts are a well experienced example to replace conservative fungicide sprays in controlling the postharvest antimicrobial decay of fruiting berries [15]. Calcium salt has been shown to play an eccentric part in upholding the cell wall of the fruit cells for its role as preservative and firming agent. Postharvest application of different salts pretreatments including calcium chloride [16], sodium carbonate and bicarbonates [17], calcium lactate [18] and various others are the promising salt treatments for maintaining the quality characteristics of fruits.

The positive impacts of calcium chloride have formerly been testified on wide ranges of horticultural produce including various fruits such as strawberries, grapes, mangoes, apples and different vegetables [19]. Akhtar et al. [20] illustrated that $CaCl_2$ treated loquats exhibited higher degree of firmness as compared to water washed control loquats. Yousefi et al. [16] reported that nutritional profile of $CaCl_2$ treated apricots such as Ca, Mg, N, and vitamin C were significantly higher than non-treated apricot fruits at termination of storage duration. Extended duration of fruits storage in modified atmosphere where

***Corresponding author:** Imlak M, Food Safety Laboratory, National Institute of Food Science and Technology, University of Agriculture, Faisalabad, Pakistan, Tel: +92-3066407635; E-mail: imlak.khalid@yahoo.com

Received December 14, 2016; **Accepted** January 04, 2017; **Published** January 10, 2017

Citation: Imlak M, Randhawa MA, Hassan A, Ahmad N, Nadeem M (2017) Post-harvest Shelf Life Extension and Nutritional Profile of Thompson Seedless Table Grapes Under Calcium Chloride and Modified Atmospheric Storage. J Food Process Technol 8: 648. doi: 10.4172/2157-7110.1000648

increased CO_2 level was used proved useful in postponing the softening of skin of many fruits [21]. Al-Quarshi and Awad [22] reported that table grape vines sprayed with 1% $CaCl_2$ and 10% ethanol solution effectively reduced the incidences of decay. Furthermore, -Ca salt didn't show any negative influence on the overall worth of the fruit. Microbial infestation caused by Botrytis is a major cause of spoilage in fruits specifically grapes due to its soft texture and high perishability. Chervin et al. [23] reported reduction in grey mold incidence when berries were treated with ethanol and 1% calcium chloride (CC) during modified atmosphere storage. This study was conducted with the aim to prolong the shelf life of white seedless table grapes to cause an increase in export and processing quality of the fruit.

Materials and Methods

Procurement of raw material

Freshly harvested Thompson seedless table grapes (*Vitis vinifera*) were procured from botanical garden, University of Agriculture, Faisalabad, Pakistan. The berries were then brought to Food Safety Laboratory of National Institute of Food Science and Technology, UAF for further processing and storage.

Post-harvest treatments

After sorting and grading, healthy clusters were divided in three equal lots. 1st lot was simply immersed in tap water and named as control sample (T_0), 2nd lot was dipped in 1% $CaCl_2$ (T_1) and the 3rd lot in 2% $CaCl_2$ solution (T_2).

This dipping pretreatment to all samples at ambient conditions was given for 5 minutes followed by packing in polypropylene perforated storage bags and stored at modified atmospheric chambers (ICH260 Memmert, Germany). In all three storage chambers, temperature and relative humidity were attuned at 10 ± 1°C and 80%, however the level of CO_2 for T_1 and T_2 inside the chambers was maintained at 5% and 0% for T_0 as shown in treatment plan (Table 1).

Total phenolic contents

Preparation of sample: Weighed amount (200 g) of samples were taken in glass bottles and the bottles were filled with methanol until a layer was formed above the sample. These samples were continuously shaken for 48 h with 3 h intervals at ambient temperature. After this, samples were filtered with filter paper and the extract obtained was concentrated to rotary evaporation for the removal of solvent from samples under vacuum. The distillation was stopped when the volume of the extract remains 1 mL. The solvent was further removed under purified gentle stream of N_2 gas. The sample was stored in freezer at -4°C till further analysis.

Determination of total polyphenols: The total phenolic compounds were estimated by Folin-Ciocalteu method by using an ultraviolet visible spectrophotometer (CECIL CE7200, UK) [24]. Extract mixture of 0.1 mL and 0.75 mL of Folin-Ciocalteu reagent that was previously diluted with deionized water was prepared in a test tube that was then allowed to stand at ambient conditions for 5 min. 0.75 mL of sodium carbonate 6% w/v was later added in the mixture. The absorbance of the samples was recorded from UV-Vis spectrophotometer at 275 nm. Gallic acid was run as a standard along with the samples and its standard curve was used for the calculation of the total phenolic contents in the samples.

Treatments	$CaCl_2$ conc. (%)	CO_2 level (%)
T_0	0	0
T_1	1	5
T_2	2	5

Table 1: Treatment plan.

Total sugars and TSS

The total sugar contents (glucose, fructose and sucrose) were determined in terms of g/100 g by following the procedure (Method No. 967.21) as described in AOAC [25] and total soluble solids (°Brix) were measured using digital hand Refractometer (Carl Zeiss Jena-Germany) after being calibrated against sucrose.

Titratable acidity (%)

TA of the fruiting berries was determined by titrating diluted sample against 0.1 N NaOH with phenolphthalein indicator according to method described by AOAC [25].

Firmness (N/mm)

Firmness of the berries was measured by using texture measuring system fitted with needle probe. Berries were randomly selected from each treatment and placed at the base of the texture analyzer (Mod. TA-XT2, Surrey, UK). The force (N) required to penetrate the fruit surface up to a specific depth (mm) was recorded and expressed in terms of N/mm [26].

Total viable count (log CFU/g)

Fruits of known weight from treatments were washed in sterile distilled water using a shaker, with fruit to distilled water ratio as 1:9. The wash water was then further diluted using peptone water, up to 105 and plated in triplicate on potato dextrose agar prepared as per manufacturer's instructions and incubated at 25°C for 24 hours to count the microbial colonies [27].

Statistical analysis

The data was scrutinized statistically to determine the level of significance [28]. Experiment was a completely randomized design with factorial arrangement. Difference and comparison between the means were evaluated by LSD multiple range test at 5% level of significance.

Results and Discussion

The effects of calcium chloride and modified atmosphere storage showed a significant effect in maintaining the nutritional profile and physicochemical attributes of the berries as depicted (Table 2).

Total phenolic compounds (TPC)

Results: Present study investigations revealed that polyphenols of the berries were continuously decreasing throughout the storage irrespective of the given treatments and storage conditions; however the rate of this fall was highly dependent upon the given treatments (Figure 1). Maximum loss in TPC was observed in control sample. At harvest, TPC were recorded as 159.14 ± 6 mg GAE/100 g that reached to 116.2 and 94.6 at 4th and 8th day of storage, moreover significant lost was recorded at 12th day when the recorded value for trait reached 58.1 in T_0. Likewise, in T_1, a gradual decrease in phenolic contents was recorded that reached 99.2 at storage termination. Minimum fall in polyphenol count was recorded in T_2 under which grapes were treated with 2% $CaCl_2$ and stored at 5% CO_2 where value from harvest of 159.14 reached 124.2 at 12th day of storage indicating best and statistically significant results as compared to T_0 and T_1. This concludes that treated grapes with 2% $CaCl_2$ could adopt a sturdier defense mechanism which T_0 failed to adopt.

Storage Days	Treatments	TSS (⁰ Brix)	Total Sugars (g/100 g)	Titratable Acidity TA (%)	Firmness (N/mm)	Polyphenols (mg of GAE 100g^{-1}	TVC (log CFU g^{1})
0	--	17.8 ± 0.9	14.12 ± 0.2	0.89 ± 0.03	2.74 ± 0.2	159.14 ± 6.0	2.73 ± 0.06
4	T_0	22.5 ± 1.3	16.56 ± 0.9	0.61 ± 0.08	2.12 ± 0.3	116.2 ± 5.1	3.2 ± 0.1
	T_1	19.0 ± 0.8	14.40 ± 0.2	0.83 ± 0.04	2.69 ± 0.2	138.3 ± 5.6	2.4 ± 0.1
	T_2	17.9 ± 1.0	14.21 ± 0.2	0.88 ± 0.07	2.73 ± 0.1	154.3 ± 9.1	2.3 ± 0.08
8	T_0	26.9 ± 2.0	19.10 ± 0.8	0.52 ± 0.04	1.5 ± 0.13	94.6 ± 4.8	3.9 ± 0.09
	T_1	19.9 ± 1.0	15.41 ± 0.3	0.80 ± 0.03	2.45 ± 0.1	119.7 ± 5.9	2.5 ± 0.07
	T_2	18.1 ± 1.0	14.50 ± 0.3	0.86 ± 0.05	2.7 ± 0.2	142.1 ± 6	2.4 ± 0.05
12	T_0	29.5 ± 2.9	20.40 ± 1.6	0.40 ± 0.04	0.7 ± 0.08	58.1 ± 4.9	4.95 ± 0.1
	T_1	23.6 ± 2.1	17.44 ± 0.2	0.68 ± 0.03	2.0 ± 0.09	99.2 ± 6.5	2.79 ± 0.2
	T_2	18.7 ± 0.5	14.59 ± 0.4	0.82 ± 0.08	2.66 ± 0.1	124.2 ± 5.5	2.6 ± 0.06

T_0= Water Washed (0% CO_2), T_1= 1% $CaCl_2$ (5% CO_2), T_2= 2% $CaCl_2$ (5% CO_2), Temperature (10 ± 1°C) and Relative Humidity (85%) was kept same in all. Given data are the mean values with 3 replications ± SD.

Table 2: Post-harvest quality attributes of Thompson seedless table grapes under different concentrations of $CaCl_2$ and modified atmosphere storage.

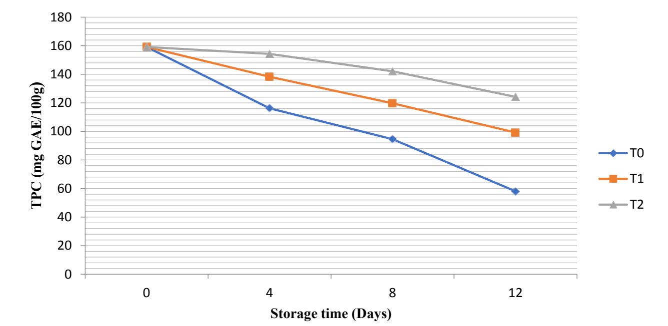

Figure 1: Total phenolic compounds.

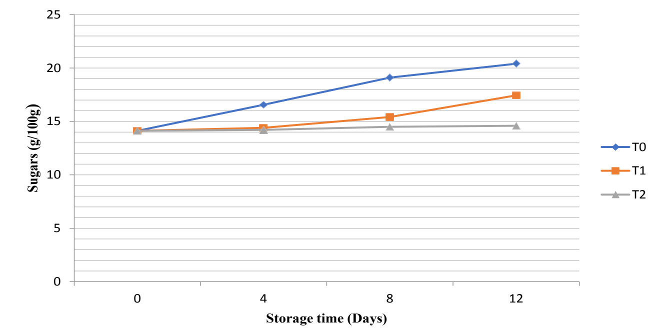

Figure 2: Showing total sugars.

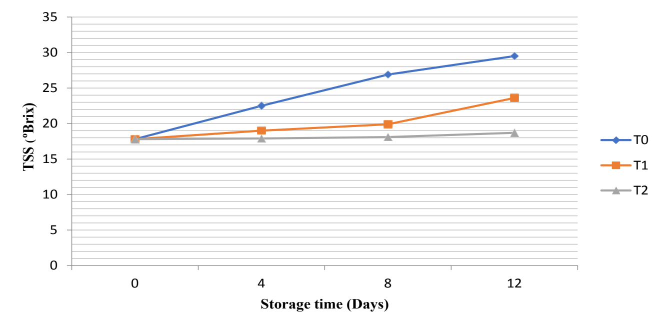

Figure 3: Graph for total soluble solids.

Discussion: Polyphenols are phytochemicals by nature and are present in highest amount in grapes than any other fruit; however, wine grapes have increased level of flavonoids, anthocyanin and phenolic contents as compared to table grapes [29]. This polyphenol composition also varies with berries skin color, cultivar, species, environmental and postharvest management skills [2]. Results of study in hand closely resemble with the investigations of Al-Quarshi and Awad [22] who reported that total polyphenols were significantly higher in $CaCl_2$ treated grapes as compared to control grapes and in promise with the fallouts of Pinheiro et al. [30] who explored total phenolic contents and anthocyanin in grape cultivars and illustrated that TPC of grapes were significantly decreasing with storage days irrespective of the given treatments.

Total sugars and total soluble solids (TSS)

Results: A gradual increase in total sugars composition and TSS was observed with progression in storage days. Amongst treatments, a similar behavior was shown by all treatments indicating a significant effect ($P<0.05$) of storage days on total sugars (Figure 2) and TSS (Figure 3), however this escalation was magnificently higher in T_0 as compared to $CaCl_2$ treated berries (T_1 and T_2).

Freshly procured grapes showed mean value of 14.1 g/100 g of total sugars at harvest that increased with storage period varying upon storage conditions and given treatments. Maximum increase in total sugars was observed in T_0 with mean values of 16.5, 19.1 and 20.4 at 4th, 8th and 12th day of storage respectively. Likewise, T_1 showed sugar contents of 14.1 at harvest to 17.44 at termination. Minimum nonconformity in total sugars was recorded in T_2 that had sugar contents of 14.59 at termination day indicating best positive results gained by 2% $CaCl_2$ given pretreatment followed by modified atmosphere storage at 5% CO_2 level.

Similarly, total soluble solids determined at harvest in fresh berries were 17.8 ± 0.9 °Brix with no noticeable changes in grapes stored at modified atmospheric conditions with 5% CO_2 level after being pretreated with $CaCl_2$ (1% and 2%). At the end of storage duration, TSS in $CaCl_2$ treated fruits were significantly lower and closer to the value at harvest. Contrary, a highly significant elevation in TSS level was found in T_0 where TSS were recorded as 22.5°, 26.9° and 29.5° at 4th, 8th and 12th days of storage respectively showing a greater degree of deviation in soluble solid contents. Likewise, T_1 also showed escalation in soluble solids reaching 19.0°, 19.9° and 23.6° during storage intervals. Minimum increase in total soluble solids was noticed in T_2 that stretched 17.8° to 18.7° from initiation to termination.

Discussion: A large percentage of the soluble solids in grapes are sugars, mainly glucose and fructose that are central sugars and are involved in cell respiration and synthesis and the third sugar is sucrose

Citation: Imlak M, Randhawa MA, Hassan A, Ahmad N, Nadeem M (2017) Post-harvest Shelf Life Extension and Nutritional Profile of Thompson Seedless Table Grapes Under Calcium Chloride and Modified Atmospheric Storage. J Food Process Technol 8: 648. doi: 10.4172/2157-7110.1000648

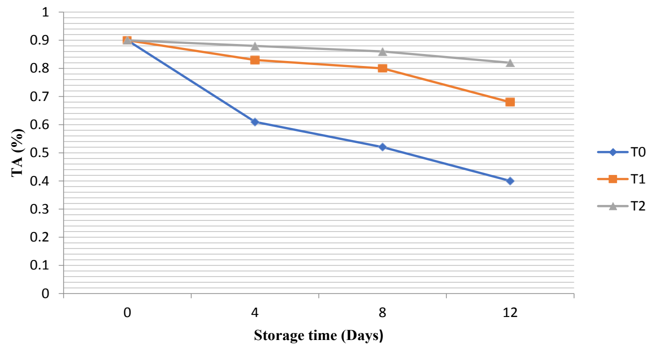

Figure 4: Showing graph for titratable acidity.

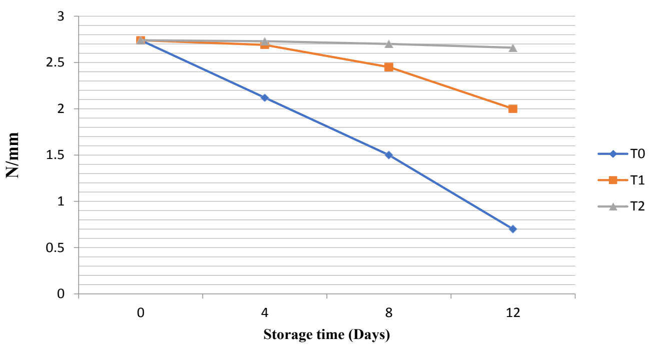

Figure 5: Showing firmness.

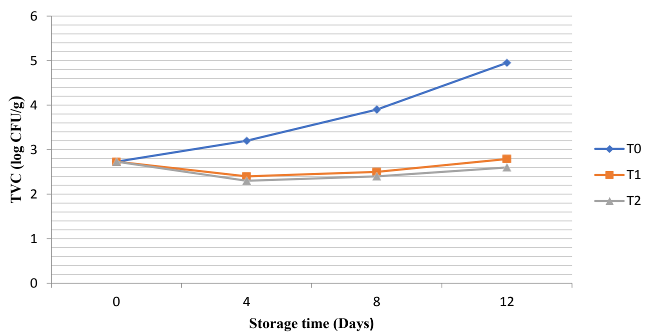

Figure 6: Total viable count.

that is non-reducing by nature and present relatively in smaller amounts with level not exceeding more than 1%. Prolonged storage resulted in greater deviation in sugar composition with reference to harvested value. This increment in soluble solids and sugars is attributed towards rapid conversion of complex starch molecules into simpler sugars [31]. Excess loss of water from the fruiting tissues may also be a valid reason behind this increment [18]. TSS of the fruits also increased during storage mainly due to glycogenesis and metabolism of fruiting tissues that becomes partially inactive due to changes in glucose and fructose. Findings of Samra [32] were in accordance with present study that SSC of fruiting berries were gradually increasing throughout the entire storage period irrespective of the given conditions and treatments.

Titratable acidity (TA)

Consumer preference of grapes relies on the peculiar taste that arises mainly from the organic acids present in the berries responsible for its titratable acidity (TA). The major organic acid present in table grapes is tartaric acid that declined in all samples with progression in storage days.

Results: Freshly procured grapes at harvest showed a TA value of 0.89% that decreased with prolonged storage varying upon storage conditions and given treatments (Figure 4). Maximum loss of organic acids was recorded in T_0 that developed off flavors at the end of the storage showing TA values of 0.61, 0.52 and 0.40 (%) at 4^{th}, 8^{th} and 12^{th} days of storage respectively. Relatively lower decrease in organic acids concentration was depicted by T_1 with TA of 0.89% at harvest to 0.68% at the end of storage period. Minimum loss in organic acids concentration from the given treatments specifically tartaric acid was observed in T_2 that depicted best results from TA of 0.89% at harvest to 0.82% at termination.

Discussion: Sugars/acids ratio is considered to be the main feature affecting taste of the berries and this ratio is highly affected during stretched storage periods [7]. In present investigation, TA of the berries was continuously decreasing throughout storage and this gradual decrease in acid level was physiologically attributed towards increase in membrane permeability of the fruit allowing the acids to respire in cell vacuoles resulting in transformation of acids into sugars [16]. These outcomes bear a resemblance with Sabir et al. [33] who exposed that TA levels in berries under modified atmosphere, apparently decreased. Randhawa et al. [34] also reported similar results with decreased level of acidity in citrus (non-climacteric) as storage duration was prolonged.

Firmness

Results: 2.74 ± 0.2 N/mm was the force required to the probe of texture analyzer to puncture the skin of the berries at harvest that gradually dropped in all treatments as storage period prolonged. However, $CaCl_2$ treated grapes stored in modified atmospheric chambers (T_1 and T_2) showed higher degree of firmness as compared to control sample (T_0) as shown (Figure 5). Higher degree of firmness was recorded in T_2 with mean values of 2.73, 2.70 and 2.66 followed by T_1 with 2.69, 2.45 and 2.0 (N/mm) at 4^{th}, 8^{th} and 12^{th} days of storage respectively. Maximum deterioration and minimal degree of firmness was depicted by T_0 where force required to the probe of texture analyzer at 12^{th} day of storage was only 0.7 N/mm indicating maximum quality degradation.

Discussion: Findings of present study are absolutely in accordance with that of Akhtar et al. [20] who treated loquats (non-climacteric) and Yousefi et al. [16] who treated apricots (climacteric) with different concentrations of $CaCl_2$ and reported that significantly higher degree of firmness was recorded in $CaCl_2$ treated fruits than untreated ones at the end of storage phase. Cell wall degrading enzymes (β-Glactocidase, Poly-Glacturonase and Pectinemethyl Esterase) may also be a reason for softening of fruit texture as mentioned by Pinzón-Gómez et al. [35].

Total viable count (TVC)

Results: TVC recorded at harvest was 2.73 ± 0.06 log CFU/g that significantly increased in T_0 while reduced microbial load was observed in $CaCl_2$ treated grapes stored at modified atmospheric chamber (T_1 and T_2) when storage phase terminated, as shown (Figure 6). Control grapes (T_0) had maximum yeast and mold count of 4.95 (log CFU/g) at 12^{th} day of storage indicating severe mold growth caused by *Botrytis cinerea* turning the berries brown in color. No signs of browning were recorded in T_1 and T_2, however, higher the concentration of $CaCl_2$, lower the mold growth was observed. T_1 (1% $CaCl_2$) had microbial load of 2.79 at 12^{th} day of storage that increased non-significantly from harvested value of 2.73. Likewise, in T_2 (2% $CaCl_2$), microbial load of

2.6 was recorded at termination that actually decreased from the values at harvest.

Discussion: Among all pathogens of different horticultural produce, *Botrytis cinerea* responsible for gray mold is amongst the list of world's top 10 most threatening fungal pathogenic microorganisms [36].

Increased CO_2 level has been proven to have antimicrobial and fungistatic effects that was the major reason behind lower microbial load in treated berries. Results of this study are in resemblance with the investigations of Romanazzi et al. [4] who reported that mere increased level of CO_2 limited the decay incidence but statistically highly significant results were observed when modified atmospheric conditions were provided. Findings of Nigro et al. [17] also endorses the current study status of minimal microbial load in grapes under calcium chloride dipping prior to storage.

Conclusion

Overall consequences of this study designate that modified atmospheric storage conditions (5% CO_2 level, 80% relative humidity and 10 ± 1°C temperatures) in combination with 2% $CaCl_2$ pre-storage dipping, successfully escalated the shelf life of grapes up to 12 days' storage by preserving attractive nutritional and safety profile. Inexpensive $CaCl_2$ salt that is readily available and acceptable due to its non-toxic nature as compared to conventional fungicide sprays, efficiently minimized the incidence of pathogens on berries by retaining maximum firmness and freshness and modified atmosphere storage successfully delayed the postharvest ripening with mean values of quality attributes much closer to the ones at harvest as compared to tap water washed control sample.

Acknowledgement

The authors thank supervisors, National Institute of Food Science and Technology and Director General, NIFSAT for their help and encouragement during the course of work and preparation of this manuscript.

References

1. Fraige K, Pereira-Filho ER, Carrilh E (2014) Fingerprinting of anthocyanin from grapes produced in Brazil using HPLC-DAD-MS and exploratory analysis by principal component analysis. Food Chem 145: 395-403.
2. Yang J, Martinson TE, Liu RH (2009) Phytochemical profiles and antioxidant activities of wine grapes. Food Chem 116: 332-339.
3. Deedwania P, Singh V, Davidson MH (2009) Low and high-density lipoprotein cholesterol and increased cardiovascular disease risk: An analysis of statin clinical trials. Ameri J Cardiol 104: 3-9.
4. Romanazzi G, Smilanick JL, Feliziani E, Droby S (2016) Integrated management of post-harvest gray mold on fruit crops. Posthar Biol Technol 113: 69-76.
5. GOP (2010) Agriculture statistics of Pakistan. Ministry of Food, Agriculture and Livestock, Islamabad, Pakistan.
6. Khan AS, Ahmad N, Malik AU, Saleem BA, Rajwana IA (2011) Phenophysiological revelation of grapes germplasm grown in Faisalabad, Pakistan. Int J Agricul Biol 13: 391-395.
7. Sen F, Oksar R, Kesgin M (2016) Effects of shading and covering on 'Sultana Seedless' grape quality and storability. J Agricul Sci Technol 18: 245-254.
8. Pedreschi R, Lurie S, Hertog M, Nicolai B, Mes J, et al. (2013) Post-harvest proteomics and food security. Proteomics 13: 1772-1783.
9. Liu Q, Xi Z, Gao J, Meng Y, Lin S, et al. (2016) Effects of exogenous 24-epibrassinolide to control grey mold and maintain post-harvest quality of table grapes. Int J Food Sci Technol 51: 1236-1243.
10. Lichter A (2016) Rachis browning in table grapes. Austral J Grape Wine Resear.
11. Wang Y, Xu Z, Zhu P, Liu Y, Zhang Z, et al. (2010) Post-harvest biological control of melon pathogens using Bacillus subtilis EXWB1. J Plant Pathol.
12. Youssef K, Roberto SR (2014) Salt strategies to control Botrytis mold of '*Benitaka*' table grapes and to maintain fruit quality during storage. Posthar Biol Technol 95: 95-102.
13. Ippolito A, Sanzani SM (2011) Control of post-harvest decay by the integration of pre and post-harvest application of nonchemical compounds. Acta Horticul 905: 135-143.
14. Aloui H, Khwaldia K, Licciardello F, Mazzaglia A, Muratore G, et al. (2014) Efficacy of the combined application of chitosan and Locust Bean Gum with different citrus essential oils to control post-harvest spoilage caused by *Aspergillus flavus* in dates. Int J Food Microbiol 170: 21-28.
15. Romanazzi G, Lichter A, Mlikota GF, Smilanick JL (2012) Natural and safe alternatives to conventional methods to control post-harvest gray mold of table grapes. Posthar Biol Technol 63: 141-147.
16. Yousefi S, Amiri ME, Mirabdulbaghi M (2015) Biochemical properties and fruit quality of '*Jahangiri*' apricot fruit under calcium chloride treatment. Int J Agron Resear 48: 81-94.
17. Nigro F, Schena L, Ligorio A, Pentimone I, Ippolito A, et al. (2006) Control of table grape storage rots by preharvest applications of salts. Posthar Biol Technol 42: 142-149.
18. Javed MS, Randhawa MA, Butt MS, Nawaz H (2015) Effect of calcium lactate and modified atmosphere storage on biochemical characteristics of guava fruit. J Food Process Preserv.
19. Chepngeno J, Owino WO, Kinyuru J, Nenguwo N (2016) Effect of $CaCl_2$ and hydro-cooling on post-harvest quality of selected vegetables. J Food Resear 5: 23.
20. Akhtar A, Abbas NA, Hussain A (2010) Effect of calcium chloride treatments on quality characteristics of loquat fruit during storage. Pak J Bot 42: 181-188.
21. Gustavo HA, Juniorb LC, Antonio SF, Jose FD (2016) Quality of guava fruit stored in low O_2 controlled atmospheres is negatively affected by increasing levels of CO_2. Posthar Biol Technol 111: 62-68.
22. Al-Qurashi AD, Awad MA (2015) Effect of pre-harvest calcium chloride and ethanol spray on quality of ' *El-Bayadi*' table grapes during storage. Vitis J Grapevine Resear 52: 61.
23. Chervin C, Lavigne D, Westercamp P (2009) Reduction of gray mold development in table grapes by preharvest sprays with ethanol and calcium chloride. Posthar Biol Technol 54: 115-117.
24. Marinova D, Ribarova F, Atanassova MA (2005) Total phenolics and total flavonoids in Bulgarian fruits and vegetables. J Uni Chem Tech Metallur 40: 255-260.
25. AOAC (2006) Official methods of analysis. The Association Off Analyt Chem (18th edn.), Gaithersburg, Maryland, USA.
26. Tian SP, Jiang AL, Xu Y, Wang YS (2004) Responses of physiology and quality of sweet cherry fruit to different atmospheres in storage. Food Chem 87: 43-49.
27. Badosa E, Trias R, Pares D, Pla M, Montesinos E (2008) Microbiological quality of fresh fruit and vegetable products in Catalonia using normalized plate-counting methods and real time polymerase chain reaction. J Food Sci Agricul 88: 605-611.
28. Montgomery DC (2008) Design and analysis of experiments. John Wiley & Sons, USA.
29. Nile SH, Kim S, Ko EY, Park SW (2013) Polyphenolic contents and antioxidant properties of different grape cultivars. BioMed Resear Int.
30. Pinheiro ES, Costa JMC, Clemente E (2009) Total phenolics and total anthocyanin found in grape from Benitaka Cultivar (*Vitis vinifera* L.). J Food Technol 7: 78-83.
31. Gallo V, Mastrorilli P, Cafagna I, Nitti GI, Latronico M, et al. (2014) Effects of agronomical practices on chemical composition of table grapes evaluated by NMR spectroscopy. J Food Composit Analys 35: 44-52.
32. Samra BN (2015) Impact of post-harvest salicylic acid and jasmonic acid treatments on quality of "*Crimson seedless*" grapes during cold storage and shelf life. Int J 3: 483-490.
33. Sabir FK, Sabir A, Kara Z (2010) Effects of modified atmosphere packaging and ethanol treatments on quality of minimally processed table grapes during cold storage. Bulgarian J Agricul Sci 16: 678-686.

34. Randhawa MA, Rashid A, Saeed M, Javed MS, Khan AA, et al. (2014) Characterization of organic acids in juices of some Pakistani citrus species and their retention during refrigerated storage. J Anim Plant Sci 24: 211-215.

35. Pinzón-Gómez LP, Deaquiz YA, Álvarez-Herrera JG (2014) Post-harvest behavior of tamarillo treated with $CaCl_2$ under different storage temperatures. Agron Colomb 32: 238-245.

36. Dean R, Van Kan JA, Pretorius ZA, Hammond-Kosack KA, Di Pietro, et al. (2012) The top 10 fungal pathogens in molecular plant pathology. Molecul Plant Pathol 13: 414-430.