Impact of Postharvest Calcium Chloride, Potassium Metabisulfite Treatments and Storage Periods on Physical Quality and Shelf-life of Zaitony Grape Cultivar

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Abstract

The present investigation was carried out at the laboratory of Horticulture and Landscape Design Department / College of Agricultural Engineering Sciences/ Salahaddin – Erbil University, in order to study the effect of Calcium Chloride ($CaCl_2$), Potassium Metabisulfite ($K_2S_2O_5$) and their combinations on maintenance of physical quality of table grapes ‘Zaitony’ (*Vitis vinifera*. L) at three periods of cold storage (25, 50 and 75 days) at 2±1 °C and 83-88% RH. Changes in berry shattering, spoilage, weight loss, total weight loss and rachis browning of grape clusters were investigated. The data obtained indicated enhancement in cluster shelf life and storage ability as follows: $CaCl_2$, $K_2S_2O_5$ and their combination for 5 minutes maintained the cluster quality grade after keeping clusters for 25 days and after 50 or 75 days of cold storage. At the end of the 75-days shelf-life period, the weight loss and all the studied characteristics in control were higher than in treated clusters during the same storage period.

Keywords: Grape, Postharvest, Calcium Chloride, Potassium Metabisulfite, Storage Periods.

Introduction

Grapes (*Vitis vinifera.L*) It is belonged to the Vitaceae family which is among the earliest, most widely grown and commercially substantial fruit yields worldwide[8] and deciduous woody vines perennial plants, being one of the most consumed non-climacteric fruits[24].

The berries are rich in vitamins B1, B2, and C as well as other elements. The fruits are consumed as table grapes when they are fresh and as fresh juice and raisins when they are processed [4]. Grapes (Vitis vinifera L.) are highly perishable fruits susceptible to post-harvest losses due to decay, desiccation, and physiological disorders. Effective post-harvest treatments are essential to maintain fruit quality during storage and transportation [9].

Fungal deterioration, berry cracking, skin browning, and water loss all shorten the shelf life of table grapes after harvest. Scientists estimate that fungal decay losses account for 10–40% of global grape production [27], making post-harvest fungal diseases one of the most important causes of fruit production losses [17]. Furthermore, there is a high likelihood that these fungi will produce mycotoxins in contaminated fruits, which could have detrimental effects on health [13]. Using safe and effective methods to minimize contamination and spoiling growth while maintaining quality is one of the main goals of table grape post-harvest technology [18].

Many methods have been investigated to increase the shelf life of grape clusters. These include postharvest physical and chemical treatments, altered environment packaging, and temperature conditioning [15, 31].

Calcium chloride is one of the many inorganic salts that has antibacterial properties against a variety of dangerous fungi. Treatments with calcium chloride have been proposed as a safe and effective alternative to postharvest decay control in some grape varieties [1]. Cleaning solutions like ethanol are also used to sterilize the fruit's surface and have demonstrated great success in controlling and preventing grape deterioration [23]. Fruits, including grapes, are known to retain their firmness, decrease deterioration, and improve cell wall stability when treated with calcium chloride ($CaCl_2$). Research has demonstrated that CaCl2 can prevent weight loss during storage and postpone ripening [25].

Calcium chloride ($CaCl_2$) is one substance that is important to the production and postharvest care of grapevines, especially Vitis vinifera L., Through a variety of physiological and biochemical processes, its use has been demonstrated to improve grape quality and increase shelf life [19]. The effects of storage conditions and $CaCl_2$ on the quality of grapes after harvest. Grape physical characteristics and shelf life were assessed for each treatment. According to the study, grape shelf-life is significantly impacted by 2% $CaCl_2$ in a cool bot kept at 85±5% RH and 8±1 °C. The 2% $CaCl_2$ group showed the least amount of weight loss on the 24th day of storage [12].

An inorganic substance called potassium metabisulfite ($K_2S_2O_5$) is essential to many different industries. Known for its potent antioxidant and antimicrobial qualities, potassium metabisulfite also called "sulfites" or "meta" is used to prevent spoiling by preventing undesirable bacteria from growing on grapes and equipment. Because it is highly soluble in water and usually comes in the form of white crystalline powder or granules, potassium metabisulfite is also used in the food industry as a preservative to prolong the shelf life of products by inhibiting oxidation and microbial growth [29]. It effectively controls post-harvest decay and maintains grape clusters in storage to prevent fungal infections by releasing sulfur dioxide (SO_2), which has potent antifungal properties. Potassium metabisulfite is widely used in the fruit industry due to its antifungal properties [16]. However, their effectiveness may vary depending on the concentration used. Furthermore, potassium metabisulfite was found to be an effective fruit preserver during postharvest storage [11].

Cold storage is a crucial piece of postharvest grape management technology which aims to preserve grape quality and increase shelf life. Given their high perishability, grapes need particular humidity and temperature levels to avoid spoiling and maintain their nutritional value and sensory qualities [5]. The most popular technique for extending the shelf life of grapes is cold storage. Grapes can be kept for up to eight weeks at 0°C [9].

The aims of the present study are to evaluate the impact of $CaCl_2$ and K2S2O5 treatments on the quality parameters of grape clusters during storage and to develop practical recommendations for post-harvest treatments of grape clusters. The findings will contribute to the development of better post-harvest management practices for grapes, benefiting growers, distributors, and consumers.

Material and Methods

The clusters of zaitony grape cultivar were taken from a private vineyard of grape on the road of Kirkuk - Erbil in Hamzakor village, Qushtapa district (28 km Southeast of Erbil city center), Kurdistan region, Iraq locate on Latitude35.97^{0}N Longitude 44.07^{0}E - Elevation 410 m above sea level.

Experimental materials

Zaitony is a contemporary grape variety that is planted in the Kurdistan Governorate in Iraq. It is regarded as a late variety that ripens in late July and makes a good table grape. Its name comes from the French because its life resembles an olive fruit. This cultivar is characterized by its well-packed cylindrical, conical clusters medium-density, medium-sized, with a medium-thick peel covered with a waxy layer of dark red-black color. The pulp is hot and sweet in taste and contains a number of seeds ranging from 2-3 seeds per berry [4, 2, 7, and 21].

On (30-7-2024) 70 kg of grape (Zaitony) cultivar clusters were harvested randomly with TSS (17-19 %) from chosen healthy grapevines of 4 years old cultivated, trained as T-Trellis training method with 2 x 4 meters apart, and 2 meters high above soil surface, system irrigated with drip system. The vines got traditional cultivation methods with regular winter and summer training, weed and diseases control. Following harvesting, the clusters were manually placed in (50 x 30 x 15 cm) plastic boxes. They were then chosen to create uniform batches based on factors like color, size, health, and greenish rachises. These were then sent straight to the laboratory of Horticulture and Landscape Design Department / College of Agricultural Engineering Sciences/ Salahaddin–Erbil University. Decomposed, overripe, wilted, injured, and damaged berries with a dull look and/or quality faults were separated or removed by a shear on the same day of harvesting. Grape clusters were then stored in a cooled room at 10°C for 24 hours in order to eliminate field heat (pre-cooling)[20].

After initially pre-cooling the grape clusters were disinfected using a diluted chlorine solution at a concentration of 2 ml/L of water for five minutes to ensure any potential surface contaminants were eliminated. We then rinsed the clusters thoroughly with clean water to remove any traces of chlorine solution at a concentration of 2 ml/L of water for five minutes, and then rinsed the clusters thoroughly with clean water to remove any traces of chlorine.

This experiment composed of three factors:

1- Calcium Chloride ($CaCl_2$) concentration 0 and 4%, control treatment (0) clusters were dipped in distilled water and 4% clusters were dipped in for 5 minutes to ensure through coverage and absorption.
2- Potassium Metabisulfite ($K_2S_2O_5$) concentrations 0 and 2%, For 5 minutes, clusters were dipped in order to guarantee that every berry was completely submerged and covered with the solution.
3- Three storage periods 25, 50and 75days.
After dipping, grape clusters were furnished on a thick piece of cloth and left to air-dry, each groups weighted (9 kg) then putted in polyethylene plastic bags (30×40 cm with 12 holes of) in addition of three replicates for each treatment and divided into 42 parts as follow:

- 3 bags only using distillated water before storage.
- 9 bags of distillated water.

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- 9 bags of $CaCl_2$.
- 9 bags of ($K_2S_2O_5$).
- 9 bags Combined Treatment: $CaCl_2$ followed by $K_2S_2O_5$.
- 3 bags weight loss.

Lastly, the bags were kept in cold storage size (120 x 140 cm) for 25, 50, and 75 days at 2±1 °C and 83–88% relative humidity.

Measurement parameters

Berry shattering %

The berries that separated from the cap stem following moderate shaking were weighed for each replicate, and the percentage of berries that shatter was then calculated as follows:

Weight of berry shatter

Shatter% = ---------------------------- ×100 (1)

Initial clusters weight

Spoilage %

The original weight of clusters was used to estimate it after the spoiled berries for each replicate during each storage period were weighed.

Weight of spoiled berries

Berry spoilage % = ------------------------- ×100

Initial clusters weight (2)

Weight loss (%)

Individual sample weights were noted on the first day and at the conclusion of each storage period [3]. At the start of the experiment and then every 25 days while they were being stored, grape clusters were weighed. The percentage of the initial total weight lost was used to represent weight loss.

Rachis condition (Stem browning)

The rachis's visual quality was evaluated after 25, 50, and 75 days of storage to gauge the presence or absence of dehydration signs, browning for principal and secondary branches, and mild, moderate, severe, and extremely severe browning[28].

The color and appearance of the berries and table grape rachis were assessed upon cooling during the cold storage phase. The following scoring system was used to assess stem browning: healthy = whole stem, including cap stems (where berries and rachis meet); slight = only cap stems displaying browning; moderate = cap stems and secondary stems exhibiting browning; and severe = entirely brown cap stems, secondary stems, and primary stems.

Total loss in weight (%)

It was calculated in this way:

(100-weight loss)×(100-Spoilage)

Total loss in weight= ---------------------------- - 100

100 (3)

Experimental Design

The experiment was performed in a Factorial experiment according to a Complete Randomized Design (C.R.D) with three factors, Calcium Chloride ($CaCl_2$) (0 and 4 %), Potassium Met bisulfite ($K_2S_2O_5$), (0 and 2 %) with overlap between them and 3 storage periods (25, 50 and 75 days), as well as the control treatment (without storage) with three replicates (2×2×4×3=48).

An analysis of variance (ANOVA) was performed on the collected data using the SAS statistical tool [26]. If significant differences are discovered, the mean values are evaluated using Duncan's

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Multiple Range Test [22] at the $p<0.05$ level of significance.

Results and Discussion

Effect of treatments $CaCl_2$, $K_2S_2O_5$ and their combination on the physical characteristic of grape berries

Berry shattering (%)

The table (1) shows that zaitony grape clusters were significantly affected berry shattering, the higher value recorded in control (0.64%) and the lower value recorded in $CaCl_2$+$K_2S_20_5$ treatments (0.06%).

Spoilage (%)

As it revealed in results from table (1) shows significant differences in spoilage percentage among the treatments applied. Spoilage percentage ranges from (0.01 to 0.50 %), the control treatment recorded the highest value (0.50%), and notably the lowest percentage (0.01%) was recorded from clusters treated with $CaCl_2$ and $CaCl_2$ +, $K_2S_2O_5$.

Weight loss (%)

The results depicted in table (1) relived that weight loss decreased with dipping clusters on $K_2S_2O_5$ (0.42 %) and maximum weight loss (1.67 %) was noticed in control.

Total loss in weight (%)

The results on total loss in weight was presented in table (1) indicated that total weight loss was significantly between treatments. The highest ratios (2.16%) were observed in the control compare with other treatments, the lowest value (0.47%) in $K_2S_2O_5$ followed by clusters treated with $K_2S_2O_5$ and $CaCl_2$.

Table 1. Effect of treatments ($CaCl_2$, $K_2S_2O_5$ and their combination) on the physical characteristic of grape berries*

Treatments (%)	Parameters				
	Berry shattering (%)	Spoilage (%)	Weight loss %	Total loss in weight (%)	Rachis condition
Control	0.64 a	0.50 a	1.67 a	2.16 a	Moderate
$CaCl_2$	0.24 b	0.01 b	0.61 b	0.62 b	Slight
$K_2S_2O_5$	0.15 bc	0.05 b	0.42 c	0.47 c	Slight
$CaCl_2$+$K_2S_2O_5$	0.06 cd	0.01 b	0.48 c	0.49 c	Slight

*Values within each column followed by the same letter are not significantly different from each other according to Duncan's Multiple Range Test at 5% level of probability.

Potassium metabisulfite prolongs the shelf life of fruits by preventing enzymatic browning and microbiological growth. It functions by producing sulfur dioxide,

ISSN 2072-3857

which has antibacterial and antioxidant properties. Fruit quality can be preserved throughout storage and weight loss can be minimized with KMS treatment, according to studies. However, the type of fruit, the concentration utilized, and the storage circumstances can all affect how effective KMS is [10].

Effect of storage periods on the physical characteristic grape berries

Berry shattering (%)

During the storage period, which spanned from (25 - 75 days), significant differences in berry shattering were observed between storage periods table (2). The highest ratios (0.49 %) were recorded at the end of storage periods (75 days), the lowest ratio was observed in the control without storage (0 %).

Spoilage (%)

The study found that the spoilage percentage significantly differ based on the storage period table (2). However, it was observed that percentage increased during the storage period. On the 75 days of storage had the highest value (0.29 %), followed by 50 day, on the (25 days) of storage had the lowest percentage (0.06 %).

Weight loss (%)

The minimum weight loss of clusters was recorded (0.38 %) under 25 days storage period and maximum weight loss was recorded with increased storage periods, table (2). 75 days increased the weight loss (2.04 %).

Total loss in weight (%)

The data represented in table (2) regarding total weight loss %, of the grape clusters cv. `Zaitony' stored for (25, 50 and 75 days) showed statistically significant differences, the value increased with increasing storage period. The highest total loss in weight was observed (2.33 %) when clusters stored for 75 days comparison with the lowest (0.45 %) in (25 days) storage periods. Data cleared that fruit decay and total weight loss were increased by extending storage period. Harvested fruits lose moisture due to respiration, transpiration (water evaporation), and continuous metabolic processes. The fruit loses weight and moisture content as a result, which degrades its quality and renders it unsuitable for sale [30].

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Table 2. Effect of storage periods on the physical characteristic of grape berries*

Storage periods (days)	Parameters				
	Berry shattering (%)	Spoilage (%)	Weight loss %	Total loss in weight (%)	Rachis condition
25	0.01 c	0.06 c	0.38 c	0.45 c	Slight
50	0.33 b	0.14 b	1.55 b	1.77 ab	Moderate
75	0.49 a	0.29 a	2.04 a	2.33 a	Severe

*Values within each column followed by the same letter are not significantly different from each other according to Duncan's Multiple Range Test at 5% level of probability

Effect of interaction between storage periods and treatments on the physical characteristic of grape berries

Berry shattering (%)

It is obvious from table (3) that berry shatter (%) was gradually increased by storage period advanced. Thus, clusters treated with $CaCl_2$+$K_2S_2O_5$ (0.09 %) significantly reduced berry shatter than the control (1.15%) at the end of storage period (75 days). In this respect, data also revealed that berry shattering gave a significantly lower value at (25 days) (0%) than other treatments and storage periods.

Spoilage (%)

As table (3) outlines the impact of interaction between storage periods and treatments on the spoilage (%) in zationy cultivar. 75 days with control treatment of both had the maximum influence (1.09%) respectively, (0%) is the minimum value from 25 days in all treatments.

Weight loss (%)

It is clear from the data that weight loss showed increasing after post- harvest treatment with $CaCl_2$, $K_2S_2O_5$ and $CaCl_2$+ $K_2S_2O_5$ with increasing period of storage. The weight loss was found to be significant from 25 to 75 days of storage. Data presented in(Table 3) Indicated that, the post-harvest treatments affected significantly on weight loss. However, the percentage was found to be significant maximum in clusters under treatment $K_2S_2O_5$ at 75 days, whereas, minimum weight loss was found at 25 days storage period under different treatments.

Total loss in weight (%)

The table (3) shows that the effect of interaction between storage periods and treatments on zationy clusters in total loss in weight (%) has significant effect, that 75 days gave the higher value (1.70 %) in control treatment which was at par with control at 50 days compared with 25 days the lower value in all treatments (0 %). At the end of storage period (75 days), the control treatment caused the highest value of total weight loss (1.70%) while the lowest (1.12 %) value was measured in the berries treated with $CaCl_2$.

In general view, the obtained results cleared that, the storage period was 25 days for the control, 50 and 75 day for $CaCl_2$ and 50 days for other treatments.

Softening of the fruit is conducive to disease infestation is successfully postponed by $CaCl_2$ treatment; this is

ISSN 2072-3857

strongly linked to calcium's function in preserving the cell wall [6].

Table 3. Effect of interaction between storage periods and treatments on the physical characteristic of grape berries *

Storage periods (days)	Treatments (%)	Parameters				
		Berry shattering (%)	Spoilage (%)	Weight loss (%)	Total loss in weight (%)	Rachis condition
25	Control	0.00 e	0.00 c	0.00 e	0.00 e	Severe
	$CaCl_2$	0.00 e	0.00 c	0.00 e	0.00 e	Slight
	$K_2S_2O_5$	0.00 e	0.00 c	0.00 e	0.00 e	Slight
	$CaCl_2+K_2S_2O_5$	0.00 e	0.00 c	0.00 e	0.00 e	Moderate
50	Control	0.78 b	0.43 b	1.08 c	1.48 a	Moderate
	$CaCl_2$	0.31 cd	0.00 c	0.26 de	0.26 d	Slight
	$K_2S_2O_5$	0.21 d	0.03 c	0.69 d	0.70 cd	Moderate
	$CaCl_2+K_2S_2O_5$	0.01 e	0.00 c	1.04 c	1.04 c	Moderate
75	Control	1.15 a	1.09 a	0.61 d	1.70 a	Severe
	$CaCl_2$	0.41 c	0.02 c	1.12 c	1.12 b	Slight
	$K_2S_2O_5$	0.25 cd	0.11 c	1.48 b	1.64 b	Moderate
	$CaCl_2+K_2S_2O_5$	0.09 de	0.02 c	1.67 b	1.69 b	Moderate

*Values within each column followed by the same letter are not significantly different from each other according to Duncan’s Multiple Range Test at 5% level of probability.

Clusters of grapes are vulnerable to enzymatic browning and dehydration after harvest, especially when they are exposed to ambient, uncontrolled conditions during marketing. Berry shriveling, cluster wilting, and berry shattering can result from excessive water loss [14].

Conclusion

Maintaining and enhancing fruit quality after harvest is becoming more and more crucial in a market where customers demand high-quality products all year round.

ISSN 2072-3857

To preserve the postharvest quality of table grapes, low temperature storage is frequently utilized.
However, if left untreated during storage, grape clusters are prone to degradation.

Clusters that were treated with $CaCl_2$, $K_2S_2O_5$, and their combination for 5 minutes during cold storage at 2 ± 1 °C and 83–88% relative humidity showed preserved quality over storage periods of 25, 50, and 75 days improved berry shattering (%) and spoilage (%) weight loss (%) and rachis condition. However, additional research over several seasons is required to test and corroborate these findings, as they are based on data from one cultivar.

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ISSN 2072-3857