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LONG TERM STORAGE QUALITY OF SUPERIOR GRAPE AS INFLUENCED BY PRE-HARVEST APPLICATION

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Abstract

Influence of pre-harvest application of "Superior" grape of AMINOQUELANT- CA at 0.05, micro elements mixture (0.05% Zinc chelated+0 .05%Boric acid +0.05% Manganese sulphate), Antioxidant (100ppm benzoic acid +50ppm vitamin B complex +250ppm Ascorbic acid + 500ppm Citric acid) as compared with Control vines (sprayed with water). All treatments were done four times at the beginning of vegetable growth, at the beginning of flowering, after fruit set, after month of fruit set. The Sprayed fruits were stored up to 6weeks at 0 °C and 90–95% R H and fruit quality was evaluated at harvest, during cold storage. Results showed that weight loss, total soluble solids, total sugars content and respiration rate increased whereas, firmness, total acidity, vitamin c decreased by increasing storage periods. All treatments increased fruit weight and yield at harvest, during storage periods decreased decay, weight loss and delayed the changes in firmness, Shatter, berry adherence, total acidity, total soluble solids, vitamin C, total sugars, and respiration rate compared with control. The best results of market life obtained by pre-harvest treatments. The study suggests that these treatments might be a promising candidate as maintain Superior grape quality and also to get a product safe and healthy, especially during cold storage.
***Keywords*:** grape, pre-harvest sprays, calcium, amino acids, ascorbic acid, citric acid, vitamin B, quality, cold storage

Introduction

Grape (*Vitis vinifera* L.) is one of the most important commercial fruit crops of temperate to tropical regions (Gowda *et al*., 2008). The first use of grapes by man is probably as fresh fruit, but it is consumption as juice and dry raisin. So, attention to improve product quality and increased seems to be necessary. Quality of table grapes is usually considered as a combination of appearance (average size of clusters as uniformly large, size berry, perfect berries (without shot berry) with the characteristic color and texture of the variety) (Kamiloglu, 2011), flavor characteristics, sugar concentration, Acidity (Jonathan, 2012). Increasing quality of grape is dependent on different practices (Kamiloglu, 2011).

In Egypt, grape is considered the second most important fruit crop after citrus. The planted area reached 289,752 feddan in 2017 producing 1849914 tons (Ministry of Agriculture statistics).

Superior grape is considered one of the most important table grapes varieties in Egypt and characterized by its earliest crop, and has bunches light to medium weight, long to medium length, shouldered loose to semi compact and cylindrical, winged shape. Moreover Superior seedless table grape has very good quality attributes, good price because it could be harvested earlier than the majority varieties, and it very important for exporting to the Arabian and European markets. So nowadays it receives greet interest for increasing its productivity and quality.

For the enhancement of their post-harvest life along with quality, it is necessary to use pre harvest treatments of different agrochemicals that may led to relate fruit physiology to ripening and senescence, maintain grapes with high quality for longer time in markets or after storage for a certain period.

Amino acids as organic nitrogenous compounds are the building blocks in the synthesis of proteins in plants and regulates the plant metabolism (Davies, 1982). Amino acids can directly or indirectly influence the physiological activities in plant growth and development. Moreover, the exogenous application of amino acids have been reported to modulate the growth, improve fruit weight, yield and fruit quality (Fayek *et al*., 2011) of Le Conte pear, (Khan *et al*., 2012) of Perlette, Red Globe grapes, (Abd El-Razek and Saleh, 2012) of 'Florida Prince' peach. Also, (Ahmed *et al*., 2014) of El-Saidy date palm. Application of Fulvic amino acid on Thompson seedless grape, which enhancing yield per vine, cluster weight, berry weight, soluble solids content and total phenols while reducing total acidity, cluster weight loss%, berry shatter % and berry decay% and total loss in cluster weight percentages during storage and shelf life period. Also, enhanced berry adherence strength as compared with control (El-Kenawy, 2017).

Calcium salts used to increase Ca content of the cell wall fruits. Pre harvest calcium application have been effective in controlling of several physiological disorders in various fruits like peaches, nectarines and apples (Dunn and Able, 2006) reduced the incidence of fungal pathogens and maintaining fruit firmness, reduced the respiration rate at harvest stage, delaying senescence ,ripening and resulting in higher quality fruit (Raese and Drake, 2006).Calcium significantly improved maintenance of fruit quality as Ahmed *et al*. (2017) showed that pre-harvest application with 2% calcium was most effective in minimizing weight loss (%) and decay (%), as well as in maintaining maximum firmness and lengthening shelf life of 'Early Swelling' peach during cold storage. Results of El-Wahab *et al*. (2014) on crimson grapes and Bijayanka (2018) on strawberry indicated that, preharvest treatment of calcium spray showed minimum loss in physiological weight, maximum total soluble solid, reducing sugar and total sugar and retain texture with less acidity during cold storage.

Foliar application of amino calcium delayed and decreased decay of apple fruit during storage and retained firmness (Salehi *et al*., 2013; Sahar, 2015 and Arabloo *et al.,* 2017)

Pre-harvest spray Red Roomy grapevines three times with Micro elements such as boric acid at 0.1%, magnesium sulphate at 0.5% and chelated zinc at 0.05%increased cluster weight and dimension as well as fruit weight and total sugars%. (Abd el- Gaber, 2009) Also, (Abd-Elmegeed *et al*., 2015) reported that spray Saccon substance (9% N + 25%P + 0.3%Fe + 0.3%Mn + 0.3% Zn + 0.1% Cu + 0.005% Mo) at 3 cm/L2 weeks before harvest for improving skin color and storability of "Anna" apple fruits as well as maintaining fruit quality. Pre-harvest spray of benzoic acid used to inhibit the decay and supply a long protection to grapefruit during storage and handling processes (Abdel-Kader *et al*., 2011). Application Sodium benzoate spray gave better values of TSS, sugars, ascorbic acid and acidity than untreated fruits (Suman *et al*., 2017).

Zinc could be regulated the enzymatic activities, and would have activated the enzymes involved in the conservation of polysaccharide into simple sugars that increase the TSS of fruits (Sachin *et al.,* 2017).

Magnesium could be considered as key elements of fertilizers with regard to delay of ripening, increase firmness and prolong shelf-life with increasing Mg concentration as high Ca: Mg ratio (20:1) in the nutrient solution decreases pH, titratable acidity, total soluble solids of tomato fruits (Musah, 2015).

Antioxidants such as Ascorbic acid and citric acid have auxinic action and also synergistic effect on flowering and fruiting of fruit vines of most fruit vines, recently antioxidants used instead of auxins and other chemicals for enhancing growth and fruiting of various fruit vines (Ragab, 2002). In addition, the positive action of antioxidants in catching or chelating the free radicals which could result in extending the shelf life of plant cells and stimulating growth aspects is reported (Rao *et al*., 2000). Previous studies showed that using antioxidants in different fruit crops was very effective in improving growth ,yield and fruit quality of fruit crops vines (Maksoud *et al*., 2009) of olive, (Fayed, 2010) of pomegranate, (Ibrahim *et al*., 2013) of Zaghloul Date Palms and (Fayek *et al*., 2014) of Le Conte pear. Also, Hafez *et al*. (2010) reported that antioxidants such as ascorbic acid, citric acid decreased the decay, weight loss and fruit softening during cold storage and marketing period of Le Conte pear. Also, using vitamins B is might be responsible for improving the tolerance of plants to stresses, photosynthesis, cell division and pigments (Samiullah, 1988). The results of Ibrahim,2012; Abdelaal *et al.*

(2013, 2014) and El-Khawaga (2014) emphasized the positive effects of using vitamins B on growth and fruiting of grapevines.

The present study was carried out as a trial to improve fruit quality and storability to prolong marketing season of Superior grape cultivar via pre-harvest treatments besides studying physical and chemical characteristics changes during storage. Thus, these treatments will open a new window for Egyptians to successful exportation of this cultivar.

Materials and Methods

Fruit Material

Nine-years old of Superior grapevines (*Vitis vinifera* L.) were used as the plant material for this study. The present investigation was carried out during the two successive seasons 2017 and 2018 in private vineyard located at Pico Company, Behera governorate, Egypt. Plants devoted for this work were healthy, carefully selected as being representative of the chosen cultivar and as uniform as possible in vigor and shape. All selected vines were grown in sandy soil, planted at 2 x 3 meters apart and irrigated by the drip irrigation system, gable system, grown in sandy soil and received regularly the same horticultural care adopted in this orchard. The vines were cane-pruned system (Y-shape). The vines were pruned during the last week of December for the three seasons of the study so as to (7 canes per vine) and seven renewals spur (2buds/spur) per vine. Sixty vines were selected in a completely randomized design and divided into four groups. Each group was replicated three times and each replicate was represented by five vines. Spraying was conducted on the vegetative growth and clusters .Triton B as a wetting agent was added to all spraying solutions at 0.05%. Spraying was continued till run off (2 L/vine). All treatments were sprayed four times at the beginning of vegetable growth, at the beginning of flowering, just after berry setting and at one month later.

Pre harvest Treatments Were:

1. Control (sprayed with water)
2. Micro elements (0.05% Zinc chelated +0.05%Boric acid +0.05% Manganese sulphate)
3. Anti-Oxidant mixture(100ppm benzoic acid +50ppm vitamin B complete+250ppm Ascorbic acid + 500ppm Citric acid
4. AMINOQUELANT- CA at 0.05% (as a commercial name, liquid formula containing collection of free amino acids and calcium).

The clusters were harvested at maturity stage on 5 June in both seasons when attained total soluble solids percentage (TSS) in berry juice higher than or equal to 14% according to Ramming and Tarailo (1995). Grapes were transported to the laboratory without signs of mechanical damage and deterioration were selected and standardized in clusters showing homogeneous size, color and form, then randomly distributed into 4 groups. Cluster were taken from each replicate of each treatment at the harvest date for determining average Cluster Weight(g) and Yield (kg)/vine) and fruit quality (physical and chemical characteristics of berries for each treatment was estimated in both seasons.

Storage fruits

Treated clusters were rapidly carefully were placed in four performed cartoon boxes (30×40×20 cm) for each treatment, as box to determine decay, the second to determine weight loss and the third for determine fruit quality parameters every 1 week during 6 weeks period at different sampling time i.e. 0 day at harvest, 7, 14, 21, 28, 35 and 42 days of cold storage, each box contained of (2 kg) was replicated three times, and the experiment was repeated twice (2016 and 2017 seasons). Boxes were subjected randomly to one of the following treatments and stored at 0ºC and 90% RH for 6weeks in laboratory of refrigeration Agriculture Development Systems (ADS) project in the Faculty of Agriculture, Cairo University.

Fruit Quality Assessments

Decay percentage: Fruit showed any sign of decay or visual disorders were weighted. The percentage of decay berries were calculated on the bases of total fruit weight, using the following formula

$$\text{Decay \%} = \frac{\text{Dedecayed berries (g.)}}{\text{Ini initial weight (g.)}} \times 100$$

Weight loss percentage: The difference between the initial weight of the clusters and that recorded at the date of sampling was translated as weight loss percentage according to the following equation

$$\text{Weight loss\%} = \frac{\text{Weight loss in (g.)}}{\text{Th initial weight of the clusters at the beginning of storage (g.)}} \times 100$$

Berry firmness was determined by using Shatilon's instrument for measuring firmness for grape, average of all berry firmness was recorded as (g/cm^2)

Adherence strength (g): Berry adherence force measured by using scale and force meter Shatilon's instrument.

Shattering percentage:

This value was determined as follows.

$$\text{Shattering \%} = \frac{\text{Weight of shattered berries (g.)}}{\text{Initial weight of the clusters (g.)}} \times 100$$

Total soluble solids (TSS) % of the berries was determined using a digital refractometer (Model PR-32, Atago, Japan) by squeezing the juice.

Total acidity (TA) % was determined by titration with a standard solution of sodium hydroxide (0.1N), using phenolphthalein as an indicator (A.O.A.C., 2005). The results were expressed as percentages of anhydrous tartaric acid according to the following equation.

$$\text{Total acidity} = \frac{\text{M1 of NaOH x 0.0075}}{\text{M1 juice used}} \times 100$$

Respiration rate: Individual small clusters for each treatment were weighed and placed in 2-liter jars at 20°C. The jars were sealed for 3 h with a cap and a rubber septum. The resulting O_2 and CO_2 samples of the headspace were removed from the septum with a syringe and injected into Servomex Inst. Model 1450C (Food Pack Gas Analyzer) to measure oxygen and carbon dioxide production. Respiration rate was calculated as ml CO_2/kg fruits/hr. (Lurie and Pesis, 1992). Initial reading was scored under room temperature) then every week till the end of cold storage (6 weeks).

Statistical Analysis: The obtained data were subjected to analysis of variance. Means were compared using the L.S.D. values at 5% levels. The data were tabulated and statistically factorial analyses according to Snedecor and Cochran (1980).

Results and Discussion

Effect of pre-harvest treatments on fruit quality parameters

Cluster Weight and Yield:

Data in Table (1) show that the use of per harvest application played a significant influence on increasing Cluster Weight and Yield (Kg) per vine. Moreover, The highest significant values of Cluster Weight and Yield were recorded in "Superior" grape vines sprayed with AMINOQUELANT- CA, Antioxidant (benzoic acid + vitamin B complete+ Ascorbic acid + Citric acid and micro elements mixture (Zinc chelated +Boric acid +Manganese sulphate), compared with the control as it gave the lowest values of Cluster Weight and Yield in both seasons. From economical point of view treating Superior grapevines with all treatments gave the best results with regard to yield. Under such promised treatment, yield per vine reached (14.28 and 15.2kg) in AMINOQUELANT- CA, micro ((13.2 &13.8) in elements mixture, (11.4 & 11.9) in Antioxidant while in the untreated vines reached(8.4 and 9.0 kg) per vine during both seasons, respectively. The promoting effect of amino acids on increase in fruit weight and yield of superior grapevines might be attributed to their positive action on protecting plants from oxidative stress, enhancing the biosynthesis of proteins through polymerization of amino acids, ethylene, GA3, IAA, cyokinins, plant pigments, and organic foods (Davies, 1982) Meanwhile amino acid - calcium led to significant increase in fruit weight and yield of "Superior" grape. The positive effect of antioxidants as (Benzoic acid 100 ppm + Vitamin B 50 ppm + Ascorbic acid 250 ppm + Citric acid 500 ppm ascorbic acid +citric acid) was participate in fruit development through their positive action on enhancing the biosynthesis of natural hormones, nutrient uptake, photosynthesis and biosynthesis of sugars (Rao *et al*., 2000). Previous studies showed that using Ca (ELWahab *et al*., 2014) on crimson grape, using amino acids (Khan *et al*., 2012) on Red Globe grapes, (Belal, 2016) on flame grape. Using antioxidants (Mohamed, 2014) on Thompson Seedless Grapevines, using micro elements (Abd El-Gaber, 2009) on red roomy grapevines as they were very effective in improving growth and promoting yield quantitatively and qualitatively yield.

Decay

Data in Table (2 & 3) show that the all pre harvest treatments reduced decay in all storage periods as AMINOQUELANT- CA 0.05% (Amino acids + Calcium) was the best treatment followed by mixture of Antioxidants (Benzoic acid 100 ppm + Vitamin B 50 ppm + Ascorbic acid 250 ppm + Citric acid 500 ppm) then mixture of micro nutrients (Zinc 0.05% + Boric acid 0.05% + Magnesium sulphate 0.5%)in descending order as compared with control treatment under study. Moreover, the percentage of decayed fruits increased gradually with prolonging storage period as previously recorded by (El-Wahab *et al*., 2014) As for the effect of interaction between the tested pre harvest treatments and storage periods, i.e. 7, 14, 21 up to 42 days the control treatment had higher decay percentage at 42 days storage but AMINOQUELANT- CA had the loof apple west decay percentage in both seasons. These results show that addition calcium to amino acids gave better effect in reducing decay. Superior grape fruits treated had the best storability that may be due to Ca induced high fruit resistance for fungi prevented physiological disorders during storage (Dunn and Able, 2006) while antioxidants and micro nutrients lowered decay rate may be related with higher levels of antioxidant enzymes during storage leading to improved storability " Superior " grape. The present results go in parallel to calcium salts decrease decay of grape fruit under cold storage (El-Wahab *et al*., 2014) and of peach (Ahmed *et al*., 2017). Applied amino acid- calcium reduced fruit deterioration, increasing storability apricot (Sahar, 2015). Also, antioxidants decrease decay during cold storage of le conte pear (Hafez *et al*., 2010) and (Sahar, 2015) of apricot. Applied micro elements (Abd-Elmegeed *et al*., 2015) decrease decay during cold storage of apple and this led to improve storability of " Superior " grape fruits.

Weight loss

Data in Table (4&5) show that there were a significant difference between treatments and control in terms of their effects on weight loss. The highest values of weight loss were obtained in "Superior" grape control fruits. These results hold true in the two seasons, the lowest weight loss percentage was recorded in sprayed fruits with pre harvest treatments as AMINOQUELANT- CA (amino-calcium) followed by Antioxidant (benzoic acid + vitamin B complete+ Ascorbic acid + Citric acid and then in descending order. Meanwhile, loss in fruit weight increased significantly as storage period advanced and the highest loss of weight was obtained at the end of storage. Similar results were also reported by (EL-Wahab *et al*., 2014). The interaction between pre harvest treatments and storage periods, referred that the lowest values for weight loss at different storage period i.e., 1, 2, 3, 4, 5 and 6 weeks of storage were significant in pre harvest application specially in AMINOQUELANT- CA maintaining more fruit weight until ending stage of storage. The decrease in weight loss may due to respiration and transpiration (Wolucka *et al*., 2005). Calcium plays a role in reducing the respiration (Raese and Drake, 2006) and amino acid – calcium with cold storage reduced transpiration in fruits and thus led to minimize the impact of weight loss of grape fruits and this led to improve storability of grape fruits. Similar results have been reported by (El-Wahab *et al*., 2014) on calcium of Crimson grape and of peach (Ahmed *et al*., 2017). in decreasing weight loss during cold storage. Also, amino acid-calcium or antioxidants reduced weight loss during cold storage and increasing storability of fruits (Sahar, 2015) Applied micro elements (Abd-Elmegeed *et al.*, 2015) decreased weight loss during cold storage of apple.

Fruit firmness

As shown in Table (6 & 7) all pre harvest treatments resulted significantly highest firmness whereas the highest fruit softening rate was recorded in control treatment. During all storage period, it is cleared that as AMINOQUELANT- CA followed by Antioxidant (benzoic acid + vitamin B complete + Ascorbic acid + Citric acid and then micro elements mixture (Zinc chelated + Boric acid + Manganese sulphate), treatments retained maximum fruit firmness as compared with control in both seasons of study. Fruit firmness decreased gradually and significantly with the progress of cold storage in both seasons, a result supported the finding of (El-Wahab *et al*., 2014). The most firm was found in treated fruits that could be due to the addition of calcium to amino acid treatment that could be responsible for the higher pulp firmness observed at harvest and also at the end of storage compared to control. A significant role has been proposed for calcium in conferring mechanical strength on the cell wall, as a result of its binding to pectin to form calcium pectate, which increases the rigidity of the middle lamella of the cell wall (Conway *et al*., 1997). The potential role calcium in increasing firmness of fruit was by the cohesion of cell-walls (Kazemi *et al*., 2011)and thus it contribute to the linkages between pectin substances within the cell-wall (Arhtar *et al*., 2010). Also role of pre harvest treatments as inhibition of the action of wall-degrading enzymes, this led to increasing hardness at harvest till 42 days of cold storage which enhanced fruit handling and storability. While the control vines (without receiving pre harvest treatment) had the softest fruits. In response to fruit firmness, it is clear that firmness showed a trend of decrease with the extending of storage period. Control fruits presented the lowest significant values, while fruits from vines treated with pre harvest treatments produced the highest positive effect on firmness at both seasons. The incensement in fruit firmness during cold storage was stated by El-Wahab *et al*. (2014) and (Ahmed *et al*., 2017). on Calcium and Sahar (2015) on amino acids - calcium or antioxidants and Applied micro elements (Abd-Elmegeed *et al.*, 2015) increased firmness during cold storage of apple and so pre harvest treatments led to improve storability of " Superior " grape fruits.

Adherence Strength: Berry adherence of superior grape cv. during cold storage at 0 °C and 90 - 95% RH decreased towards the end of storage period (El-Wahab *et al*., 2014). Tables (7&8).Furthermore, AMINOQUELANT- CA (amino acids +Ca) treatment gave the highest significant berry adherence followed by Antioxidant(benzoic acid + vitamin B complete+ Ascorbic acid + Citric acid treatment and finally micro elements mixture (Zinc chelated +Boric acid +Manganese sulphate)treatment as compared with the control in both seasons. Coercing the interaction, the highest berry adherence at different periods of sampling during the storage was recorded as a result of AMINOQUELANT- CA treatment compared with control treatment during both seasons of study. These results are agreement with Sahar (2015) on amino acids- calcium and antioxidants as their gave the highest berry adherence during cold storage.

Shattering percentage: Regarding the effect of pre harvest treatments on shattering character, data in table (9 & 10) It is clearly that that the average values increased as the storage period increased reaching its highest values at the end of storage (El-Wahab *et al*., 2014), the lowest values were recorded as result of all pre harvest treatments AMINOQUELANT- CA, Antioxidant(benzoic acid + vitamin B complete + Ascorbic acid + Citric acid and micro elements mixture (Zinc chelated + Boric acid +Manganese sulphate), compared with control treatment. Such results were true during both season of study. In addition, AMINOQUELANT- CA reflected the lowest values in this respect with regard to the effect of the interaction, during the different periods of storage in two seasons of study. These results are parallel with Sahar (2015)on amino acids- calcium and antioxidants (ascorbic acid +citric acid) as their gave the highest berry adherence during cold storage.

Total Soluble Solids:

Results in Table (11 & 12) show that increased levels of TSS were recorded in fruit of vines treated with AMINOQUELANT- CA, micro elements mixture (Zinc chelated + Boric acid +Manganese sulphate), Antioxidant (benzoic acid + vitamin B complete+ Ascorbic acid + Citric acid at harvest day in both seasons. It is obvious that TSS increased with extending of the storage period reaching the maximum values at the end of storage period (42 days) as previously detected by EL-Wahab *et al*. (2014). These results might be due to loss of dry matter through respiration and metabolic activity and the loss of moisture from fruit through transpiration. During storage and at the end of cold storage, all treatments showed increases in content of total soluble solids, although the increases were significantly lower in fruits treated with pre harvest treatments of AMINOQUELANT- CA, mixture Antioxidant and micro elements than in control treatment. As for the interaction, holding Superior grape fruits in cold storage for a period of 6 weeks resulted in a significant low increasing in T.S.S specially pre harvest treatments of AMINOQUELANT- CA followed by Antioxidant and then micro elements mixture in descending order in both seasons. Moreover, fruits of pre harvest treatments showed the lowest increase in T.S.S values than control. The lowest increase in the TSS during cold storage by pre harvest treated fruits was probably due to pre harvest treatments may had slowed down respiration and metabolic activity, hence retarded the senescence and lowered contents of TSS during cold storage and this led to improve storability of " Superior " grape fruits. Applied amino acids –calcium or antioxidants can be reduced fruit soluble solids concentration of (Sahar, 2015)

Total acidity

Table (13 & 14) show that fruit acidity was significantly decreased as the storage period extended till the end of storage period 6 weeks. (EL-Wahab *et al*., 2014) on grape detected a decrease in acidity of fruits during storage. Pre harvest treatments especially AMINOQUELANT- CA, followed by Antioxidant(benzoic acid + vitamin B complete+ Ascorbic acid + Citric acid and then micro elements mixture (Zinc chelated +Boric acid +Manganese sulphate) delayed the decrease in concentrations of total acidity during cold storage. Moreover, control treatment gave the lowest value of acidity in both seasons. As for the combined effect of storage period and pre harvest treatments on total acidity, AMINOQUELANT- CA, Antioxidant and micro elements and mixture treatments were more effective in delayed the decreasing titratable acidity during 2017 and 2018 seasons. The decrease of total acidity during storage was faster in control fruits compared to treated fruits which indicated more use of organic acids and high respiration rate of untreated fruit. In the present study it seems that decrease of total acidity during cold storage and indicated that use of organic acids in respiratory process (Ishaq *et al.,* 2009). Pre harvest treatments delayed the decrease of acidity during cold storage that may be due to additional calcium reduce respiration (Raese and Drake, 2006) which led to delay in metabolic changes of organic acids (Pila *et al*., 2010) and maintain titratable acidity of fruits and this led to improve storability of "Superior" grape fruits. Similar results shown by (Sahar, 2015) with amino acids – calcium or Anti-Oxidant and (El-Wahab *et al*., 2014 & Bijayanka (2018) with calcium and micro elements (Abd-Elmegeed *et al.*, 2015).

Vitamin C

Results presented in Table 15 and 16 indicated that the maximum values of Vitamin C content was observed at harvest or during storage in Antioxidant (benzoic acid + vitamin B complete+ Ascorbic acid + Citric acid) treatment, followed by AMINOQUELANT- CA(amino acids + Ca) and micro elements mixture (Zinc chelated +Boric acid +Manganese sulphate) in descending order while the lowest value of vitamin C was recorded by control treatment in both seasons. Means for weekly intervals show that fruit vitamin C content was gradually decreased and significantly with the progress of storage and reached the lowest significant level at the end of storage period compared with fruits at harvest. Also, (El-Wahab *et al*., 2014) on grape fruits obtained similar results. Fruits of the antioxidants (benzoic acid + vitamin B complete+ Ascorbic acid + Citric acid) still had the highest value of ascorbic acid while that control had the least content. This study has demonstrated that the pre harvest treatments especially Antioxidant treatment, delayed the loss of ascorbic acid at the end of stored grape. This may be due to increase in fruit content of antioxidants may give it a defense against oxidative stress thus keeping its vitamin C and calcium reduce physiological disorders which causing oxidation of ascorbic acid and led to maintain quality and improve post harvest life of Superior grape. These results are in agreement with those obtained by, (El-Wahab *et al*., 2014) reported that calcium minimized the disorders and maintained the loss of ascorbic acid of Crimson grape. Mix of ascorbic acid and citric acid increased vit. C and Amino acid delayed the decline of ascorbic acid content of apricot fruit (Sahar, 2015).

Total sugars

The effect of different pre harvest treatments on total soluble sugars content of stored Superior grape fruits are presented in Table (17 & 18). It clearly showed that total soluble sugars increased gradually and significantly with extending of storage period as previously detected by El-Wahab *et al*. (2014). However, control treatment resulted in higher and faster increase in total soluble sugars during cold storage than that occurred in fruits treated with pre harvest treatments at the two seasons of this study. The increase in sugars content of fruits could be due to ripening process that led to the transformation of some carbohydrates components as starch to sugars by the enzymatic activities (Karemera and Habimana, 2014). In this respect AMINOQUELANT- CA followed by Antioxidant(benzoic acid + vitamin B completete+ Ascorbic acid + Citric acid and then micro elements mixture (Zinc chelated +Boric acid +Manganese sulphate) treatments in descending order gave the lowest values of total sugars as compared with the control treatment for both investigate seasons .Moreover, the effect of interaction revealed that at the end of storage period (6weeks), fruits were of the pre harvest treatment AMINOQUELANT- CA showed the lowest values of total sugars than untreated fruits in the first and second seasons. Concerning the total soluble sugars of fruits, it is evident that all pre harvest treatments decline increases in total soluble sugars, whereas, the control gave the highest content of total sugars in both seasons. The pre harvest treatments maintained on total sugars from rapid increasing during cold storage may be related with slow respiration with Ca and high levels of antioxidant enzymes and defense mechanisms from high ripening during storage, so leading to improve storability of superior grape. The obtained results are in agreement with calcium (El-Wahab *et al*., 2014 & Bijayanka (2018) and amino acids – calcium or anti-oxidant applications (Sahar, 2015) as she maintained on total sugars during cold storage.

Total phenols

Results illustrated in table (19 & 20) showed that there was significant decrease in total phenols content as the storage period prolonged. Similar result was obtained by El-Wahab *et al*. (2014) on Crimson grape cultivar as the total phenols levels at the initial of the storage period were higher than the end ones just for the all treatments .Moreover, the present data reveal that the highest values of total phenols were recorded for Superior grape treated with pre harvest treatments AMINOQUELANT- CA followed by Antioxidant(benzoic acid + vitamin B complete+ Ascorbic acid + Citric acid and then micro elements mixture (Zinc chelated +Boric acid +Manganese sulphate) in descending order compared with untreated Superior grape fruits which had the lowest significant means of total phenols at the end of storage period in both seasons of study .Concerning the effect of the interaction between the tested pre harvest treatments and storage period, the lowest values for total phenols was rapidly decreased in control compared with treated fruits . During storage, decrease level of total phenols might be due to breakdown of cell structure at senescence stage (Ghasemnezhad *et al*., 2010). It was assumed that the effect of AMINOQUELANT- CA, Antioxidant(benzoic acid + vitamin B compelete+ Ascorbic acid + Citric acid and micro elements mixture (Zinc chelated +Boric acid +Manganese sulphate), treatments on maintain of total phenol content can be attributed to delay in senescence process .Phenol compounds are responsible for the flavor and color of fruits (Jeong *et al*., 2008) and act as antioxidants(Robarts *et al*., 1999). Polyphenol oxidase (PPO) activity is responsible for the browning of tissues fruits through oxidation of phenolic compounds (Zhang and Zhang, 2008). It is evident that all pre harvest treatments gave the lowest decrease in total phenols with the advancing of market life compared with the control fruits .The maximum retention in phenolic compounds can be inferred by the reduced respiration ,softening and acidity loss with adding calcium to pre harvest treatments. Also calcium maintained a reduced PPO activity during storage of Crimson grape fruits (Ali *et al*., 2013). Furthermore, pre harvest treatments specially amino acids –Calcium or Anti oxidant or micro elements mixture treatments decreased losses total phenols that may be due to delay oxidation of phenol substances through Polyphenol oxidase (PPO) activity and this led to improve storability of Superior grapes. These results are in harmony with those obtained by (El-Wahab *et al*., 2014) and (Sahar, 2015) as they increased total phenol content during cold storage.

Respiration Rate

It can be seen from (Tables 21 & 22) that there was a noticeable increased initial respiration rate values in treated and untreated "Superior" fruits at harvest day due to the acquisition of the fruits of the temperature field. Meanwhile values of rate of respiration decreased in the first week of storage due to lower temperature of cold storage at0°C during the two seasons of investigation. At the end of storage time, all pre harvest treatments AMINOQUELANT- CA and Antioxidant(benzoic acid + vitamin B complete + Ascorbic acid + Citric acid and micro elements mixture (Zinc chelated +Boric acid +Manganese sulphate) tended to have the effective role in reducing the rate of respiration of Superior grapes. Meanwhile, control fruits had the highest respiration rate specially on 6 weeks. Interaction data show significant reduced respiration rate by AMINOQUELANT- CA, mixture Antioxidant and micro elements treatments at different storage periods. Reduced respiration retards softening and slows down various compositions. Similar results have also been reported by other researchers that calcium plays a role in reducing the respiration during cold storage (Raese and Drake, 2006) and (El-Wahab *et al*., 2014) and that amino acids or antioxidants (Sahar, 2015) as reduced respiration rates during cold storage which result in reducing senescence rate after harvest so, this led to improve storability of "Superior" grape fruits.

Conclusion

The results presented in this study indicated that treated pre- harvest "Superior" grape with AMINOQUELANT- CA (amino - Calcium), Antioxidant(benzoic acid + vitamin B complete+ Ascorbic acid + Citric acid and micro elements mixture (Zinc chelated +Boric acid +Manganese sulphate), were the most effective in increasing yield and controlling post-harvest decay and maintain on compositional changes by delaying physical and chemical changes, slowing down respiration rate during cold storage and extending post-harvest life. Pre-harvest treatments are safe and simple and suggested being a good recommendation for keeping fruit quality as well as extending market life and "Superior" grape fruits intended for long distance shipping for export.

Table 1: Effect of pre-harvest treatments on Cluster Weight and Total yield of Superior grape fruits during two seasons.

Treatments (T)	2017 season		2018 season	
	Cluster Weight (g)	Total yield (kg)	Cluster Weight (g)	Total yield (kg)
Control	1.7	8.4	1.9	9.0
Micro nutrients (Zinc 0.05% + Boric acid 0.05% + Magnesium sulphate 0.5%)	2.12	11.4	2.18	11.9
Antioxidants (Benzoic acid 100 ppm + Vitamin B 50 ppm + Ascorbic acid 50 ppm + Citric acid 500 ppm)	2.38	13.2	2.44	13.8
AMINOQUELANT- CA 0.05% (Amino acids + Calcium)	2.45	14.28	2.60	15.2
Mean	**2.16**	**11.82**	**2.28**	**12.48**
L.S.D at 5%	0.06	0.084	0.09	0.092

Table 2: Effect of preharvest treatments on Decay % of Superior grape fruits during 6 weeks storage at (0^0 C – 90 RH %) in 2017 season.

Treatment	Storage period (weeks)							Mean
	0	1	2	3	4	5	6	
Control	0.00	3.83	6.73	13.43	18.13	19.33	21.53	13.83
Micro nutrients (Zinc 0.05% + Boric acid 0.05% + Magnesium sulphate 0.5%)	0.00	0.93	1.80	2.73	3.53	4.90	5.65	3.26
Antioxidants (Benzoic acid 100 ppm + Vitamin B 50 ppm + Ascorbic acid 50 ppm + Citric acid 500 ppm)	0.00	0.53	1.13	2.20	3.23	4.60	5.43	2.85
AMINOQUELANT- CA 0.05% (Amino acids + Calcium)	0.00	0.20	0.33	1.10	1.60	2.08	2.23	1.26
Mean	0.00	1.37	2.50	4.87	6.62	7.73	8.71	

LSD value at 0.05:
Treatments (T): 0.17 Storage periods (P): 0.16 Interactions (TxP): 0.46

Table 3: Effect of preharvest treatments on Decay % of Superior grape fruits during 6 weeks storage at (0 ^{0}C – 90 RH %) in 2018 season

Treatment	Storage period (weeks)							Mean
	0	1	2	3	4	5	6	
Control	0.00	3.71	6.92	10.52	16.80	17.90	22.30	**13.03**
Micro nutrients (Zinc 0.05% + Boric acid 0.05% + Magnesium sulphate 0.5%)	0.00	0.81	1.22	1.82	2.20	2.70	3.70	**2.08**
Antioxidants (Benzoic acid 100 ppm + Vitamin B 50 ppm + Ascorbic acid 50 ppm + Citric acid 500 ppm)	0.00	0.81	1.02	1.82	2.10	2.60	3.40	**1.96**
AMINOQUELANT- CA 0.05% (Amino acids + Calcium)	0.00	0.31	0.52	1.22	1.60	1.80	2.00	**1.24**
Mean	**0.00**	**1.41**	**2.42**	**3.85**	**5.68**	**6.25**	**7.85**	

LSD value at 0.05:
Treatments (T): 0.05 Storage periods (P): 0.04 Interactions (TxP): 0.12

Table 4: Effect of preharvest treatments on Weight loss % of Superior grape fruits during 6 weeks storage at (0^0 C – 90 RH %) in 2017 season.

Treatment	Storage period (weeks)							Mean
	0	1	2	3	4	5	6	
Control	0.00	1.98	2.87	3.95	4.84	6.21	10.25	5.02
Micro nutrients (Zinc 0.05% + Boric acid 0.05% + Magnesium sulphate 0.5%)	0.00	1.35	2.55	2.93	3.95	5.80	7.33	3.99
Antioxidants (Benzoic acid 100 ppm + Vitamin B 50 ppm + Ascorbic acid 50 ppm + Citric acid 500 ppm)	0.00	0.20	0.85	1.55	2.10	2.53	2.88	1.69
AMINOQUELANT- CA 0.05% (Amino acids + Calcium)	0.00	0.13	0.23	1.10	1.53	2.00	2.40	1.23
Mean	0.00	0.92	1.63	2.38	3.11	4.14	5.72	

LSD value at 0.05:
Treatments (T): 0.17 Storage periods (P): 0.15 Interactions (TxP): 0.4

Table 5: Effect of preharvest treatments on Weight loss % of Superior grape fruits during 6 weeks storage at (0^0 C – 90 RH %) in 2018 season.

Treatment	Storage period (weeks)							Mean
	0	1	2	3	4	5	6	
Control	0.00	1.92	2.78	3.83	4.69	6.02	9.94	4.87
Micro nutrients (Zinc 0.05% + Boric acid 0.05% + Magnesium sulphate 0.5%)	0.00	1.31	2.47	2.84	3.83	5.63	7.11	3.87
Antioxidants (Benzoic acid 100 ppm + Vitamin B 50 ppm + Ascorbic acid 50 ppm + Citric acid 500 ppm)	0.00	0.19	0.82	1.50	2.04	2.45	2.79	1.63
AMINOQUELANT- CA 0.05% (Amino acids + Calcium)	0.00	0.13	0.22	1.07	1.48	1.94	2.33	1.19
Mean	0.00	0.89	1.58	2.31	3.01	4.01	5.54	

LSD value at 0.05:
Treatments (T): 0.07 Storage periods (P): 0.06 Interactions (TxP): 0.18

Table 6 : Effect of preharvest treatments on Firmness (g/cm^2) of Superior grape fruits during 6 weeks storage at (0^0 C – 90 RH %) in 2017 season.

Treatment	Storage period (weeks)							Mean
	0	1	2	3	4	5	6	
Control	540	530	500	485	455	400	375	469.29
Micro nutrients (Zinc 0.05% + Boric acid 0.05% + Magnesium sulphate 0.5%)	560	555	525	490	440	400	390	480.00
Antioxidants (Benzoic acid 100 ppm + Vitamin B 50 ppm + Ascorbic acid 50 ppm + Citric acid 500 ppm)	590	575	550	520	495	455	415	514.29
AMINOQUELANT- CA 0.05% (Amino acids + Calcium)	630	600	585	565	530	500	490	557.14
Mean	580.00	565.00	540.00	515.00	480.00	438.75	417.50	

LSD value at 0.05:
Treatments (T): 0.25 Storage periods (P): 0.24 Interactions (TxP): 0.68

Table 7 : **Effect of preharvest treatments on Firmness (g/cm^2 of Superior grape fruits during 6 weeks storage at (0^0 C – 90 RH %) in 2018 season.**

Treatment	Storage period (weeks)							Mean
	0	1	2	3	4	5	6	
Control	595	585	550	535	500	440	410	516.43
Micro nutrients (Zinc 0.05% + Boric acid 0.05% + Magnesium sulphate 0.5%)	615	610	575	540	485	440	430	527.86
Antioxidants (Benzoic acid 100 ppm + Vitamin B 50 ppm + Ascorbic acid 50 ppm + Citric acid 500 ppm)	650	630	605	570	545	500	455	565.00
AMINOQUELANT- CA 0.05% (Amino acids + Calcium)	690	660	645	620	580	550	540	612.14
Mean	637.50	621.25	593.75	566.25	527.50	482.50	458.75	

LSD value at 0.05:
Treatments (T): 0.34 Storage periods (P): 0.31 Interactions (TxP): 0.89

Table 8: Effect of preharvest treatments on Adherence Strength (g) (g/cm^2) of Superior grape fruits during 6 weeks storage at (0^0 C – 90 RH %) in 2017 season.

Treatment	Storage period (weeks)							Mean
	0	1	2	3	4	5	6	
Control	590	575	540	520	490	430	400	506.43
Micro nutrients (Zinc 0.05% + Boric acid 0.05% + Magnesium sulphate 0.5%)	600	595	565	530	475	430	420	516.43
Antioxidants (Benzoic acid 100 ppm + Vitamin B 50 ppm + Ascorbic acid 50 ppm + Citric acid 500 ppm)	640	620	595	560	535	490	445	555.00
AMINOQUELANT- CA 0.05% (Amino acids + Calcium)	675	645	630	605	570	540	530	599.29
Mean	626.25	608.75	582.50	553.75	517.50	472.50	448.75	

LSD value at 0.05:
Treatments (T): 0.35 Storage periods (P): 0.33 Interactions (TxP): 0.92

Table 9 : Effect of preharvest treatments on Adherence Strength (g) (g/cm^2) of Superior grape fruits during 6 weeks storage at (0^0 C – 90 RH %) in 2018 season.

Treatment	Storage period (weeks)							Mean
	0	1	2	3	4	5	6	
Control	600	585	550	530	500	440	410	516.43
Micro nutrients (Zinc 0.05% + Boric acid 0.05% + Magnesium sulphate 0.5%)	610	605	575	540	485	440	430	526.43
Antioxidants (Benzoic acid 100 ppm + Vitamin B 50 ppm + Ascorbic acid 50 ppm + Citric acid 500 ppm)	650	635	605	570	545	500	455	565.71
AMINOQUELANT- CA 0.05% (Amino acids + Calcium)	690	655	640	615	580	550	540	610.00
Mean	637.50	620.00	592.50	563.75	527.50	482.50	458.75	

LSD value at 0.05:
Treatments (T): 0.35 Storage periods (P): 0.33 Interactions (TxP): 0.92

Table 10: Effect of preharvest treatments on Shattering % of Superior grape fruits during 6 weeks storage at (0^0 C – 90 RH %) in 2017 season.

Treatment	Storage period (weeks)							Mean
	0	1	2	3	4	5	6	
Control	0.00	2.70	3.99	5.85	7.96	9.89	11.75	7.02
Micro nutrients (Zinc 0.05% + Boric acid 0.05% + Magnesium sulphate 0.5%)	0.00	1.17	1.99	2.85	3.33	3.75	4.54	2.94
Antioxidants (Benzoic acid 100 ppm + Vitamin B 50 ppm + Ascorbic acid 50 ppm + Citric acid 500 ppm)	0.00	1.27	1.79	2.09	3.01	3.51	4.10	2.63
AMINOQUELANT- CA 0.05% (Amino acids + Calcium)	0.00	00.65	0.79	1.19	1.71	2.11	2.41	1.48
Mean	0.00	1.45	2.14	3.00	4.00	4.82	5.70	

LSD value at 0.05:
Treatments (T): 0.44 Storage periods (P): 0.41 Interactions (TxP): 1.16

Table 11 : Effect of preharvest treatments on Shattering % of Superior grape fruits during 6 weeks storage at (0^0 C – 90 RH %) in 2018 season.

Treatment	Storage period (weeks)							Mean
	0	1	2	3	4	5	6	
Control	0.00	2.81	4.15	6.08	8.28	10.29	12.22	**7.30**
Micro nutrients (Zinc 0.05% + Boric acid 0.05% + Magnesium sulphate 0.5%)	0.00	1.22	2.07	2.96	3.46	3.90	4.72	**3.06**
Antioxidants (Benzoic acid 100 ppm + Vitamin B 50 ppm + Ascorbic acid 50 ppm + Citric acid 500 ppm)	0.00	1.32	1.86	2.17	3.13	3.65	4.26	**2.73**
AMINOQUELANT- CA 0.05% (Amino acids + Calcium)	0.00	0.68	0.82	1.24	1.78	2.19	2.51	**1.54**
Mean	**0.00**	**1.51**	**2.23**	**3.11**	**4.16**	**5.01**	**5.93**	

LSD value at 0.05:
Treatments (T): 0.09 Storage periods (P): 0.08 Interactions (TxP): 0.23

Table 12 : Effect of preharvest treatments on T.S.S % of Superior grape fruits during 6 weeks storage at (0^0 C – 90 RH %) in 2017 season.

Treatment	Storage period (weeks)							Mean
	0	1	2	3	4	5	6	
Control	13.85	16.54	19.84	22.54	25.36	28.41	31.86	22.63
Micro nutrients (Zinc 0.05% + Boric acid 0.05% + Magnesium sulphate 0.5%)	14.25	16.51	18.25	20.34	22.14	24.14	26.31	20.28
Antioxidants (Benzoic acid 100 ppm + Vitamin B 50 ppm + Ascorbic acid 50 ppm + Citric acid 500 ppm)	15.95	16.21	17.84	18.65	19.54	20.57	21.84	18.66
AMINOQUELANT- CA 0.05% (Amino acids + Calcium)	16.8	16.97	17.54	17.95	18.23	18.87	19.2	17.94
Mean	15.21	16.56	18.37	19.87	21.32	23.00	24.80	

LSD value at 0.05:
Treatments (T): 0.07 Storage periods (P): 0.06 Interactions (TxP): 0.17

Table 13: Effect of preharvest treatments on T.S.S % of Superior grape fruits during 6 weeks storage at (0^0 C – 90 RH %) in 2018 season.

Treatment	Storage period (weeks)							Mean
	0	1	2	3	4	5	6	
Control	14.13	16.87	20.24	22.99	25.87	28.98	32.50	23.08
Micro nutrients (Zinc 0.05% + Boric acid 0.05% + Magnesium sulphate 0.5%)	14.54	16.84	18.62	20.75	22.58	24.62	26.84	20.68
Antioxidants (Benzoic acid 100 ppm + Vitamin B 50 ppm + Ascorbic acid 50 ppm + Citric acid 500 ppm)	16.27	16.53	18.20	19.02	19.93	20.98	22.28	19.03
AMINOQUELANT- CA 0.05% (Amino acids + Calcium)	17.14	17.31	17.89	18.31	18.59	19.25	19.58	18.30
Mean	15.52	16.89	18.73	20.27	21.74	23.46	25.30	

LSD value at 0.05:
Treatments (T): 0.63 Storage periods (P): 0.59 Interactions (TxP): 1.68

Table 14 : Effect of preharvest treatments on Acidity % of Superior grape fruits during 6 weeks storage at (0^0 C – 90 RH %) in 2017 season.

Treatment	Storage period (weeks)							Mean
	0	1	2	3	4	5	6	
Control	0.8	0.68	0.62	0.61	0.57	0.48	0.45	0.60
Micro nutrients (Zinc 0.05% + Boric acid 0.05% + Magnesium sulphate 0.5%)	0.72	0.7	0.68	0.61	0.58	0.55	0.5	0.62
Antioxidants (Benzoic acid 100 ppm + Vitamin B 50 ppm + Ascorbic acid 50 ppm + Citric acid 500 ppm)	0.69	0.67	0.66	0.65	0.63	0.6	0.57	0.64
AMINOQUELANT- CA 0.05% (Amino acids + Calcium)	0.68	0.67	0.67	0.66	0.65	0.64	0.63	0.66
Mean	0.72	0.68	0.66	0.63	0.61	0.57	0.54	

LSD value at 0.05:
Treatments (T): 0.02 Storage periods (P): 0.01 Interactions (TxP): 0.04

Table 15 : Effect of preharvest treatments on Acidity % of Superior grape fruits during 6 weeks storage at (0^0 C – 90 RH %) in 2018 season.

Treatment	Storage period (weeks)							Mean
	0	1	2	3	4	5	6	
Control	0.82	0.69	0.63	0.62	0.58	0.49	0.46	0.61
Micro nutrients (Zinc 0.05% + Boric acid 0.05% + Magnesium sulphate 0.5%)	0.73	0.71	0.69	0.62	0.59	0.56	0.51	0.63
Antioxidants (Benzoic acid 100 ppm + Vitamin B 50 ppm + Ascorbic acid 50 ppm + Citric acid 500 ppm)	0.70	0.68	0.67	0.66	0.64	0.61	0.58	0.65
AMINOQUELANT- CA 0.05% (Amino acids + Calcium)	0.69	0.68	0.68	0.67	0.66	0.65	0.64	0.67
Mean	0.74	0.69	0.67	0.65	0.62	0.58	0.55	

LSD value at 0.05:
Treatments (T): 0.07 Storage periods (P): 0.02 Interactions (TxP): 0.09

Table 16 : Effect of preharvest treatments on Vitamin C (mg/100 mL juice) of Superior grape fruits during 6 weeks storage at (0^0 C – 90 RH %) in 2017 season.

Treatment	Storage period (weeks)							Mean
	0	1	2	3	4	5	6	
Control	3.11	3.05	2.44	2.3	2.15	2.05	1.80	2.41
Micro nutrients (Zinc 0.05% + Boric acid 0.05% + Magnesium sulphate 0.5%)	3.34	3.12	3.00	2.81	2.7	2.61	2.52	2.87
Antioxidants (Benzoic acid 100 ppm + Vitamin B 50 ppm + Ascorbic acid 50 ppm + Citric acid 500 ppm)	3.54	3.29	3.20	3.15	3.10	3.05	2.98	3.19
AMINOQUELANT- CA 0.05% (Amino acids + Calcium)	3.42	3016	3.05	2.92	2.87	2.80	2.73	2.99
Mean	3.35	3.16	2.92	2.80	2.71	2.63	2.51	

LSD value at 0.05:
Treatments (T): 0.04 Storage periods (P): 0.01 Interactions (TxP): 0.07

Table 17: Effect of preharvest treatments on Vitamin C (mg/100 mL juice) of Superior grape fruits during 6 weeks storage at (0^0 C – 90 RH %) in 2018 season.

Treatment	Storage period (weeks)							Mean
	0	1	2	3	4	5	6	
Control	3.13	3.07	2.45	2.31	2.16	2.06	1.81	2.43
Micro nutrients (Zinc 0.05% + Boric acid 0.05% + Magnesium sulphate 0.5%)	3.36	3.14	3.02	2.82	2.71	2.62	2.53	2.89
Antioxidants (Benzoic acid 100 ppm + Vitamin B 50 ppm + Ascorbic acid 50 ppm + Citric acid 500 ppm)	3.56	3.31	3.22	3.17	3.12	3.07	2.99	3.20
AMINOQUELANT- CA 0.05% (Amino acids + Calcium)	3.44	3.18	3.07	2.93	2.88	2.81	2.74	3.01
Mean	3.37	3.17	2.94	2.81	2.72	2.64	2.52	

LSD value at 0.05:
Treatments (T): 0.06 Storage periods (P): 0.03 Interactions (TxP): 0.10

Table 18 : Effect of preharvest treatments on Total sugar % of Superior grape fruits during 6 weeks storage at (0^0 C – 90 RH %) in 2017 season

Treatment	Storage period (weeks)							Mean
	0	1	2	3	4	5	6	
Control	13.25	16.80	17.20	18.30	19.64	20.46	21.95	18.23
Micro nutrients (Zinc 0.05% + Boric acid 0.05% + Magnesium sulphate 0.5%)	14.20	16.54	16.98	17.67	18.95	19.69	20.25	17.75
Antioxidants (Benzoic acid 100 ppm + Vitamin B 50 ppm + Ascorbic acid 50 ppm + Citric acid 500 ppm)	14.85	16.10	16.88	17.36	18.73	19.35	19.90	17.60
AMINOQUELANT- CA 0.05% (Amino acids + Calcium)	15.34	15.88	16.27	16.46	17.00	17.48	18.73	16.74
Mean	14.41	16.33	16.83	17.45	18.58	19.25	20.21	

LSD value at 0.05:
Treatments (T): 0.06 Storage periods (P): 0.05 Interactions (TxP): 0.16

Table 19 : Effect of preharvest treatments on Total sugar % of Superior grape fruits during 6 weeks storage at (0^0 C – 90 RH %) in 2018 season.

Treatment	Storage period (weeks)							Mean
	0	1	2	3	4	5	6	
Control	13.36	16.93	17.34	18.45	19.80	20.62	22.13	18.37
Micro nutrients (Zinc 0.05% + Boric acid 0.05% + Magnesium sulphate 0.5%)	14.31	16.67	17.12	17.81	19.10	19.85	20.41	17.90
Antioxidants (Benzoic acid 100 ppm + Vitamin B 50 ppm + Ascorbic acid 50 ppm + Citric acid 500 ppm)	14.97	16.23	17.02	17.50	18.88	19.50	20.06	17.74
AMINOQUELANT- CA 0.05% (Amino acids + Calcium)	15.46	16.01	16.40	16.59	17.14	17.62	18.88	16.87
Mean	14.53	16.46	16.97	17.59	18.73	19.40	20.37	

LSD value at 0.05:
Treatments (T): 0.08 Storage periods (P): 0.04 Interactions (TxP): 0.12

Table 20: Effect of preharvest treatments on Respiration Rate (ml CO_2 /kg/h) of Superior grape fruits during 6 weeks storage at (0^0 C–90 RH %) in 2017 season

Treatment	Storage period (weeks)							Mean
	0	1	2	3	4	5	6	
Control	15.21	3.58	3.90	4.25	5.98	6.51	7.58	6.72
Micro nutrients (Zinc 0.05% + Boric acid 0.05% + Magnesium sulphate 0.5%)	14.92	2.40	2.54	2.64	2.73	2.82	2.82	4.41
Antioxidants (Benzoic acid 100 ppm + Vitamin B 50 ppm + Ascorbic acid 50 ppm + Citric acid 500 ppm)	13.87	2.34	2.42	2.50	2.56	2.67	2.82	4.17
AMINOQUELANT- CA 0.05% (Amino acids + Calcium)	12.59	1.92	2.00	2.10	2.18	2.25	2.30	3.62
Mean	14.15	2.56	2.72	2.87	3.36	3.56	3.88	

LSD value at 0.05:
Treatments (T): 0.06 Storage periods (P): 0.03 Interactions (TxP): 0.10

Table 21: Effect of preharvest treatments on Respiration Rate (ml CO_2 /kg/h) of Superior grape fruits during 6 weeks storage at (0^0 C – 90 RH %) in 2018 season

Treatment	Storage period (weeks)							Mean
	0	1	2	3	4	5	6	
Control	15.35	3.61	3.94	4.29	6.03	6.57	7.65	6.78
Micro nutrients (Zinc 0.05% + Boric acid 0.05% + Magnesium sulphate 0.5%)	15.05	2.42	2.56	2.66	2.75	2.85	2.85	4.45
Antioxidants (Benzoic acid 100 ppm + Vitamin B 50 ppm + Ascorbic acid 50 ppm + Citric acid 500 ppm)	13.99	2.36	2.44	2.52	2.58	2.69	2.85	4.21
AMINOQUELANT- CA 0.05% (Amino acids + Calcium)	12.70	1.94	2.02	2.12	2.20	2.27	2.32	3.65
Mean	14.27	2.58	2.74	2.90	3.39	3.59	3.91	

LSD value at 0.05:
Treatments (T): 0.07 Storage periods (P): 0.04 Interactions (TxP): 0.12

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